

**APPROPRIATE MANAGEMENT OPTIONS OF MEDICAL WASTE FOR
DEVELOPING COUNTRIES (THE CASE OF BANGLADESH AND THAILAND)**

by

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Technical Science.

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Abstract

The primary goal of this research was to formulate appropriate environmental management options for medical waste in developing countries. The purpose was to improve the health conditions of the people and environmental quality of developing countries with special emphasis on Bangladesh. Therefore, the overall objective of this study was to assess the effects of disposed medical wastes on health and the environment and to develop a management intervention to improve the medical waste disposal system in developing countries, especially Bangladesh and Thailand. Specific objectives of the study were to (1) review the current status of hospital waste management (policy, regulation and practices) in Bangladesh and Thailand and draw on references from other developed countries; (2) compare the management techniques and practices in Thailand and Bangladesh related to proper handling and disposal of medical waste; (3) determine the effectiveness of infectious waste handling and disposal by testing pathogens; and (4) recommend appropriate management options for medical waste, in developing country specifically in Thailand and Bangladesh.

The study was conducted mainly in 2 cities in Bangladesh and in 2 cities in Thailand. The study concentrates on hospital's waste generation, management and waste disposal sites. Health and environmental aspects of waste in and out of hospital premises and disposal sites were taken into account. Data and information were collected (March 2000 to March 2001) through (i) literature review (ii) secondary data (iii) interview (iv) field investigation (v) questionnaire survey (vi) laboratory analysis (vii) discussion (viii) observation and (ix) case studies.

The overall situation analysis showed evidence of a lack of proper attention given by hospital authorities. There was a lack of resource availability; training, monitoring, and evaluation; adequate law and negligence in implementation, enforcement of existing law in proper medical waste management in Bangladesh and Thailand. It was also observed that Thailand has a better situation compared to Bangladesh in relation to infectious waste management, training, guidelines and regulations. A few identified problems related to waste management were lack of cooperation between different agencies; lacks of proper waste management policy, specified standards, and regular monitoring. Resource availability, skilled manpower, and awareness should also be taken into account to address the proper medical waste management issue. Overall findings also indicate that there was a lack of in-house management of medical waste in both countries to some extent. There were good initiatives found in the case studies of both countries, such as, building awareness among local communities with higher authorities; using a bottom-up approach of management; involvement of local communities and all stockholders in planning and implementation of projects; in-house training and evaluation; good housekeeping as well as low cost technology of collection, storage, treatment and disposal; and sharing the facilities with small hospitals.

Improvements in medical waste management involve a number of activities, which can be undertaken in a series of small steps on the road to improvement. Considering the whole situation there are some specific suggestions and recommendations for medical waste and infectious waste management. These were adequate in-house treatment/ management; cost reduction of management; formulation and enforcement of laws and regulations. Suggestions were made for each aspect that influences or relates to medical waste management. An action plan with appropriate options has been given for Bangladesh and Thailand at the end of this dissertation.

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ADB	Asian Development Bank
ARI	Acute Respiratory Infection
BCAS	Bangladesh Center for Advanced Studies
BMA	Bangkok Metropolitan Administration
BRAC	A National NGO as BRAC
CDC	Centers for Disease Control and Prevention
CMH	Combined Military Hospital
DALYs	Disability Adjusted Lost Years
DCC	Dhaka City Corporation
DGH	Directorate General of Health
DGHS	Directorate General of Health Services
DMCH	Dhaka Medical College Hospital
DOE	Department of Environment
DOH	Department of Health
DPC	Department of Public Cleansing
EPA	Environmental Protection Agency's
EPI	Expanded Program on Immunization
ESP	Essential Services Package
GOB	Government of Bangladesh
HBV	Hepatitis B virus
HCOA	Hospital and Clinics Owner's Association
HDI	Human Development Index
HIV	Human immunodeficiency virus
HW	Hospital Waste
HWM	Hospital Waste Management
ICDDR,B	International Center for Diarrhoeal Disease Research, Bangladesh
ICMH	Institute of Child and Mother Health
IPGMR	Institute of Post Graduate Medicine Research
IW	Infectious Waste
JCAHO	Joint Commission on Accreditation of Healthcare Organizations
KCC	Khulna City Corporation
MOHFP	Ministry of Health and Family Planning
MOHFW	Ministry of Health and Family Welfare
MOPH	Ministry of Public Health
MOSTE	Ministry of Science, Technology and Environment
MWIs	Medical Waste Incinerators
MWM	Medical Waste Management

MWTA	Medical Waste Tracking Act
NGO	Non-government organization
NIH	National Institute of Health
NRC	Nuclear Regulatory Commission
OPD	Out Patient Department
OSHA	Occupational Safety and Health Administration
OT	Operation Theatre
PCD	Pollution Control Department
RCRA	Resource Conservation and Recovery Act
RTI	Reproductive Tract Infection
SSMCH	Sir Salimullah Medical Collage Hospital
STD	Sexually Transmitted Disease
SWMP	Solid Waste Management Project of Phitsanulok Province
THFPO	Thana Health and Family Planning Officer
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Program
UNICEF	United Nations Emergency Children's Fund
WB	World Bank
WHO	World Health Organization

CHAPTER 1

Introduction

1.1 Preamble

Waste is essentially anything, which someone no longer requires or wants. This term includes things we commonly describe as garbage, refuse, and trash. The U.S. Environmental Protection Agency's (EPA) regulatory definition is broader in scope. It includes any discarded items; things destined for reuse, recycle, or reclamation; sludges; and hazardous wastes. Any anthropogenic activity generates some waste. Hospital is one of those kinds generate various types of waste that includes household type waste, infectious and hazardous waste. A wide variety of waste components have always been generated by various sections of medical establishments.

Millions of tons of medical waste are generated each year throughout the world. When talking about waste from hospitals or health facilities, different nomenclatures are in use: "healthcare waste" is the new European terminology; in the United States this types of waste is called "medical waste", and in the text of Basel Convention for Hazardous waste it is called "clinical waste". Since this study will mainly deal with the waste coming from medical establishments, therefore, the waste will be termed as "medical waste".

A large part of medical waste usually consists of clinical and non-clinical waste. Such pollutants can, therefore, be broadly classified into a) solid wastes, and b) liquid waste (wastewater). Both are important source of physical and natural environmental degradation and constitute a health hazard. Solid waste mean non-liquid wastes or 'refuse'. It is a variety of materials, such as, dust, ash, food-waste, rags, paper, plastic, glass, metals (sharps, needles), and radioactive and pathological wastes. Liquid waste contains chemicals used in laboratory, pathogen containing urine, blood and other sample for testing disposed off to the wastewater.

Wastes produced in medical establishments needs special care include sharps (syringes, disposable scalpels, blades etc.), non-sharps (swabs, bandages, disposable medical devices etc.), blood and anatomic waste (blood bags, diagnostic samples, body parts etc.), chemicals (solvents, disinfectants etc.), pharmaceuticals, and may be infectious, toxic, create injuries or radioactive. Medical waste considered as a reservoir of pathogenic microorganisms, which can cause contamination and give rise to infection. If waste is inadequately managed, these microorganisms can be transmitted by direct contact, in the air, or by a variety of vectors. In other word hospital wastes can produce undesirable effects by biological, chemical, physical, mechanical, or psychological means. For example, human pathogen in infectious waste provide a biological threat, chemical used in hospital create chemical hazards, flammable materials involved a physical danger through fires or explosion, and broken glass and other sharps-edged waste create mechanical hazards.

1.2 Statement of the Problem

Improper management of wastes generated in hospitals can have direct health impacts on the community, the personnel working in hospital facilities, and on the environment. Inadequate management of medical waste lead to serious environmental and public health

consequences. Improper management of solid wastes from healthcare activities may contribute to the spread of disease, as well as pollution of the air, soil and water. Runoff from untreated infectious wastes or human excrement dumped on the land can contaminate surface and ground water supplies, exposing the population to the risk of diseases and parasites.

The risk to the community includes intentional and unintentional exposure in the absence of a safe waste management system. Intentional exposure occurs through the widespread reuse of disposable materials (especially syringes) in developing countries and results in the main disease burden caused by inadequate medical waste management. Main disease outcomes of concern include HBV, HCV and HIV transmission, TB/ Throat infection, Typhoid, Dysentery, Diarrhoea, Bacterial/ Viral diseases, ARV (Rabies), VDRL (STD), UTI/ all C/S, and Leprosy. Unintentional injuries may occur when the community is exposed to inadequately disposed waste, for example waste workers and scavengers may be injured by improperly discarded sharps and exposed to life-threatening infection with above mentioned diseases. Uncontrolled burning of medical wastes may pollute the air with acid gases, dioxins, furans and heavy metals.

The public perceived hospital waste, as being the waste stream creating the greatest risk to public health. This is a matter that is exacerbated by the adverse publicity that these incidents have caused. It's importance therefore, is well established and whilst in terms of waste production, in any country, the amount to be dealt with is small in comparison with the total amount of waste produced, the overall effect if it is mishandled is proportionately greater.

According to WHO (2000), throughout the world every year an estimated 12 000 million injections are administered. And not all needles and syringes are properly disposed of, generating a considerable risk for injury and infection and opportunities for re-use. Worldwide, 8-16 million hepatitis B, 2.3 to 4.7 million hepatitis C and 80 000 to 160 000 HIV infections are estimated to occur yearly from re-use of syringe needles without sterilization². Many of these infections could be avoided if syringes were disposed of safely. The re-use of disposable syringes and needles for injections is particularly common in certain African, Asian and Central and Eastern European countries. In June 2000, six children were diagnosed with a mild form of smallpox (vaccinia virus) after having played with glass ampoules containing expired smallpox vaccine at a garbage dump in Vladivostok (Russia).

While hospitals and other health facilities in developing countries have developed certain safety standards in order to minimize the risk resulting from medical waste, the situation in developing countries is worrying. In developing countries, where many health concerns often compete for very limited resources, the management of medical waste may not get the priority it deserves. Currently available information on medical waste management in developing countries shows lack of adequate or appropriate management structures/options, lack of funding, trained personnel, technical equipment and awareness is often the reason for improper waste management practices. Most of the developing countries use incinerator as the only options for treating medical waste. Even in some countries there is no existence of treatment facility or any kind of medical waste management practices. From the literature it is also found that, this technology is not always viable or appropriate for all developing countries considering the quality of incinerator, cost-effectiveness, acceptability, proper handling and maintenance. Regulatory or legal accepts of medical waste management in developing countries also an issue that has a role on proper handling and management of medical waste.

To date no low-cost, environmentally friendly and safe disposal options for health-care waste are available. Low-cost options are often polluting and are therefore indirectly potentially harmful to human health. The absence of management however also puts human health at risk. Significant improvements can however be achieved by management options such as introduce policies, guidelines, and segregation and proper treatment of significant portion of the waste.

This study discussed those aspects of which need to be considered to adopt appropriate management options of medical waste for developing countries.

1.3 Objectives of the Study

The overall objective of this study is to assess the effects of disposed medical wastes on health and environment and develop a management intervention to improve the medical waste disposal system in developing countries, specially Bangladesh and Thailand.

Specific objectives of the study:

1. To review the current status of hospital waste management (policy, regulation and practices) in Thailand and Bangladesh and draw references from other developed countries.
2. To compare the management techniques and practices in Thailand and Bangladesh related to proper handling and disposal of medical waste.
3. To determine the effectiveness of infectious waste handling and disposal by testing pathogens.
4. To recommend appropriate management options for medical waste, in developing country specifically in Thailand and Bangladesh.

1.4 Hypothesis

There is no well-established existing solid waste management system in most of the developing countries. Hospital waste is a part of total solid waste management system. Therefore, how can it incorporate in total solid waste management system and where to start is a question.

1. Medical waste management (MWM) does not get importance or medical waste is not a priority issue for developing countries as it is related with various factors. Such as national budget, public awareness, legal aspects etc.
2. MW is treated as a part of municipal solid waste stream. Management of medical waste thus integrated in solid waste management system.
3. Factor affecting MWM are in-house management, division of work (job distribution), responsibility, and workload among the hospital staff.
4. Improper management of medical waste has a threat to the environment and health of the people related with this job and who are scavenging on it.
5. Technology alone may not be fruitful for medical waste management without considering the resource availability (service, skilled manpower), public awareness, institutional involvement, policy formulation/legal bindings, in-house management (resource recovery, reuse, recycle, proper segregation).

6. Management could be effective if whole process is reviewed (waste generation to end of pipe disposal). i.e. what is management system (organizational structure) in hospital and how it is operating.

Considering (reviewing and analyzing) all these aspects this study may come up with specific recommendations and an action plan for MWM. This may help to improve the MWM system both in Bangladesh and Thailand.

- guideline;
- weakness of current system and its cause;
- possible solution/ suggestions; and
- action plan.

1.5 Scope of the Study

Study conducted mainly 2 cities in Bangladesh and 2 cities in Thailand. Data and/or information from developed countries also reviewed to compare and find out the appropriate alternatives. This study considered only the medical waste coming out from hospital, health service center, clinics and laboratories.

Study concentrate on hospitals waste generation, management and waste disposal sites. Health and environmental aspects of waste in and out of hospital premises and disposal site were taken into account. Focus was given to the infectious waste. Study were focused on the followings:

1. Waste characterization

- Solid waste from hospitals
- Qualitative
- Quantitative

These were collected from secondary data as well as field visit. Laboratory analyses of waste were done for different infectious pathogen particularly in Bangladesh.

2. Pathogen identification

Emphasis was given on Pathogen identification, quantification and origin of pathogen such as from pathological laboratory, diagnosis section, or treatment section etc.

3. Awareness level of doctors and nurses in Bangladesh about medical waste were determined by questionnaire.

4. Health effect of improper disposal and handling of medical waste and municipal waste were analyzed using questionnaire for hospital staff, scavengers in and out side of hospital premises and dumping site.

5. One waste disposal site from Bangladesh was selected to know the status of the environment and health status around the area. Waste analyzed for selected pathogen same as medical waste sample.

1.5.1 Limitations of this Study

1. Biases- any study involving interviews and visual observations might be prone to biases, which may or may not affect the findings. It was tried to maintain a unbiased outlook when collecting the data and conducting interviews.
2. Language- it was difficult to communicate and understand information obtained from the Thai hospitals and interviews the target group of respondents in Thailand. There might be gap between translator understanding and interpretation with the researcher's view and expectation. Cross-checking was done to minimize the gap of understanding.
3. Complexity- waste collected from the waste disposal site might be influenced by different factors (e.g. temperature, sunlight, and mixture of garbage) other than hospital waste. It was tried to collect waste immediate after disposing from the hospital or directly from the cleaner's container before throwing to the bin.
4. Unavailability: in Bangladesh, responsible person or section in-charge did not allow collecting waste directly from the generation site inside hospital (e.g. OT, OPD or patient's ward) though hospital authority give permission for that. Even the waste pickers near dustbin did not allow picking up any waste from there. Therefore, they were paid to give waste for analysis. Somewhere it was difficult to take photo of waste bin or waste inside hospitals.
5. Difficulties in Thailand- after trying for 4 to 5 months in Bangkok to visit some hospital only 2 hospitals gave permission in very formal way. Doctors or nurses were not willing to talk without the permission of director. Even the director also needed written permission from the Ministry. It was even completely not allowed to collect waste from Thai hospitals. Waste collected from Treatment Company was refused to analyze in the laboratory in Bangkok.

CHAPTER 2

Literature Review

2.1 Definitions and Characterization of Medical Wastes

2.1.1 Defining Medical Waste

Definitions of medical waste have a view to aid in regulating it. Given the fact that the medical waste stream is an extremely complex one including chemicals, which could be hazardous, as also normal kitchen or office waste akin to municipal solid waste, the definition of regulated medical wastes produced by hospitals, clinics, pathological laboratories, diagnostic centers, doctors offices, and other medical and research facilities. These wastes include infectious, pathological, sharps, pharmaceuticals, hazardous, genotoxic, chemicals, heavy metals, radioactive and other general wastes.

Definitions of medical waste vary in different countries and institutes as well, based on different categories of wastes. In general, medical wastes are wastes arising from diagnosis, monitoring and preventive, curative or palliative activities in field of the veterinary and human medicine. Broadly, medical waste is defined as any solid or liquid waste generated in the diagnosis, treatment or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals (BAN & HCWH, 1999).

Different categories of medical wastes defined by WHO (1999b) and EPA (2000) are given below:

2.1.1.1 Infectious waste: Infectious waste is suspected to carry pathogens, such as bacteria, viruses, parasites or fungi, in sufficient concentration or quantity to cause disease in susceptible human or animal hosts. Most infectious wastes are generated from patient care activities, laboratories and research efforts. In North America, the quantities of waste categorized as infectious increased after Canada and the United States adopted Universal Precautions (EPA, 2000). Under universal precautions, blood and certain body fluids of all patients are considered potentially infectious for human immunodeficiency virus (HIV), hepatitis B virus (HBV), and other blood borne pathogens.

Specific examples of infectious wastes include:

- Culture and stocks of infectious agents from laboratory, live vaccines, and the dishes, swabs and other devices used in working with these cultures.
- Waste from surgery and autopsies on patients with infectious diseases. These may include human tissue and materials (such as. Towels, gowns, aprons, gloves, laboratory coat) or surgical equipment and supplies soiled with blood or other fluids.
- Waste from infected patients' isolation wards. These may include dressings from wounds, as well as clothing and bedding that has been saturated with blood or other body fluids from those patients.
- Infected animals from laboratory

- Any other instruments or materials having in contact with infected persons or animals.
- 2.1.1.2 Pathological waste: Pathological waste consists of tissues, organs, body parts, human fetuses and animal carcasses, blood, and body fluids. These wastes may be generated during medical procedures, surgeries and autopsies on patients who may harbor infectious diseases. Pathological waste also includes specimens of body fluids, such as blood, serum, plasma and other blood components, and their containers, including intra-venous (IV) bags. This category should be considered as a subcategory of infectious waste, even though it may also include healthy body parts.
- 2.1.1.3 Sharps waste: Sharps are items that could cause cuts or puncture wounds, including needles, hypodermic needles, scalpel and other blades, knives, infusion sets, saws, broken glass, and nails. Irrespective of their infection potentiality, such items are usually considered as highly hazardous health-care waste.
- 2.1.1.4 Pharmaceutical waste: Pharmaceutical waste includes expired, unused, split, and contaminated pharmaceutical products, drugs, vaccines, and sera that are no longer required and need to be disposed of appropriately. The category also includes discarded items used in the handling of pharmaceuticals, such as bottles or boxes with residues, gloves, masks, connecting tubing, and drug vials.
- 2.1.1.5 Genotoxic waste: Genotoxic wastes include chemicals, drugs and substances that may have the potential to affect human genes causing mutation (mutagenic), developmental malformations (teratogenic) or cancer (carcinogenic). It raises serious safety problems, both inside hospitals and after disposal. Substances in this category include 'cytotoxic' drugs, used in chemotherapy of cancer. These drugs are enabled to kill or stop the growth of certain living cells.
- 2.1.1.6 Chemical waste: Chemical waste consists of discarded solid, liquid, and gaseous chemicals, for example from diagnostic and experimental work and from cleaning, housekeeping, and disinfecting procedures. Chemical waste, from healthcare either hazardous or non-hazardous, in the context of health protection, considered hazardous if having at least one of the following properties:
- Toxic;
 - Corrosive (e.g. acids of pH <2 and bases of pH >12)
 - Flammable;
 - Reactive (explosive, water-reactive, shock sensitive);
 - Genotoxic (e.g. cytotoxic drugs).
- 2.1.1.7 Heavy metal bearing waste: Waste with high heavy metal (such as lead, cadmium, arsenic, mercury) content represent a subcategory of hazardous chemical waste, and are usually highly toxic. Mercury can be spilled from broken medical equipment including thermometers or blood pressure monitor. Residues from dentistry have high mercury content.
- 2.1.1.8 Radioactive waste: Radioactive waste includes solid, liquid, and gaseous materials contaminated with radio-nuclides. It is produced as a result of procedures, such as in-vitro analysis of body tissue and fluid, in-vivo organ imaging and tumor localization, and various investigative and therapeutic practices. Radioactive waste

emits one or more types of radiation, such as alpha (a-) and beta (b-) particles and gamma (y-) rays. Radioactive wastes are genotoxic.

2.1.2 Medical Waste Classification

Classification done by Eigenheer and Zanon (1991). They classified medical waste according to their liquid and solid state. This is shown in the following Table 2.1.

Table 2.1 Classification of Hospital Waste

Type	Typical examples
1. Liquid Wastes	
1.1 Biological waste	Blood, excrement, body fluid etc.
1.2 Chemical waste	Solutions, inorganic salts etc.
1.3 Over-date medicines	Unused drugs, over-date drugs
1.4 Radioactive waste	Wastes from radiology (iodine 125, iodine 131 etc.)
2. Solid Wastes	
2.1 Perforating and cutting wastes	Needles, syringes, scalpels, blades, broken glass, vials
2.2 Non-perforating and non-cutting wastes	2.2.1 Wastes from treatment (dressings, stool napkins, plaster cast etc.) 2.2.2 Parts of the body: organs, placentas, tissue etc. 2.2.3 Over-date medicines (expired drugs) 2.2.4 Household-type wastes: other wet and dry waste

Source: Eigenheer & Zanon, 1991.

Medical wastes are also classified into four different categories based on their sources and potential hazards.

A) Clinical Waste: This includes body fluid, drainage bags, blood collection tubes, vials, culture dishes, other types of broken/unbroken glassware that were in contact with infectious agents, gauze, bandages or any other materials that were in contact with infectious agents or blood, pathological waste including organs, body parts, tissues. These are potentially dangerous and expose a high risk of infection to the general population and the staff as well.

B) Laboratory Waste: This is a high-risk category waste, which includes chemicals used in the pathological laboratory, microbial cultures and clinical specimens, slide, culture dish, needle, syringes, as well as radioactive waste such as Iodine-125, iodine -131 etc.

C) Non-clinical Waste: This includes wrapping paper, office paper, and plastic having no contact with patient body fluid.

D) Kitchen waste: This includes food waste, dirty water. It is a potential source of pests and vermin, such as cockroach, mice and rats and is thus as indirect potential hazard to the staff and patients in a hospital.

2.1.3 Nature and Composition of Medical Waste

Medical waste is a small fraction of urban municipal waste. There should be a greater consensus on how much of the waste is actually **infectious or hazardous**. According to EPA (1990), medical wastes are heterogeneous mixtures of general refuse, laboratory and

pharmaceutical chemicals and containers, and pathological wastes. All of these wastes may contain potentially infectious wastes. In some cases, the wastes fired to hospital incinerators also may contain waste classified as hazardous under the Resource Conservation and Recovery Act (RCRA) or low-level radioactive waste (EPA 1990). Infectious or hazardous medical waste represents only a small part of total medical waste; yet, because of ethical questions and potential health risks, it is a focal point of public interest. Clinics and hospitals are the main source of most hazardous and toxic waste. While as, only a small amount is from domestic or industrial sources. In the US, for example, about 15% of medical wastes are regulated as infectious waste, while in India this ranges from 15 to 35% depending on the total amount of waste generated (BAN & HCWH, 1999). In Pakistan about 20% of medical waste is found potentially infectious or hazardous (Agarwal, 1998). The total garbage generation in Dhaka city is 3,500 metric tons per day of which only 5.7% comes from medical establishment (Asaduzzaman & Hye, 1997). Around 200 metric tons of medical wastes are generated per day in the Dhaka city. Of this amount, roughly 20% is infectious and hazardous (Kazi, 1998).

According to the WHO (2000), from the total wastes generated by health-care activities, almost 80% are general waste comparable to domestic waste. The remaining approximate 20% of wastes are considered hazardous materials that may be infectious, toxic or radioactive. Infectious and anatomic wastes together represent the majority of the hazardous waste, up to 15% of the total waste from health-care activities. Sharps represent about 1% of the total waste from health-care activities. Chemicals and pharmaceuticals amount to about 3% of waste from health-care activities (Figure.2.1). Genotoxic waste, radioactive matter and heavy metal content represent about 1% of the total waste from health-care activities. High-income countries can generate up to 6 kg of hazardous waste per person per year. In the majority of low-income countries, health-care waste is usually not separated into hazardous or non-hazardous waste. In these countries, the total health-care waste per person per year is ranges between 0.5 and 3 kg.

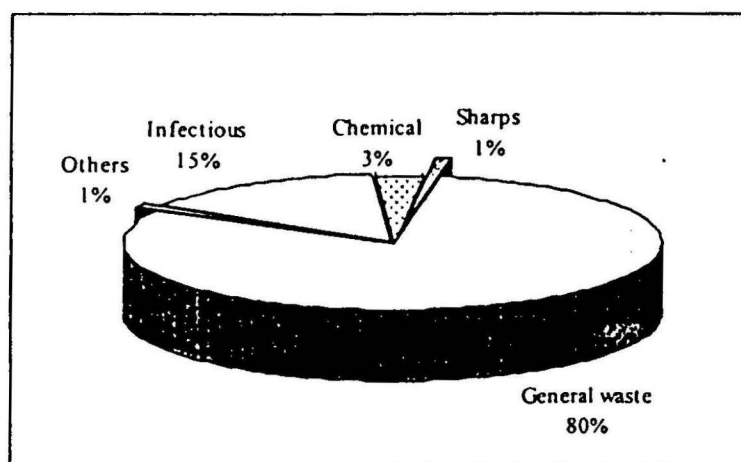


Figure 2.1 Medical Waste Composition

(source: WHO, 2000a)

Examples of different types of medical waste composition and environmental considerations are shown in the following Table (2.2).

Table 2.2 Medical Waste Composition

Category	Examples	Environmental concerns
General or Municipal Solid waste	Paper, packaging, food, floor sweepings and other items not unique to medical waste, commonly managed by municipal collection and disposal	Volume of the waste; Air emissions; Contamination of surface and ground water; Litter; Insects or other vectors; Odors; Injury; Exposure to Pathogens
Infectious waste containing pathogens in sufficient quantity that exposure could result in disease	Lab cultures and stocks of infectious agents, wastes from isolation wards, tissues, materials or equipment that have been in contact with infected patients	Land disposal of active pathogens Human health impacts
Pharmaceutical waste	Expired or unnecessary pharmaceuticals and drugs	Released to land or water Human health impacts
Pathological waste containing human tissues or fluids	Body parts, human fetuses, blood, and other body fluids.	Untreated waste released to land or water; Human health impacts
Chemical waste	Solid, liquid and gaseous chemicals from diagnostic and experimental work, cleaning materials	Released of hazardous air pollutants and releases to land or water; Human health impacts
Sharp wastes	Needles, infusion sets, scalpels, broken glass	Land disposal of active pathogens; Injury
Radioactive waste	Radioactive substances including used liquids from radiotherapy or lab work	Releases to air, land or water; Human health impacts
Pressurized containers	Gas cylinders, cartridges and aerosol cans	Potentially harmful; May explode accidentally
High heavy metal content	Batteries, broken thermometers, blood pressure gauges	Releases to air, land or water; Human health impacts
Genotoxic waste	Waste containing cytotoxic drugs (used in cancer therapy), genotoxic chemicals	Releases to air, land or water; Human health impacts

Source: Appleton & Ali, 2000; WHO, 1999b; EPA, 2000.

2.1.3.1 Examples of medical waste composition in few countries

The composition of both general waste and infectious waste underlies a great variation depending on the alignment and various other factors. However the following samples (Figures 2.2. and 2.3) from The hospitals in Thailand shall illustrate that on one side the general waste does not much differ from domestic waste and on the other that infectious waste is the minor part related to operation but mainly ward.

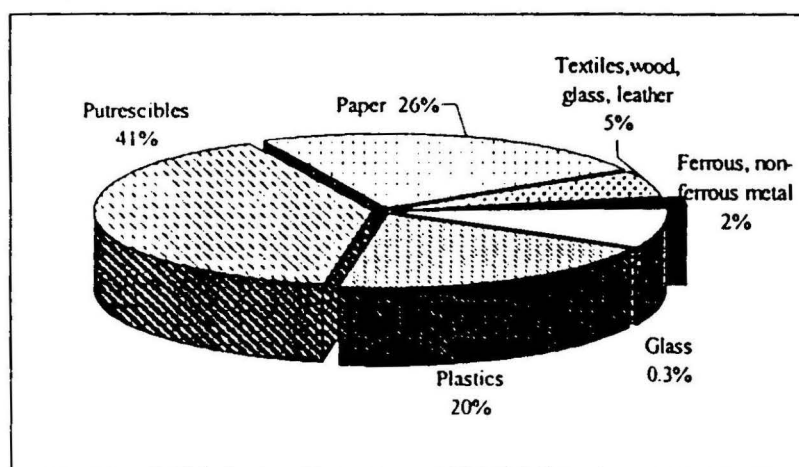


Figure 2.2 Composition of "General" Waste from a Pediatric Hospital

(Source: Paranan, 1997)

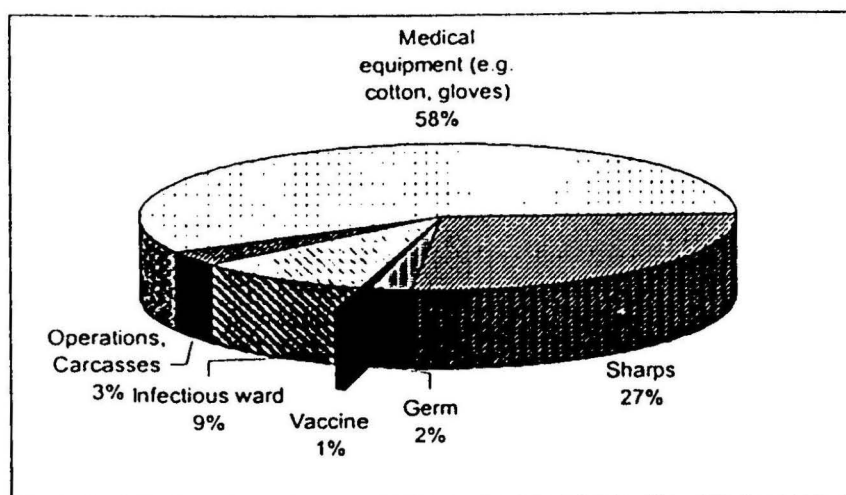


Figure 2.3 Composition of Infectious Waste from a Pediatric Hospital

(Source: Paranan, 1997)

Due to the use of radioactive substances for medication and diagnosis it is assumed that a certain amount of these low-level radiation wastes is mixed with health care waste. Medical wastes and low-level radioactive mixed wastes are considered special hazardous wastes. Since the main radioisotope users are those in the medical sector, most Thai hospital wastes originated from this quarter and are estimated to be 60% of total volume of radioactive waste produced annually. Waste coming out from a clinic at Dhaka city is shown in Figure 2.4 below. Nevertheless, there was no separate category for infectious waste as all of these clinical wastes were considered as infectious waste (BCAS, 1997).

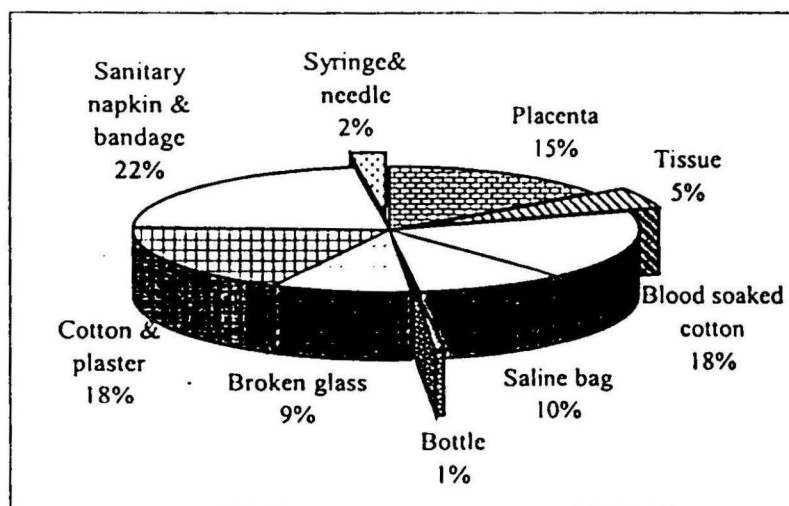


Figure 2.4 Composition of Clinical Waste Generated from a Clinic at Dhaka

(source: BCAS, 1997)

Composition of infectious waste found in hospital in Italy (Liberty *et al*, 1994) are presented (Figure 2.5) below.

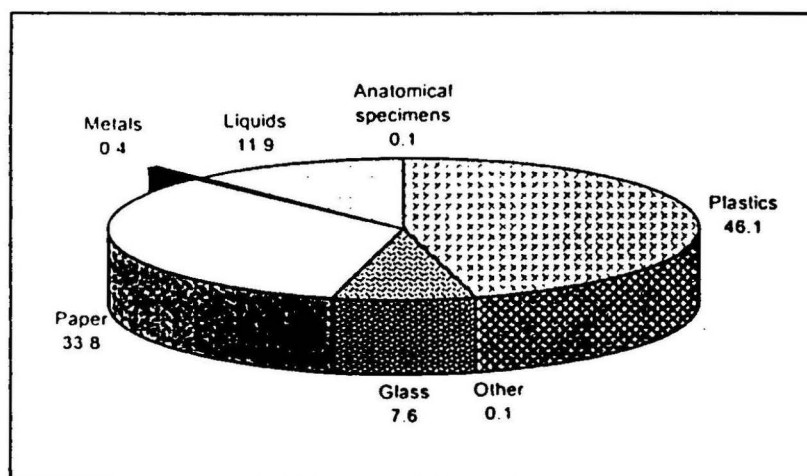


Figure 2.5 Composition of Infectious Medical Waste in Hospital in Italy

(source: Liberty *et al*, 1994)

2.2 Consequences Associated with Disposal of Medical Waste

Medical waste includes several different waste streams including infectious waste. According to World Bank (2000), infectious wastes have the potential of transmitting infectious agents to humans. Medical wastes are the source of contamination and pollution to both human and the natural environment. Improper disposal of wastes may be hazardous if it leads to contamination of water supplies or local sources used by communities or wildlife. Sometimes exposed waste might become accessible to scavengers and children if a landfill is insecure. Medical wastes are potentially capable of causing disease and illness in man, either through direct contact or indirectly by contamination of soil, groundwater, surface water and air. Wind blown dusts from these dumps have the potential to carry pathogens and hazardous materials. Where domestic animals are allowed to graze in open dumps, there is a risk of reintroducing pathogenic microorganisms into the food chain. Medical wastes therefore pose a risk to individuals, communities, and the environment if not carefully handled (Akter *et al*. 1998; 1999a). A hazard has the potential to become a risk depending upon the local conditions. If medical waste is properly managed, the hazards are controlled and the subsequent risks to people are minimal. When badly managed, the hazardous clinical part of the waste can endanger the health both of those who work with medical waste and local communities; it also poses risks to the environment.

2.2.1 Potential Risks and Hazards Associate with Medical Waste: Epidemiological Impacts

2.2.1.1 Injuries and accidents

According to Townend (2001), in healthcare establishments, nurses and housekeeping personnel are the main groups at risk of injuries with an annual 10 to 20 per 1000 workers. Of all workers who may be exposed to healthcare waste, cleaning personnel and waste handlers report the highest rate of occupational injuries, their overall annual rate reaches 180 per 1000 in the USA.

According to WHO (1994), Shirato reported from Japan that in 1987 the people were accidentally infected by syringes (HBV) had around 570 cases in 3-years-periods. A survey by the public authorities in 1986, showed 67.3% of waste handlers inside hospitals reported injury from sharps and 44.4% of waste disposal workers outside hospitals had also reported wounds when handling medical waste. Shirato could compute that the amount of virus surviving in an infectious syringes may remain above the infectious doses for eight days after it was used on an infected patient.

There is a risk of injuries related to medical waste handling and carrying by waste hauler and/or cleaner. For example cut-injury punctured wound, laceration, strain and sprain of the joint of limbs and backache due to load hauling. There were several incidents (10 cases out of 17) of injury due to exposure to medical wastes inside or outside of hospital premises (Akter *et. al.* 1998). These were as follows:

- Hands cut due to handling broken glass;
- Injured by needle and fingers permanently damaged/ became curved;
- Right hands became paralyzed by the injury by a needle;
- Two legs became paralyzed due to injury by the needle;
- Skin diseases on legs and hands/ body ;
- Pus due to injury sometimes; and
- Ulcer on legs.

As BAN & HCWH (1999), sharps, which include syringes and needles, have the highest disease transmission potential amongst all categories of medical wastes. Almost 85% of sharp injuries are caused during their usage and subsequent disposal. More than 20% of those who handle them encounter 'stick' injuries. The study also mentioned that needle-stick and sharp injuries occur frequently in developing countries, and that safer disposal facilities and routine hepatitis B vaccine should be adopted.

It has been reported that (WHO, 1999b, in Nessa *et al*, 2001), in France, by 1992, eight cases of HIV infection were recognized as occupational infections, two of these, involving transmission through wounds, occurred in waste handlers. It has also been reported that, in the USA, by June 1994, 39 cases of HIV infection were recognized by the Centers for Disease Control and Prevention (CDC) as occupational infections. By June 1996, the cumulative recognized cases of occupational HIV infection had risen to 51, comprising nurses, medical doctors, and laboratory assistants. Showing in Japan, the risk of infection after hypodermic needle puncture is as follows: HIV is 0.3%, HBV is 3%, and HCV is 3-5%.

2.2.1.2 Infectious medical waste risk

According to Litchfield and Phelan (1992), that infectious waste as any substance containing microorganisms, helminthes or viruses pose a threat to the health of human beings or any other beneficial user of the environment due to their volume or virulence.

Infectious medical waste represents only a small part of special waste; yet, because of ethical questions 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. Table 2.3 shows few examples of different pathogen and diseases caused by them.

Table 2.3 Pathogenic Organisms in Infectious Waste

Bacterial	Tetanus, gas gangrene and other wound infection, anthrax, cholera, other diarrhoeal diseases, enteric fever, shigellosis, plague etc.
Viral	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, cryptococcoses, coccidioidomycosis etc.

Meaney & Cheremisinoff (1989) has defined that infectious disease occurred as a result of interaction between infectious agent (pathogen) and a susceptible host. Medical wastes are such a source of pathogen. Interaction between the host and the pathogen may take place either in the form of infection or intoxication. Intoxication refers to the induction of a disease by the production of a toxin by a pathogen. *Clostridium botulinum* causes botulism in this manner. Infection in the host by the pathogen and is a more common form of disease induction. Diseases are largely named by after the inducing pathogen. Typhoid fever is caused by *Salmonella typhi*; cholera is caused by *Vibrio cholerae* and dysentery is caused by *Shigella dysenteriae*. By establishing a strict medical waste management plan and enforcing it, this can eliminate the potential infection by staff, patients and general public.

According to Townsend (2001), contaminated sharps particularly syringe needles together with the concentrated cultures of pathogens are considered waste items that pose the greatest risk to human health. Sharps may not only cause physical damage to those coming into contact with them but may also infect the wounds so caused by the pathogens present on the contaminated sharps. The double risk of injury and the possibility of the transmission of disease place sharps in the category of being a very hazardous waste. The disease of greatest concern are those that are likely to be transmitted by subcutaneous injection for example viral blood infections. Syringe needles are often contaminated with patient's blood and hence are of particular concern since they form the largest quantitative item in the sharps waste category.

Infected medical waste can transmit diseases, especially if it finds portals of entry. WHO (1992, in Paranan, 1997; BAN & HCWH, 1999) found strong epidemiological evidences from Canada, Japan and the USA, that the main concern of infectious medical waste is the transmission of HIV/AIDS virus and more often of Hepatitis B or C virus (HBV) through injuries caused by syringes needles contaminated by human blood. Other than these, there is potential risk of TB/ throat infection, typhoid, dysentery, diarrhoea, bacterial/ viral diseases, ARV (Rabies), VDRL (STD), UTI/ all C/S, and Leprosy etc. as the pathological laboratories do all these analysis to diagnose the diseases (Akter *et. al.*, 1998). In the USA the Public Health Implications of Medical Waste (US Congress, 1990 in Paranan 1997) reported to the US congress that HIV had extremely validity outside host, live virus survival time depended upon the environment and virus concentration. Except for those persons within the health care setting, the potential to develop HIV infection from medical waste contact is remote. Moreover, hepatitis B virus (HBV) remained viable for an extended time in the environment the potential for HBV infection following contact with medical waste is higher than that associated with HIV. The risk groups such as doctor, nurse, hospital housekeepers and all personnel handling wastes must be immunized against HBV. Pertinent literature quotes the frequency of hospital infections as being 4% to 10% of all admissions (Mittermayer, H. 1995 in Colgate, D., 2001). According to the literature, the estimation of annual mortality rate due to hospital infections are around 80,000 for the USA and 40,000 for Germany (Millar JM, 1993 and Zastrow & Schoneberg, 1994 in

Colgate, D., 2001). It is therefore, not enough just to treat infectious waste to prevent infections, because staff and patients are already endangered by infectious agents during collection, manipulation and transportation.

Pathways of disease transmission through medical waste are sketched below in Figure 2.6.

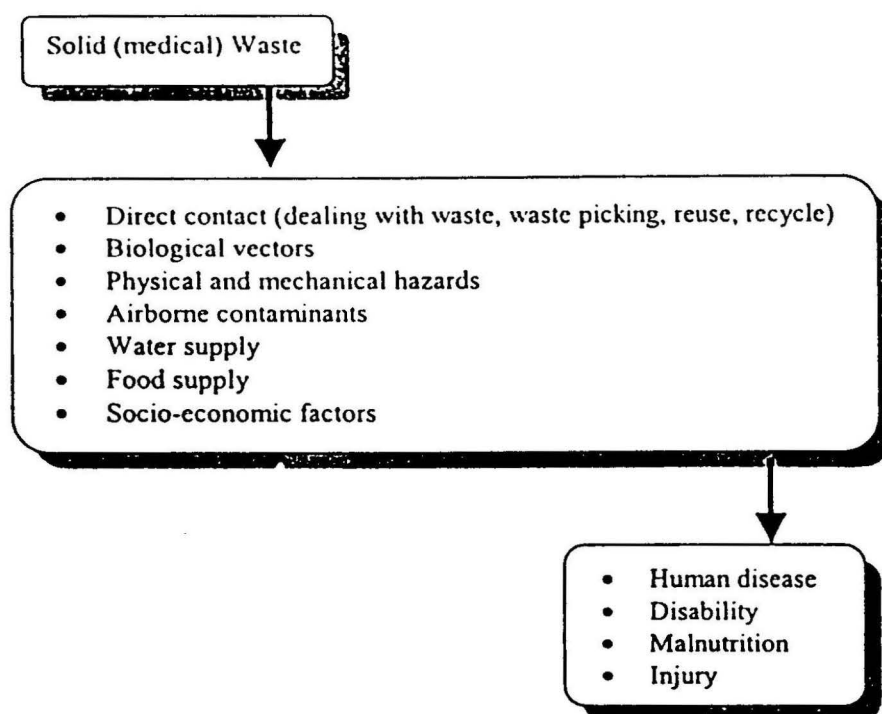


Figure 2.6 Pathways of Disease Transmission

(modified from Meaney & Cheremisinoff, 1989 in Wangsaatmaja, 1997)

2.2.1.3 Hazardous medical waste risk

This class of medical waste, while largely ignored, poses risk to workers handling them. Hazardous medical waste consists primarily of chemicals and discarded cytotoxin drugs. The medical laboratories examine blood, stool, urine, and sputum. The chemicals used for the staining and preservation of slides and for the sterilization and cleaning of equipment and surroundings are potentially harmful to the laboratory technician and the environment. Most of the chemicals are poured down the sink and drain out next to the clinic. Xylene, phenol, methylene blue, hydrochloric acid, chlorine and carbol fuchsin are used in the laboratory, and some could have very damaging effects (Akter *et. al.* 1998). Other than these, a large number of chemicals also use in different diagnosis and treatment (e.g. chemotherapy). Some common hazardous chemicals, some of which are probable carcinogens or pose other health risks and effects, are summarized in Table 2.4.

Table 2.4 Types of Chemicals Used in Medical Facilities, Pharmaceuticals Industries, and Their Uses and Effects (few available examples)

Chemical	Purpose of Use	Properties	Potential Effects
Xylene	Removal of seederwood oil for TB slides	Toxic	Inhalation of vapors can cause: headaches; euphoria; light-headedness; dizziness, drowsiness; nausea; vapor can irritate skin, eyes, and lungs over exposure can lead to irregular heart beat, fainting, and eventually death
Carbol Fuchsin	Fixing of sputum slides	Corrosive poisonous	Readily absorbed and can cause severe burning if brought into contact with skin/eyes/lungs inhalation results in chest pains, increased heart rate, coughing, nose and throat irritation, convulsions, and eventually death
Phenol	Disinfectant and sterilizer	Corrosive combustible poisonous	Can cause severe burning to skin, eyes or lungs if contact made can seriously affect lungs and respiratory system in inhaled (pulmonary edema, lung inflammation); potentially fatal; ingestion causes nausea, vomiting, gastro-intestinal irritation and bleeding; over exposure can lead to kidney and liver damage
Hydrochloric Acid	Fixing of sputum slides	Corrosive poisonous	May cause burning sensation if brought into contact with skin/eyes; inhalation causes coughing/restricts breathing and damage to upper respiratory system
Methylene Blue	Fixing of blood & sputum slides		Can cause damage if brought into contact with eyes, skin, clothing
Chemotherapy and Anti-neoplastic chemicals	Treatment	Hazardous Toxic	Carcinogenic; other health risk
Formaldehyde	Pathology, autopsy, embalming	Hazardous Toxic	Health risk; suspected carcinogens; eye, nose and throat irritation
Glutaraldehyde (fixer, developer)	Photographic (X-ray)	Hazardous Toxic	Health risks
Ethylene Oxide	Sterilizers	Hazardous Toxic	Harmful to health
Acid gases (e.g. HCl, NOx, SO ₂)	Laboratory	Hazardous	Acute effects such as eye and respiratory irritation; may enhance the toxic effect of heavy metals
Chlorine made material (e.g. PVC)	Laboratory	Hazardous	Creates dioxin; animal carcinogen and considered human carcinogen
PCBs(Poly-chlorinated biphenyls)	Medicine industries	Hazardous Toxic	Harmful to fish and other aquatic forms of life because they interfere with reproduction; PCBs produce liver ailments and skin lesions in human; In higher concentration, they can damage the nervous system, and are suspected carcinogens
Heavy metals (mercury, arsenic, and zinc, for example)	Instruments, Treatment, Medicine industries	Toxic (neurotoxic)	Women and children are most vulnerable; have carcinogenic, mutagenic and teratogenic effects Exposure lead to pneumonitis, branchitis muscle tumor, irritability, gingivitis; nerve damage; enter to the food chain and concentrated; in humans, these metal can produce kidney and liver disorders, weaken the bone structure, damage the central nervous system; Cause blindness, and lead to death

Source: Akter et. al. 1999. NWFSC MSDS Search; BAN & HCWH, 1999; Shaner, 1997.

As Appleton and Ali (2000) described, the hazards of healthcare waste can become risks to the population at large if pathways exist between the two. Possible pathways include:

- direct contact;
- contact through vectors;
- airborne transmission; and
- the pollution of water sources or local environment.

Each sub-category of clinical waste has the potential to pose different risks: Table 2.5 outlines the risks that may be posed by healthcare waste and the associated hazards and pathways.

Table 2.5 Risks, Pathways and Hazards of Healthcare Waste

Risk	Pathway	Hazard
Contraction of disease/infection	Direct or indirect contact through a carrier	Pathological wastes and infectious wastes may transmit disease and infection through direct contact or via vectors
Cuts	Direct contact	Sharp waste including syringes, glass and scalpels may cause cuts which provide an entry into the body for infection: for example, used syringes may be recycled by unscrupulous medical practitioners, or played with by children and are potential transmission routes for HIV and Hepatitis B
Ineffective medical care	Direct	Consumption of expired pharmaceuticals possibly through inappropriate prescription by unscrupulous medical practitioners
Cancer	Direct or indirect contact, or proximity to waste	Radioactive waste
Burns and skin irritation	Direct or indirect contact, proximity to waste	Toxic chemicals Radioactive waste
Injury from explosion	Being within the vicinity when explosion occurs	Pressurised containers
Pollution of ground and surface water and the air	Direct or indirect contact with polluted water or release to the atmosphere	Toxic chemical wastes Pharmaceuticals Waste with high heavy metal content

Source: Appleton and Ali, 200.

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, antineoplastics and disinfectants disposed of into the sewage system may kill bacteria necessary for the treatment of sewage. Antineoplastics flushed into watercourses may damage aquatic life or contaminate drinking water.
- Burning of waste at low temperatures or in open container results in release of toxic pollutants (e.g. dioxin) into the air.
- Carcinogenic waste such as heavy metals, chemical solvents and preservatives pose serious human health risks not only to workers but to the general public as well.
- Inefficient and insecure sorting and disposal may allow drugs beyond their expiry date

- Unprotected and insecure landfill may pose health hazard to the scavengers and inhabitants at the vicinity.

(Source: WHO, 1999)

2.2.1.4 Groups at most risk

Potential occupational exposures include direct exposure to patients, visitors and workers who handle or come into proximity to waste. All personnel at the hospital are exposed to health hazards of contaminated or infectious waste, specially those involved in direct case (Feres, 1991 in Wangsaatmaja, 1997). Nursing personnel and laboratory technicians, are exposed to blood and blood soaked objects from patients and should beware of the health hazard of handling any kind of blood sample or object contaminated with blood, regardless diagnosis of the patients.

Reinhardt & Gordon (1991) stated that occupational risks are the serious concern outside of institution. Normal trash is subject to a great deal of scrutiny in many parts of the country. Landfill and refuse incinerator operators attempt to segregate waste for recycling and other disposal route. Therefore, workers working at landfill and refuse incinerator are also at risk.

Appleton and Ali (2000) mentioned that, the impacts of poor healthcare waste management differ from one population group to another. Specific groups coming directly into contact with healthcare waste include:

- waste pickers;
- waste recyclers;
- drug addicts (who scavenge for used needles and disposed medicines); and
- hospital sweepers and other low-grade hospital staff.

They can be affected in two ways:

- through direct contact with waste of their daily working lives as a result of poor healthcare waste management practices; and
- through dependency on existing healthcare waste practices for their livelihoods.

Qualitative comparison of relative risk levels for different groups of the population is given in Tables 2.6, 2.7 and 2.8.

Table 2.6 Risks to Informal Actors

	Group	Risk Level	Why
Informal actors	Waste pickers	Very High	Close and direct contact with waste. No alternative method of income generation - healthcare waste often provides greater economic return than other waste. Low level of education and low awareness of risks. Little use of protective equipment due to cost, low awareness and the fact that it hinders their work. Often low resistance to disease and infections due to poor diet and poor living conditions. Poor access to healthcare. More likely to use unscrupulous doctors and be affected by the primary recycling of products. Residential areas likely to be near/on waste sites. Contamination of living environment.
	Recycling industry: itinerant waste buyers middle dealers main dealers	High	Close contact with waste but less than waste pickers. Exposure to by-products from waste processing. No alternative - livelihood depends on contact with waste. Low level of education and low awareness of risks. Little use of protective equipment due to cost, low awareness and it often hinders their work. Often low resistance to disease and infections due to poor diet, poor living conditions etc. but usually have higher income and quality of life than waste pickers. Poor access to healthcare. Likely to use unscrupulous doctors and be affected by the primary recycling of healthcare products. Contamination of environment

Source: Appleton and Ali, 2000.

Informal actors come into direct contact with healthcare waste but are very often left unattended by organizations and institutions. They usually act on an independent, self-employed basis although individuals may join groups to form small micro-enterprises. Their income is highly variable and insecure; it is largely dependent on their personal day to day activities/work patterns and good fortune. Informal waste workers are usually considered as outcasts of society and their opinions are rarely considered. They usually come from very poor backgrounds and have little education, turning to waste picking as the only option left open for them to earn their livelihood. Itinerant waste buyers and those involved in the recycling industry have slightly more secure jobs.

Table 2.7 Risks to Formal Actors

	Group	Risk Level	Why
Formal actors	Healthcare workers	Medium	Highest awareness of dangers. May have undergone training in best practices therefore more likely to apply these routines. Involved in creation of waste but have little contact with waste after its generation i.e. are usually not involved with waste collection. If working within healthcare establishment may be provided with free healthcare and likely to be immunised against certain diseases that can be transmitted through waste. Contamination of living environment
	Healthcare waste workers Sweepers in hospitals other low grade hospital staff	High	Some awareness of dangers as may have undergone training in best practices. Often supplied with protective equipment but may be reluctant to use it. Relatively high level of contact with waste. If working within healthcare establishment may be provided with free healthcare and likely to be immunised against certain diseases that can be transmitted through waste. Contamination of environment.
	Municipal waste workers	High	If co-disposal practiced may come in close contact with healthcare waste. Low awareness of dangers - reluctance to use protective equipment even if provided. May not be aware that they are in contact with healthcare waste. Often also involved in waste picking activities. Close/direct contact with waste. Higher/more stable income than waste pickers therefore higher quality of life, access to healthcare. Contamination of environment

Source: Appleton and Ali, 2000.

Formal actors have wage employment that brings them into contact with the healthcare waste stream; their jobs are relatively secure. Although healthcare waste workers, still considered the lowest social groups, are more likely to have their opinions considered than the informal actors/waste pickers and may be represented by trade unions. They may be provided with protective equipment and receive basic training, although in low-income countries this is frequently neglected. Healthcare workers will have completed some medical training and have a general education. Their social status is much higher than waste pickers and waste workers and they have a greater influence on and knowledge of healthcare waste practices.

Very low-income families, who depend on waste picking for example, living in squatter settlements or even within a waste dump, are usually poorly educated and their opinions are often neglected. By comparison, higher income groups leading a better quality of life, more educated and have more influence on healthcare waste practices.

This qualitative analysis indicates that waste pickers are most likely to be at serious risk from the hazards associated with healthcare waste. The informal, with invisible nature of

their activities means have poor access to healthcare support, education or awareness raising in relation to occupational health and have most to lose if their access to the waste is prevented. Whilst their livelihoods are most vulnerable to changes in the healthcare waste management system, similar livelihood issues also affect actors further up the recycling industry chain (*Source: Appleton and Ali, 2000*).

Table 2.8 Risks to the Local Community

Local Community	Group	Risk Level	Why
	Low-income groups	Medium to High	Residential areas likely to be near/on waste sites. Closer contact with waste than higher income groups, e.g. through vectors, contact with waste pickers. Little access to healthcare. Likely to use unscrupulous doctors and be affected by the primary recycling of healthcare products. Low level of education and low awareness of risks. Often low resistance to disease and infections due to poor diet, poor living conditions etc. Contamination of environment.
	Children	High	Low awareness of dangers. Attraction to parts of waste e.g. syringes as toys. At more risk if from low-income families as likely to have greater access to waste due to location & lack of supervision. Likely to have a lower resistance to disease and infection than adults. Contamination of environment
	Drug addicts	High	Exposed to similar risks as waste pickers as they scavenge for used hypodermic needles and syringes to use to inject drugs. May attempt to use (misuse) drugs found on healthcare waste sites. If from low-income groups, also subject to the above risks.
	Health establishment visitors & patients	Medium	Where healthcare waste management practices are poor, they may be exposed to waste. Visitors less at risk than patients as shorter stay and have greater resistance to infection. Contamination of environment
	Middle-high income groups	Low	Little or no contact with waste or with waste workers. Good living conditions and access to good healthcare. Contamination of environment. Greater political power to stop bad practices occurring near homes. Higher level of education and greater awareness of risks

Source: Appleton and Ali, 2000.

2.2.2 Environmental Hazards Related to Medical Waste

2.2.2.1 Medical waste in the environment

Wastes attract scavenging animals and bats. With fermentation it gives off foul odors, favors fly feeding and contaminates both water and air. Piles of refuse or landfill during its decomposition process generate several gases, the most important are methane (CH_4), nitrogen (N_2) and occasionally hydrogen sulfide (H_2S). If burnt, carbon di-oxide (CO_2) is released. CH_4 and CO_2 , greenhouse gases, have potential greenhouse effects. The soil underlying these wastes is typically contaminated by pathogenic micro-organisms, heavy metals, salts, and chlorinated hydrocarbons. These wastes also causing public nuisance by clogging sewers and open drains, encroaching on roadways, diminishing landscape aesthetics and giving off unpleasant odors and dust (World Bank, 1991). According to Sangodoyin (1993 in Coker *et al*, 1998), wells water close to medical waste disposal systems at Ibadan, Nigeria were slightly alkaline and undesirable taste.

Expired drugs pilfering from a stockpile of waste drugs or during sorting may result in expired drugs being diverted to the market for resale and misuse. Most pharmaceuticals expired their date become less efficacious and a few may develop a different adverse drug reaction profile.

Medical waste incineration is one of the largest sources of dioxin and mercury pollution in the United States. According to the United States Environmental Protection Agency (EPA), dioxin from medical waste incineration ends up in dairy foods and meat and both mercury and dioxin are taken up by fish and shellfish. Once these foods are consumed the existing dioxin and mercury body burdens are increased. Other than these, the ash from incinerator consists of both fly ash and bottom ash. The ash is highly toxic concentration of heavy metal, dioxins and furans. Ironically, as the air pollution equipment becomes more effective in removing particulate matter, the toxicity of the fly ahs increases. One of the largest hospitals in Delhi, was found to have lead in its incinerator ash at levels, which would classify the ahs as hazardous (BAN & HCWH, 1999). In most cases, disposal of incinerator ash in landfills without a sufficient soil or other impermeable cover may cause leachate to contaminate groundwater.

Incineration has specific health concern since it destroys the pathogen and the material which the pathogen resides on. Thus, those materials go under a process of transformation and dematerialization. In the process they transform solid and liquid toxic waste into gaseous emissions and particulate matters. The acid gases (e.g. hydrogen chloride, nitrogen oxides and sulphur dioxides), can cause acute effects such as eyes and respiratory irritation, can contribute to acid rain, and may enhance the toxic effects to heavy metals. Particulate matter can cause chronic health effects. Burning of chlorine made material e.g. PVC, creates dioxin, a known animal carcinogen, and considered as human carcinogen.

Cheremisinoff and Shah (1990) identified the relation between the medical waste system and its wastes in the environment. This can be relied that medical wastes are released to the environment by many activities in terms of air emission, wastewater and solid waste. The flow of medical waste and its environmental relation is given below (Figure 2.7)

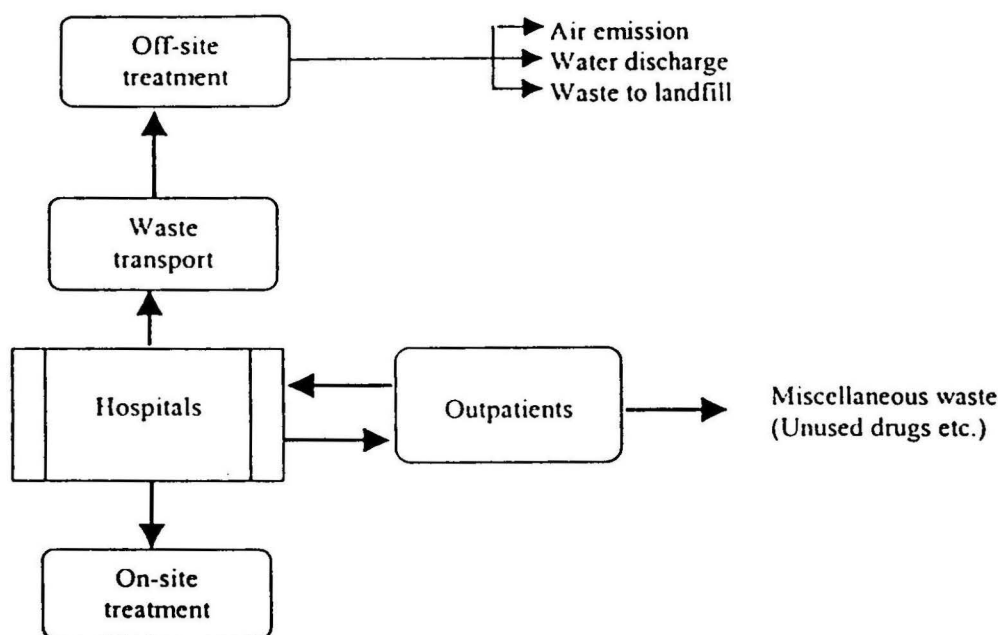


Figure 2.7 Medical Waste in the Environment

(modified from Cheremisinoff & Shah, 1990 in Wangsaatmaja, 1997)

EPA-Victoria (1994) reported¹ that the environmental consequences, which result from the pollution of air include the enhanced green house effect (global warming), ozone layer depletion, acid rain, phyto-toxicity, damage to materials and aesthetics (odor and visibility) and the human health threat associated with toxic emission. These are summarized in Tables 2.9, 2.10 and 2.11.

Table 2.9 Hospital Functions Contributing to Global Warming

Hospital Function	Equivalent tones CO ₂ /year	%
Motor Vehicles	4,320	10.3
Bioler House	21,280	50.7
Electricity Use	14,461	36.8
CFCs	906	2.2

Source: EPA-Victoria, 1994.

Table 2.10 Hospital Functions Contributing to Ozone Depletion in terms of CFC Emission

CFC	Yearly volume purchased (kg)	Estimated loss to atmosphere (kg)
R12 (refrigerator)	200	140
R22 (AC)	250	175
502 (large freezer)	10	7

Source: EPA-Victoria, 1994.

¹ Study in a hospital in Victoria, Australia with 516 beds, occupancy rate 0.87 and 2500 staff.

Table 2.11 Hospital Functions Contributing to Air Emission (tones per annum)

Hospital Functions	Oxides of Nitrogen	Carbon Monoxide	Particulate	Oxide of Sulfur
Boiler House	105.0	3	125	58.5
Incinerator	0.2	N/A	0.2	0.2
Electricity Use	21.5	N/A	N/A	27.3
Vehicle Use	29.0	142	14	N/A

Source: EPA-Victoria, 1994.

2.2.2.2 Environmental impacts of improper disposal of medical wastes

The following are 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 agricultural fields, humans, soil organisms, wildlife, cattle);
- ground water contamination, decrease in water quality;
- bio-accumulation in organism's fat tissues, and bio-magnification 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 leads to long term accumulation of toxic substances in the soil;
- specimens collected for analysis have the potential to cause disease and illness in man, either through direct contact or indirectly by contamination of soil, groundwater, surface water, and air;
- wind blown dusts from indiscriminately dumping have the potential to carry and hazardous particulates;
- with domestic animals being allowed to graze in open dumps, there is the added risk of reintroducing pathogenic micro-organisms into the food chain'
- public nuisance (e.g. odors, scenic view, block the walkway, aesthetics, etc.);
- improper sterilization of instruments used in labor room may cause infection to mother and child;
- combination of both degradable and non-degradable waste increase the rate of habitat destruction due to the increasing the number of sites necessary for disposal of wastes (degradation of habitat);
- plastic-bags, plastic containers, if not properly destroyed may contaminate the soil and reduces the chance for water percolation into the soil during precipitation; and
- open air burning does not guarantee proper incineration, and releases toxic fumes (dioxin) into the atmosphere from the burning of plastics i.e., PCB's.

2.3 State of Medical Waste Management in Industrialized and Developing Countries: a Comparison

2.3.1 Medical Waste Generation

The International Healthcare Waste Network (EPA, 2000) has compiled comparative regional data on annual medical waste generation in kilogram per day per occupied hospital bed as shown in Table 2.12. The quantity of waste shows significant variation. Factors that influencing variations in waste composition and quantity include:

- Type of medical establishment;
- The number and specialties of medical facilities;
- The level of in-patient and out-patient services offered;
- The proportional use of disposable versus reusable products;
- The waste prevention methods utilized;
- The internal segregation, storage and waste handling procedures;
- Waste management methods and policies; and
- Access to treatment technology.

Table 2.12 Healthcare Waste Generation by Region

Region	Daily waste generation in kg/bed
North America	7-10
Western Europe	3-6
Latin America	3
Eastern Asia	
- High income countries	2.5-4
- Low income countries	1.8-2.2
Eastern Europe	1.4-2
Eastern Mediterranean	1.3-3

Source: HcWN in EPA, 2000.

Several surveys of WHO (1999b) indicated typical healthcare waste generation. Data endorse there is inter country and intra-country difference in healthcare waste generation.

In middle and low-income countries, medical waste generation is generally lower than those in high-income countries (Table 2.13). However, the range of values for countries of similar income level is probably as wide as in high-income countries (Tables 2.14 and 2.15) as in less wealthy countries.

Table 2.13 Health-care Waste Generation According to National Income Level

National income level	Annual waste generation (kg/head of population)
High-income countries:	
- All health-care waste	1.1-12.0
- Hazardous health-care waste	0.4-5.5
Middle-income countries:	
- All health-care waste	0.8-6.0
- Hazardous waste	0.3-0.4
Low-income countries:	
- All health-care waste	0.5-3.0

Source: WHO, 1999b.

Table 2.14 Medical Waste Generation According to Source Size

(data from High Income Countries)

Source	Daily waste generation (kg/bed)
University hospital	4.1-8.7
General hospital	2.1-4.2
District hospital	0.5-1.8
Primary health-care center	0.05-0.2

Source: WHO, 1999b.

2.15. Medical Waste Generation by Waste Type (Western Europe)

Waste class	Daily waste generation (kg/bed)
Chemical and pharmaceutical waste	0.5
Sharps	0.04
Combustible packaging	0.5

Source: WHO, 1999b.

2.3.1.1 Medical waste generation in some selected countries

USA: Hospitals in the US produce approximately two million tons of solid waste each year, which is about 1% of the US municipal solid waste stream, or approximately 15 pounds per patient per day. About 85% of this amount is commercial waste (e.g., food, paper and plastic). The remainder is largely "red-bag"² waste. Hospitals generate a small volume but complex mix of hazardous waste (Shapiro *et al.* 2000). According to estimates from the early 1990s, medical waste is generated at a rate of 3.5 million tons per year (Medical Waste Disposal, 1994 in Kaiser *et al.* 2001). This statistics is amplified by the increasing prevalence of home health care, generating waste at about 50,000 tons per year (NaQuin, 2000 in Kaiser *et al.* 2001). With proper waste segregation practices, roughly 15% (by weight) of medical waste can be classified as infectious waste, requiring treatment before disposal (Rutala *et al.* 1989).

Europe: Increase in medical waste in Europe is due to better health care, modern technology and extended life expectancy. Commonly wastes generation for whole Europe are 3-6 kg/day (Pürss, 1999). In tertiary level, health care waste are generated 4.1-7 kg/day and primary level 0.05-0.2kg/day/bed. In most of the countries hazardous waste are 10% of the total generated waste.

Germany: Approximately 1.4 million tons of wastes were generated in 3,500 hospitals in Germany in 1990. Only around 10-15% of the total amount were health care wastes arising from medical activities viz. diagnosis, treatment and prevention of diseases including clinical research. Approximately 30,000 tons of infectious wastes and 4,000 tons of body parts and organ wastes were segregated as risk waste from medical waste streams and disposed of as hazardous waste (Drauschke, 1999).

Thailand: A recent country wide survey in Thailand revealed that in hospital waste is produced in a range of 1.12 –2.79 kg/bed day. For infectious waste a range of 0.26 – 0.38 kg/ bed-day is reported (Tränkler and Akter, 2001). In Bangkok, medical waste ranges between 0.22-6.45 kg/bed/day, while infectious waste ranges 0.06-0.59 kg/bed/day. The percentage of infectious waste in Bangkok ranges from as lower as 4.5 to as higher as 29% depending on the source of infectious waste (Paranan, 1997).

² Waste composed of body tissues, or materials contaminated with blood, body fluids or cultures, and considered potentially infectious.

Bangladesh: Total garbage generation in Dhaka city is 3,500 metric tons per day of which only 5.7% comes from medical establishment (Asaduzzaman & Hye, 1997). Around 200 metric tons of medical wastes are generated per day in the city, roughly 20% is infectious and hazardous (Kazi, 1998). Total waste generation rate ranges between 0.55 kg/bed/day and 1.10 kg/bed/day with 0.169 kg/bed/day hazardous waste. The contribution of infectious, sharps and pathological waste is about 10.5%, 3.5% and 1.5% respectively. Medical wastes generated in private clinics of Dhaka city (Rouf, 1996) were general solid waste 70%, medical waste 25% and special waste 5%. The average waste generation was 2.39 kg per patient per day.

2.3.2. Health Statistics

2.3.2.1 Causes of disease occurrence rate

Data on causes of disease occurrence rate are given in following Tables 2.16, 2.17, and 2.18. Ten diseases mentioned in Table 2.16 contribute 88 percent of Disability Adjusted Lost Years (DALYs) in Bangladesh.

Table: 2.16 Ten Diseases of DALYs in Bangladesh

Cause	% of Patients
Respiratory diseases	16.6%
Perinatal causes	13.9%
Diarrhoeal diseases	12.1%
Unintentional injuries	10.3%
Nutrition/Endocrine	10.0%
Cardio-vascular diseases	6.4%
Maternal causes	6.1%
Neuro-Psychotic	5.5%
Childhood infections	5.0%
Tuberculosis	2.6%

Source: World Bank, by using the published data of Bangladesh Bureau of Statistics, 1998.

Table: 2.17 Morbidity Pattern and Cause of Diseases in Bangladesh and Thailand

Bangladesh		Thailand	
Causes	% of Patients	Causes	% of Patients
Peptic Ulcer	17%	Respiratory	12.04
Diarrhoea	18%	GI Tract	8.85
Cold/Cough	15.9%	Muscular	7.12
Fever/PUO	19.3%	Blood System	6.82
Skin Disease	6.1%	Endocrine	6.53
Rheumatic	5.5%	Urine Metabolism	4.82
Malaria	5.5%	Infectious Parasite	4.49
Influenza	5.5%	Eye	4.26
Asthma	4.2%	Skin	3.35
Dysentery Hypertension	4.8%	Pregnant & Delivery and Post Period	2.87
Headache/migraine	2.8%		
Typhoid	2.8%		
Toothache	2.6%		
Others	2.2%		
	56.1%		

Source: Bangladesh Bureau of Statistics, 1998; Statistical year book 1999, Thailand.

Table 2.18 Leading Global Health Crises and Challenges

Countries with HDI ranking	People living with HIV/AIDS			Malaria cases (per 100,000 people)	Tuberculosis cases (per 100,000 people)	Cigarette consumption per adult (annual average)
	Adults (%age 15-49)	Women (age 15-49)	Children (age 0-14)			
13 France	0.44	35,000	1,000	..	12	1,785
17 Germany	0.10	7,400	500	..	12	1,748
66 Thailand	2.15	305,000	13,900	163	26	1,120
132 Bangladesh	0.02	1,900	130	56	58	237

source: Human Development Report, 2001

2.3.2.2 Indicators relating to the health systems attainment and performance

A composite index used by UNDP and WHO to measure the health system performance in different countries. Some selected indicators are extracted and gathered in this section (Tables 2.19, 2.20, 2.21 and 2.22). These indicators might have influence on health care systems of a country as well as waste management system in hospitals.

Table 2.19 Commitment to Health: Access, Services and Resources (1999)

Country	Physicians per 100,000 population / Year	Nurses per 100,000 population / Year	Births attended by skilled health staff (%)	Health expenditure			Priorities in public spending	
				Public	Private	Per capita	education	health
				(%of GDP)	(%of GDP)	(PPP US\$)	(as %of GNP)	(as %of GDP)
France	303.0	497.0	..	7.3	2.3	2,102	6	7.3
Germany	350.0	957.0	..	7.9	2.6	2,488	4.8	7.9
Thailand in 1995	24.0	87.0	95	1.9	4.1	349	4.8	1.0
Bangladesh in 1997	20.0	11.0	14	1.7	1.9	51	2.2	1.7

Source: <http://w3.who.sea.org/eip/annex1.htm> (downloaded in 2002)

Table 2.20 Health and Health-related Indicators in Bangladesh and Thailand

Indicator	Latest data available	
	Bangladesh	Thailand
Population		
Total population (in millions)	129.2	60.76
Population density (persons per sq km)	834	118
Urban Population(as %of total)	23.9	21.2
Adult literacy rate (%)	50.5 (Male) 35.9 (Female)	93.0
Population with safe drinking Urban water available in the home or Rural with reasonable access (%)	49.1 96	93.2
Population using adequate sanitation facilities (%)	53	96
Population using improved water source (%)	97	80
Health Resources		
Number of hospital beds	41,514*	118,417
Population per hospital bed	3,307	501
Hospital beds per 10,000 population	3.02	20.0
Number of (thana) health centers	379	8,808
Number of physicians	29,981	14,181
Population per physician	4,512*	4,180
Physicians per 10,000 population	2.44	2.4
Budgetary Resources		
Government health expenditure as percentage of total expenditure	7.54	6.64
Total national health expenditure as % of GNP	3.04	5.12
Life expectancy at birth (years): Total		
Male	59.5	
Female	58.4 58.1	69.97 74.99

source: HUMAN DEVELOPMENT REPORT 2001; <http://w3.who.sea.org/eip/annex1.htm>
*BBS survey, July 1998 (source: Line Director 2000)

Table 2.21 Human Development Index (HDI) Rank of few Countries with Selected Indicators (1999)

HDI rank	Life expectancy at birth (years)	Adult literacy rate (%age 15 and above)	Combined primary, secondary and tertiary gross enrolment ratio (%)	GDP per capita (PPP US\$)	Human development index (HDI) value
13 France	78.4	..	94	22,897	0.924
17 Germany	77.6	..	94	23,742	0.921
66 Thailand	69.9	95.3	60	6,132	0.757
132 Bangladesh	58.9	40.8	37	1,483	0.470

³ Country report on the third evaluation of the implementation of HFA strategy, Bangladesh, 1997; Bangladesh Bureau of Statistics, Health and Demographic Survey: Summary Findings, 1994 and 1995, Dhaka, April 1996; Population census 2001; Preliminary report. Bangladesh Bureau of Statistics, Statistics Division, August 2001; Mahidol University, Mahidol Population Gazette, Vol.6, No.2, Thailand, January 1998; Ministry of Public Health, Public Health Statistics, A.D. Thailand 1995; Ministry of Public Health, Health in Thailand 1995-1996.

Table 2.22 Health System Attainment and Performance of Selected States, Estimates for 1997 (WHO)

Country	Health expenditure per capita in international Dollars (rank)	overall health system performance (rank)	Total health expenditure as % of GDP
Bangladesh	144	88	4.9
France	4	1	9.8
Germany	3	25	10.5
India	133	112	5.2
Japan	13	10	7.1
Pakistan	142	122	4.0
Thailand	64	47	5.7
USA	1	37	13.7

Source: http://www3.who.int/whosis/whr_statistics-locate.cfm?path=statistics,whr_statistics,whr_locate&language=english

2.3.3 State of Legislation on Medical Waste Management in Industrialized and Developing Countries

The minimization and disposal of waste has become one of the most significant environmental concerns of recent years. One estimate shows that some 5.2 million people (including 4 million children) die each year from waste-related diseases in the world. Globally, the amount of municipal waste generated will double by the year 2000 and quadruple by year 2025" (Haque, 1994 in Akter *et. al.* 1999). Concerned with this situation Agenda 21, adopted in the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June, 1992, set the following goals and targets with regard to waste management in cities:

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

It has been recognized that there is no separate goal or target found for medical waste disposal in Agenda 21. Very recently medical waste has become a part of state legislation or regulations for few countries. Followings are some of those examples.

2.3.3.1 Medical regulations and guidelines in the USA:

In the US the evolution of a separate category of medical waste within the municipal waste stream dates back to the late 1970s, when medical wastes including syringes and bandages were washed up on the eastern US coast. The public outcry that followed led to the formulation of the US Medical Waste Tracking Act (MWTa) which, finally came into force in November 1, 1988. The first solutions adopted to solve this problem was reflected in the installation of 6500 on-site, small and unregulated medical waste incinerators in health care facilities. It was soon realised that these small burners are not only causing more pollution than the medical waste, but they also provided license to create more and more waste, much of it disposable plastic, since it could all be easily burned. Besides, the end – of pipe solution did not even address itself to the crucial question of the worker safety (Agarwal, 1998; BAN & HCWH, 1999).

MWTA defines medical waste as "... any solid waste which is generated in the diagnosis, treatment, or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals..."

Various federal agencies and organizations, including the National Institute of Health (NIH), the Centers for Disease Control (CDC), and the Nuclear Regulatory Commission (NRC), have regulated or issued guidelines for handling and treating medical wastes (EPA, 1991). Many states and some local governments also regulate the management of these waste. EPA issued "Guide for Infectious Waste Management" in May 1986, in which a number of practices, including those for waste segregation, storage, packaging, treatment and disposal are recommended (EPA 1986).

2.3.3.1.1 Other Regulations and Guidelines Affecting the Management of Medical Waste

In Federal Regulations and Guidelines, most medical waste is considered a non-hazardous solid waste (i.e. ordinary trash) under Subtitle D of RCRA (Resource Conservation and Recovery Act) and thus not subject to any special handling or disposal requirements unless more stringent state or local regulations exist. Certain types of medical waste, however, are covered by Subtitle C of RCRA (as hazardous waste) or by Nuclear Regulatory Commission (NRC) Regulations. Additionally, some medical waste handling procedures are regulated by the Occupational Safety and Health Administration (OSHA) under the proposed Blood-borne Pathogen Rule (Federal Register, 1989 *in* EPA 1991).

RCRA Subtitle C includes those medical wastes only, which would include laboratory waste and chemotherapy treatment wastes, and other waste generated by medical facilities exhibits hazardous characteristics. NRC regulations address the disposal of low-level radioactive waste. OSHA proposed a regulation covering the management of medical wastes to ensure the protection of any workers exposed to human blood or body fluids in the course of their employment. This regulation is intended to protect health care workers from occupational exposure to blood-borne diseases. EPA Guidelines are recommended for procedure to follow, including labeling of infectious waste, packaging types to use, limiting access to storage areas, and transporting waste in leak-proof trucks or dumpsters. Preferred treatment methods also are indicated, which include incineration or steam autoclaving for most types of wastes and discharge of treated liquids and ground-up solids to the sewer system; land disposal of treated solids and incinerator ash is the recommended disposal methods. CDC provided only recommendations for managing one portion of medical waste- infectious waste. CDC issued recommendations for "Universal Precautions", state that all patients should be considered potentially infected with HIV or other blood-borne diseases, unless specifically diagnosed. The NIH has developed standard operating procedures for the management and disposal of infectious waste. NIH specifies secure packaging, special labeling, onsite incineration or steam autoclaving, and disposal of treated waste and ash as general waste. Joint Commission on Accreditation of Healthcare Organizations (JCAHO) standards, the overall framework in which medical facilities must operate is outlined by the JCAHO. In general, JCAHO requires compliance with all applicable laws and regulations (EPA 1991).

The U.S. Environmental Protection Agency (EPA) has regulations and guidelines, but they have also adopted state and local regulations, which vary widely (WHO, 1999b). State or local regulations also can determine the available options for treatment and disposal. A total of 45 states have some form of medical waste regulations, 14 states track waste using a chain-of-custody system, and 42 states require treatment before disposal (EPA, 1991).

In August 15, 1997 the U.S. EPA issued final standards and guidelines for air emissions from incinerators that burn medical waste. Seven years earlier, the US Congress recognized the health threat posed by medical waste incinerators (MWIs) and amended the Clean Air Act specifically to address them. In the 1990 Clean Air Act Amendments, the Congress directed EPA to promulgate regulations for MWIs "not later than 24 months after the date of the enactment of the Clean Air Amendments of 1990" (EPA 1997). According to the EPA's draft dioxin reassessment, medical waste incinerators are among the top sources of environmental contamination for both mercury and dioxin. These extremely toxic substances threaten public health after their release from medical waste incinerators.

2.3.3.2 Waste management policy in the European Union

With regard to waste of the First Environmental Action Programme 1973, emphasis was given to a remedial approach towards problems of waste disposal. The first focus on the prevention of environmental damage caused by certain substances (Directive on special waste 1975). Another Framework Directive is the Directive on Toxic and Hazardous Waste in 1978.

Directive 89/369/EEC applies to new plants and sets emission limits for dust, heavy metals and acid gases thereby distinguishing between three categories of incineration plants. For existing municipal waste incinerators, which started operating before 1 December 1990, Directive 89/429/EEC applies. It defines the time periods by when the older incinerators have to meet the standards for new incinerators as laid out in 89/369/EEC. The requirements set in the Directives do not apply to waste incineration plants for sewage sludge, chemical, toxic and hazardous waste⁴. The shortcomings of the two Directives are that the co-incineration of waste in other plants e.g. cement-kilns is not covered. Furthermore the Directives lack emission standards for dioxins.

The prevention of waste as a policy priority was first established in the Second Environmental Action Programme (1977-1981). The Third Environmental Action Programme (1982-1986) translated the prevention approach into the promotion of the re-use of waste and the development of low-waste technologies, the Fourth Environmental Action Programme (1987-1992) placed emphasis on changing the production and consumption patterns by developing economic instruments. The principles for environmental policy (1986) are that *'preventive action should be taken, that environmental damage should as a priority be rectified at source, and that the polluter should pay'* (Hempen, 2002).

Waste Strategy

Community on the Environment (ACE) established in 1987. The Communication from The Commission, 'A Common Strategy on Waste Management' SEC (89) 934, was submitted to the Council and to Parliament on September 18, 1989. The Waste Strategy, which covers the time period 1989 to 2000, sets the basis for European waste policy and therefore needs to be considered in all legislation processes relevant for waste. Five strategic guidelines, which are to be translated into action by mid-term and long-term programmes, were set (Hempen, 2002).

Prevention

Two areas of application:

Process
Products

⁴ Standards and requirements for these facilities are set in the Directive on the incineration of hazardous waste 94/67/EEC adopted in 1994.

Reuse and recycling

- Creation of economic incentives to promote reuse
- Optimisation of collection systems
- Creation of markets for products from recovered raw materials
- Research and development

Optimisation of final waste disposal

- Harmonisation of the standards for waste treatment
- Research and development
- Strict observance of legal regulations
- Suspension of high sea incineration and dumping

Regulation of waste shipment

- Continuation of on-going work on Community level

Cleaning up of contaminated sites

The document established the waste management hierarchy whereby prevention has the highest priority followed by reuse, recycling and the disposal.

With regard to waste management the Fifth Environmental Action Programme (1993) builds on the policy goals, priorities and measures as outlined in the waste strategy. In particular more attention is given to waste prevention and solving waste problems at source as opposed to end-of-pipe solutions. Objectives for the waste policy are set and transformed into targets up to the year 2000. Newly included is the approach of prioritizing waste streams, which are particularly harmful to the environment and to develop specific regulations. The approach lead to six-priority waste streams pilot projects: used tyres, halogenated solvents, end-of-life vehicles, demolition waste, hospital waste and electronic waste.

In 1996 the Commission delivered the review of the Community Strategy for Waste Management. Material recovery has a greater effect on waste prevention than energy recovery, priority is given to material recycling, where environmentally sound. The term recycling should therefore be limited to material recovery and not include energy recovery operations. With regard to the implementation of the waste strategy, the participation of all parties e.g. public authorities, private and public companies, environmental organizations and individuals is stressed, thereby applying the principle of shared responsibility. In addition, intensified work with regard to the development of life cycle analysis as a mean of determining the environmental impacts of products and the establishment of reliable European waste data was proposed.

The need for a comprehensive waste strategy which builds upon the hierarchy of prevention, reuse and recycling of waste as well as the safe disposal for the remaining residues is emphasized on the draft landfill Directive (COM (97)105 final). The standards for containment against leakage are recognized as an important step towards safer landfill within Europe whereas the possibilities to weaken the standards for underground disposal are not accepted. Furthermore the idea for cost coverage not only for the immediate costs but also for the long-term aftercare of the landfills and hence the financial guarantees required in the proposal are welcomed.

The Commission is currently revising the two Directives (89/429/EEC; 89/369/EEC) on the incineration of municipal waste. The proposed Directive does not apply to the incineration of hazardous waste and certain types of waste. Given the situation within Europe whereby a large quantity of the waste generated is undergoing an incineration process the EEB underlines the need for improvements with regard to the regulation of

waste incineration not only for environmental and health reasons but also for economic arguments. Nevertheless, the EEB stresses that incineration can only be accepted as a means of last resort. Prevention, re-use, recycling and other methods have to remain the preferred treatment methods for waste (Hempen, 2002).

2.3.3.3 Legal aspects (Germany)

2.3.3.3.1 Laws and Regulations Pertaining to Medical Waste Management

The main law applying to the management of waste from hospitals and other health care establishments is the Waste Avoidance and Waste Management Act- Waste Act -of August 26, 1986, including its statutory ordinances and its general administrative regulations on requirements for waste management (so called "Technische Anleitung Abfall - Technical Instructions on Waste Management") (Gleis, 1997). According to Article 2, para 2 of the Waste Act, additional requirements shall be laid down for the management of wastes generated by industrial, commercial or public sources which by reason of their nature, condition or quantity, constitute a particular hazard to health or to the quality of air or water or are particularly explosive or inflammable, or contain or may lead to the development of pathogenic organism (transmissible diseases). A more specific description of these special wastes is given in the Ordinance on the identification of Wastes pursuant to Art. 2 para 2 of the Waste Act (Waste Identification Ordinance - Abfallbestimmungsverordnung). The provisions of the Waste Act do not apply to nuclear fuels and other radioactive substance within the meaning of the Atomic Energy Act and materials to be disposed of in accordance with the Animal Carcass Disposal Act. The term "transmissible disease" stems from the Federal Epidemic Control Act which contains supplementary provisions for medical waste management. Provisions concerning the transport of medical waste are included in the Waste Act and the Ordinances based on it, as well as in the Gefahrgutverordnung Straße (GGVS) and ADR/RID-class 6.2 (4b) (Ordinance on the Transport of Dangerous Good by Road). Hospitals using incineration as treatment method for their waste must comply with the requirements of the Federal emission Control Act (Bundes-Immissions schutzgesetz; first version of March 15, 1974, amended May 14, 1990) and the Seventeenth Ordinance on the implementation of the Federal emission Control Act (Ordinance on Incinerators for Waste and Similar Combustible Materials - 17.BImSchV) of 23 November 1990 (Table 2.23).

Table 2.23 Emission Limits of the 17th BimSchV based on an Oxygen Content of 11 vol%

Parameter Regulated	Daily Means	Half-Hour Means
Dust	10 mg/m ³	30 mg/m ³
Organics	10 mg/m ³	20 mg/m ³
HCL	10 mg/m ³	60 mg/m ³
HF	1 mg/m ³	4 mg/m ³
SO ₂	50 mg/m ³	0.20 g/m ³
NO ₂	0.20 g/m ³	0.40 g/m ³
CO	50 mg/m ³	100 mg/m ³
Mean determined over the respective sampling period		
Heavy Metal:		
-Cd + TI		0.05 mg/m ³
-Hg		0.05 mg/m ³
-Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V + Sn		0.5 mg/m ³
Total calculated sum of dioxines and furanes		0.1 ng/m ³

Source: Gleis, 1997.

2.3.3.3.2 Present Situation of Medical Waste Management in the Federal Republic of Germany

The above mentioned laws & regulations do not provide detailed instructions concerning the segregation of medical waste. A better definition of the term "hospital specific wastes", including all possible types of waste from the medical sector, is given in a new guideline "for the avoidance and management of wastes from public & private health care establishments", which has first been published in Hesse in November 1991 as a set of technical instructions. Although the guideline deals essentially with the management of waste from hospitals, "waste from health care establishments" was considered to be a more suitable and comprehensive term, as it embraces infectious and other hazardous or obnoxious waste arising in various kinds of health care establishments other than hospitals. The term health care establishments includes health care services like medical and surgical patient services, operation-theatres, dialysis units, biochemistry and microbiological laboratories, blood banks, central sterile supplies, medical practices, dental practices & pharmacies. The term "waste" includes all types of waste material generated in health care establishments, except radioactive waste and wastewater. Based on discussions within the committee commissioned to draw up the guidance document (experts from waste management authorities and German hygiene specialists) and on the practical experience that medical wastes pose no greater hazards when handled properly than domestic waste and other waste from residential areas disposed of in accordance with the relevant regulations, the new guideline classifies health care waste as follows:

(A) Wastes, which can be managed without the use of special measures, designed to prevent infective and environmental risks

- Waste materials similar to domestic type wastes
- Disinfected wastes of waste group C (waste code 180104)
- Packing materials

- Food and kitchen wastes

(B) Wastes, which require special measures to prevent infective risks during their management inside the health-care establishment

- Wastes contaminated with blood and body fluids, e.g. bandages, plaster casts, diapers, one-way articles, syringes and needles (Waste code 18103) Where larger quantities of body fluids arise, the containers can be emptied taking hygienic aspects into consideration. The contents can be discharged into the sewer system.

(C) Wastes which require special measures to avoid infective risks during their management inside and outside the health-care establishment (infectious waste)

- Wastes which must be treated in accordance with Art.10a para 1 of the Federal Epidemics Control Act. These waste materials are contaminated with carriers of transmissible diseases and spread of disease is therefore to be feared.

Infectious waste further includes microbiological cultures arising in institutes for hygiene, microbiology and virology as well as in medical laboratories and practices in which corresponding operations are performed (Waste code 180103).

Wastes of this kind may, for example, arise in isolation wards, dialysis wards and dialysis centers "with yellow and gray dialysis (patients infected with Hepatitis B or C under going haemodialysis)", in pathology, blood banks, medical practices, as well as in veterinary practices and clinics. These wastes are generated in patient treatment, e.g. materials contaminated with pathogens-containing blood or sputum; packaging materials are not included as a rule.

The need for taking additional measures (e.g. separate collection, disinfection) results from the type of pathogens concerned involved (especially their risk of communicating diseases and their viability), the route of transmission, the extent and type of contamination, and the waste quantity. According to the current status of the discussion wastes of this category may arise in the following diseases: cholera, leprosy, anthrax, paratyphoid A, B, C; pestilence, smallpox, poliomyelitis, dysentery (bacterial), rabies, tularemia, typhus abdominalis, virus-induced hemorrhagic fever, brucellosis, diphtheria, meningitis /encephalitis, Q-fever, glanders, tuberculosis (active form) and virus hepatitis (Gleis, 1997).

- Laboratory animals, if their disposal is not covered by the Animal Carcass Disposal Law, as far as there is a risk of transmission of the listed diseases (Waste Code 180103).

- Litter and excrements from experimental animal facilities, as far as there is a risk of transmission of the above listed diseases.

(D) Wastes which require special measures to avoid environmental risks during their management inside and outside the health-care establishment

- Hazardous chemical wastes (e.g. halogenated and non-halogenated organic solvents, inorganic acids, mercury batteries, PCB-containing waste, cyto-toxic drugs etc.)

(E) Medical wastes which require special measures during their management for ethical reasons

- Body parts and organs including waste containing larger amounts of blood, e.g. units of stored blood (Waste code 180102), all sharps, such as syringes, needles and knives, should be collected and transported in protective packaging.

If the waste classification recommendations of the new guideline were adhered to widely, the proportion of infectious waste would be reduced to approx. 5 wt-percent of hospital specific waste.

2.3.3.4 Legal aspects (France):

Disposal of infectious risks healthcare wastes and assimilated waste are discussed in France Policy on hazardous waste (Décret No 97-1048 - 6 November 1997). Few selected sections are written below.

Art.R.44-1.

Healthcare Wastes are wastes arising from diagnosis, monitoring and preventive, curative or palliative activities in field of the veterinary and human medicine. The wastes that are submitted to the present regulation are those that

1. Present an infectious risk, due to the fact that they contain viable microorganisms or their toxins, whose one knows or whose one has good reasons to believe that by their nature, their quantity or their metabolism, they cause human or other living organisms sickness;
2. Even if there is no infectious risks, belong to one of next categories: sharp equipments and materials destined to be discarded, that they have been or not in contact with a biological product; blood products for therapeutic usage partly used or arrived to expiration; human anatomical wastes, that are human remains non easily reconginzable.

The waste arising from activities of teaching, research and industrial production in veterinary and human medicine, as well as waster arising from activities of thanatopraxy, when they present characteristics mentioned to 1. or 2. above are assimilated to healthcare wastes, for the application of the present regulation.

Art.R.44 - 2.

I. All producers of wastes defined in the article R.44-1 must dispose of them. The duty of this obligation is for: the healthcare establishment, the establishment of teaching, the establishment of research or the industrial establishment, when these wastes are produced in a such establishment; the person for which the healthcare professional practice the activities generating wastes; in all other cases, the person that practices the activity generating wastes.

II. - Persons or establishments mentioned to the I above can, by a convention that has to be written, to delegate the disposal of their healthcare wastes and assimilated wastes to an other person (or company) that is in measure to undertake it. A joined text from ministers of the health and the environment fixes mandatory stipulations for these conventions.

III. - Persons (or establishments) mentioned to the I above have, at each stage of the disposal of wastes, to establish documents for tracking the waste disposal. These documents are defined by a joined text from ministers of the health and the environment after advice of the Superior Council of Public Hygiene of France.

Art.R.44-3.

Healthcare Waste and assimilated defined in the article R.44-1 have to be, from their production, sorted to other wastes.

Art.R.44-4.

Healthcare Wastes and assimilated are collected in single-use packagings. These packagings must be able to be closed temporarily, and they must be closed definitively before their removal. Packaging are placed in large bulk containers, except in cases defined

by joined texts from ministers of the health and the environment. The packaging, the marking, the labeling and the transportation of healthcare wastes and assimilated waste are submitted to regulatory stipulations of the law no 42-263 of 5 February 1942 relative to the harmful material transportation and the article 8-1 of the law no 75-633 of 15 July 1975 modified relative to the disposal of wastes and to the recovery of materials, to which can be added complementary prescriptions defined by joined texts from ministers of the health, the environment and the agriculture, after advice of the Superior Council of Public Hygiene of France.

Art.R.44-5.

Storage methods of healthcare wastes and assimilated, notably the duration of storage as well as characteristics and conditions of premise maintenance of storage, are defined by a joined text from ministers of the health and the environment, taken after advice of the Superior Council of Public Hygiene of France.

Art.R.44-6.

Healthcare Wastes and assimilated wastes must be incinerated, pre-treated by disinfection devices of such manner that they could then be collected and processed by towns and groupings of towns in conditions defined in the article L. 2224-14 of the general code of territorial communities. Residues of such pre-treatment can not however be composted.

Disinfection devices mentioned to the preceding paragraph are accepted by joined texts from ministers of the work, the health and the environment. Methods of approval and requirements of disinfection devices implementation are fixed by joined texts from ministers of the work, the health, the environment and industry, after advice of the Superior Council of public hygiene of France.

Anatomical remains disposal is in Art.R.44-7.

Anatomical remains are organs or members, or part of organs or member, easily recognizable by a non - specialist, collected after healthcare activities and activities mentioned in last paragraph of the article R.44-1. Art.R.44-8. Article R.44 - 2 to R. 44-5 are applicable to the anatomical remains disposal.

Art.R.44-9.

I. Anatomical human remains intended to be discarded must be incinerated. The incineration is done in a crematorium authorized in accordance with the article L.2223-40 of the general code of territorial communities and whose manager is authorized in accordance with the article L. 2223-41 of this code. Stipulations of article R.361-42 to R.361-45-1 of the municipality code are not applicable. The incineration is undertaken outside of opening hours of the crematorium to the public.

Ashes of the incineration of anatomical human remains can be collected and processed by municipalities and groupings of municipalities in accordance to the stipulations defined in the article L.2224 - 14 of the general code of territorial communities.

II. - Anatomical animal remains intended to be discarded are treated by authorized knackereries accordingly to dispositions of articles 264 and 265 of the rural code.

Other stipulations

Art.R.44-10.

District departments of sanitary and social Affairs are in charge of the application of dispositions of the present regulation and its texts, under reserve of cases in which laws and

regulations give competence to others services. Person (and establishments) mentioned to the I of the article R.44-2 have to give at the disposal of control agents the convention and documents mentioned by the II and III of the same article.

Art.R.44-11.

Persons mentioned in the I of the article R.44 - 2 must inform their staff about the means (and the organization) that they have implanted for the disposal of healthcare wastes and assimilated wastes and anatomical remains. "

2.3.3.5 The Government policy framework (UK)

In December 1995 the Government published a White Paper entitled "Making Waste Work"(HMSO, 1995) which set out its strategy for the sustainable management of waste in England and Wales. A strategy for Scotland is due to be published in 1998. Whilst this paper was published by the previous Government, it has not yet been superseded and contains the following three objectives

- to reduce the amount of waste produced
- to make the best use of what waste is produced
- to choose waste management practices which minimize the risks of immediate and future environmental pollution and harm to human health

More specifically, two primary targets were set and a commitment to set a third. These are

- to reduce the proportion of controlled waste going to landfill to 60% by 2005
- to recover 40% of municipal waste by 2005
- to set a target for overall waste reduction by the end of 1998

The strategy, although not legally binding, also requires organizations employing more than 200 staff to have a waste management strategy in place by 1999. This obviously has implications for many HE institutions.

Unlike the Making Waste Work strategy, the Environmental Protection Act 1990 is legally binding. This imposes a "Duty of Care" on producers and handlers of waste "to take reasonable measures to prevent the unauthorized deposit, treatment or disposal of waste". In practical terms this means that all waste producers (including HE institutions) must

- know how much waste they generate and what it consists of ensure that their waste is collected by a Registered Waste Carrier or Exempt Carrier.
- ensure that all waste is covered by a waste Transfer Note (usually from the contractor) containing a description of the waste for disposal or recycling. Copies of this must be kept for three years satisfy themselves that their waste is dealt with properly and legally

Breach of the Duty of Care is a criminal offence, with a penalty of up to £20,000 or an unlimited fine if convicted on indictment.

Other legislation which may apply to HE institutions includes the Special Waste Regulations (1996) which set out the provisions for keeping, treating and disposing of controlled wastes that are dangerous or difficult to manage. These include materials such as batteries, paints, oils and laboratory chemicals. Some clinical waste may also be classified as Special Waste.

(Source: <http://www.he21.org.uk/wastbull.html>;

<http://www.defra.gov.uk/environment/waste/special/index.htm>).

Best practice Case Study
Clinical and hazardous waste management at the University of Edinburgh

The University of Edinburgh is one of the largest universities in the United Kingdom with 13,000 undergraduates and 3,500 postgraduate students.

New legislation and increasing costs of collection and disposal have recently raised the profile of waste management at Edinburgh. Of primary importance is that the University stays legal, but by managing waste responsibly and encouraging waste minimization, there are additional benefits. The University saves on direct costs, reduces the load on expensive equipment such as the incinerator and minimizes the quantity of waste going for disposal direct to landfill or to other more expensive destinations.

The Waste Reduction Policy: The University adopted a Waste Reduction Policy in October 1996. This policy applies to everyone and all departments, whether producing only "office waste" or more difficult wastes from, for example, clinical or chemical laboratories. It sets out specific responsibilities for University management and provides a framework for formalizing departmental procedures.

The following Codes of Practice are being introduced as an integral part of this Policy:

General Waste: General procedures for non-hazardous wastes from University buildings; includes re-use and recycling, disposal of redundant equipment and of confidential records.

Clinical Waste: Procedures for all departments and units handling and disposing of materials defined as clinical waste.

Hazardous Waste: Procedures for all departments disposing of hazardous chemicals, solvents etc. from laboratories and workshops; includes radioactive and special wastes

Clinical and hazardous wastes: Incidents a few years ago involving clinical and hazardous waste finding its way into general waste containers focused attention on compliance issues for the management of clinical and hazardous waste within the University.

With the help and co-operation of key staff including the superintendent of uniformed staff, senior drivers, all transport section drivers, and all staff at the medical school boiler house and incinerator, a number of improvements have been made to the management of clinical waste. For example:

- The purchase of a purpose designed waste collection vehicle. Clinical waste is now transported by trained and properly equipped transport section drivers;
- The introduction of standard yellow sacks and sharps containers and sack ties for clinical waste has brought cost benefits from centrally negotiated purchasing; and
- The development and launch of a Clinical Waste Code of Practice including briefing sessions for departmental technical staff.

The development and introduction of a barcode labeling and tracking system for all clinical and radioactive waste items incinerated at the University so that the producer of each labeled item of waste can be identified and a contribution to the costs of disposal recovered. The disposal of clinical waste is expensive. These compliance led improvements have had other benefits, including the reduction in the amount of waste unnecessarily being designated as clinical waste, the use of alternative materials and the rationalization of disposal routes.

The Clinical Waste Codes of Practice has improved all aspects of dealing with clinical waste including

- integration with departmental procedures and documentation
- departmental and individual responsibilities clearly identified
- approved waste disposal contractors vetted
- definition of clinical waste clarified e.g. excludes bulky animal bedding from healthy breeding stock
- the Duty of Care legislation complied with
- improved clinical waste segregation
- clinical waste treatment
- clinical waste handling

In a similar vein, a Hazardous Waste Code of Practice provides the framework for departments generating hazardous waste. It gives guidance on managing hazardous waste safely and legally on University sites. This has tightened up departmental procedures for hazardous waste management and formalized disposal arrangements through the chemistry department stores.

Source: <http://www.cecs.ed.ac.uk/>

2.3.3.6 Developing country

In 1995, the Regional Office for South-East Asia of the World Health Organization (WHO) made a survey of healthcare waste management in 9 countries in the region with substantial responses from Indonesia, Myanmar, Sri Lanka, Thailand, and Bangladesh (WHO, 2000). Results of the survey show that most healthcare establishments do not have any waste-management plan or procedure. In several countries, there is no legislation at all (Akter *et al.*, 1998). There is also a lack of waste-management guidelines. The responses on the types and segregation of wastes seem to indicate only a limited safe management of wastes with plenty of opportunity for mix-ups and disposal into the municipal dustbins. In Indonesia and Thailand, where legislation is in place, did better on most accounts. India has made progress in enacting legislation, but there is still a long way to go. The periodical, *Down to Earth*, published by Center for Science and Environment, India, in its February 29, 1998 issue reported, "none of the hospitals in the City's 39 wards (Patna, Bihar) have any facilities for the segregation and incineration of wastes generated by them. These wastes are disposed along the road sides in the same manner as domestic and commercial waste" (Nessa *et al.*, 2001).

2.4 Medical Waste Management: Concept and Strategy

The major elements of a medical waste management strategy are as follows (EPA-Victoria, 1993)

- Waste minimization
- Waste segregation
- Labeling and packaging
- Waste handling and transportation
- Waste treatment and disposal

The management plan also consider the required training, refresher training, guidelines and any hospital or medical plans for staff dealing with medical wastes.

Basic medical waste management concept is shown in Figure 2.8 below (according to Reinhart & Gordon, 1991 in Wangsaatmaja, 1997).

2.4.1 Infectious Medical Waste Management

EPA-US (1986) gave the objectives of effective infectious waste management program should be provide protection to human health and environment from hazards posed by the waste. Proper management ensures that infectious waste is handled in accordance with established procedure from the time of generation through treatment of the waste and its ultimate disposal. Infectious waste management system should include the following element:

- Designation of infectious wastes
- Handling of infectious wastes which includes
 - Segregation
 - Packaging
 - Storage
 - Transport and handling

- Treatment techniques
- Disposal of treated waste
- Contingency planning
- Staff training

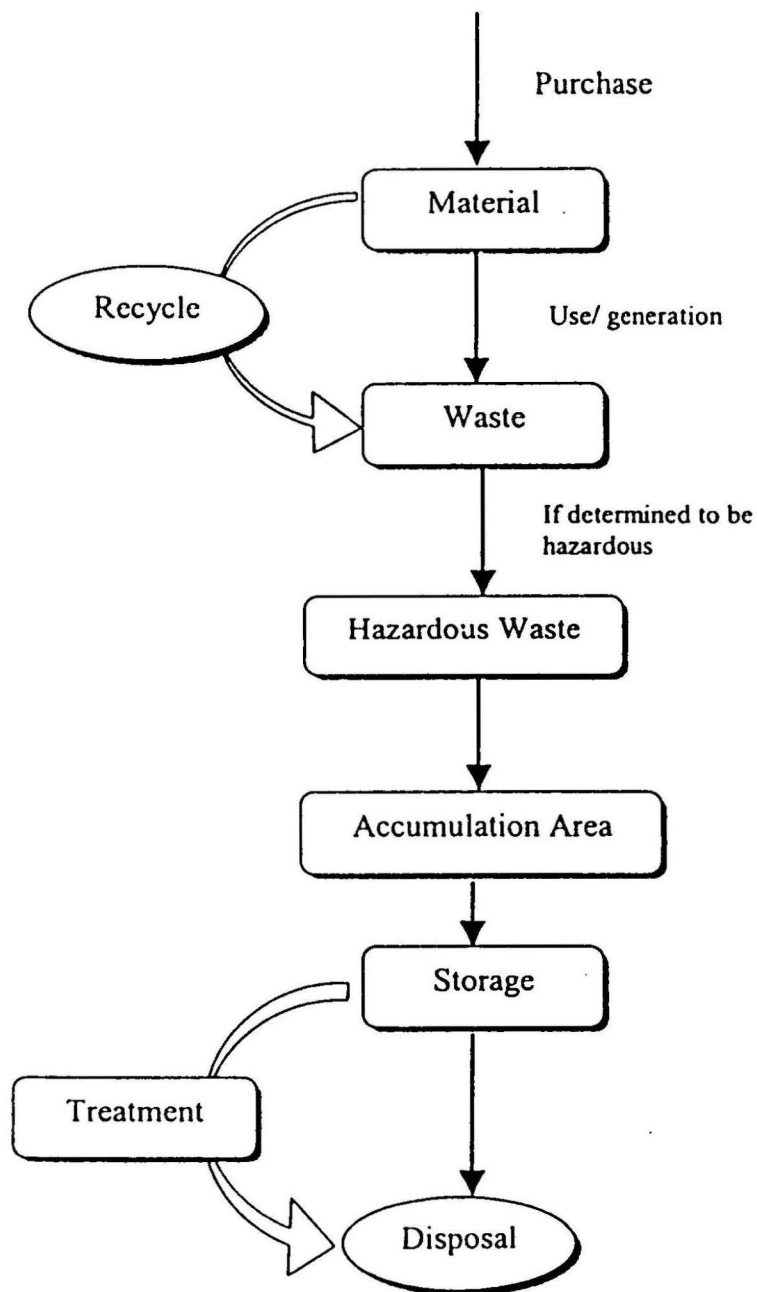


Figure 2.8 Basic Waste Management Concepts

(source: Reinhartdt & Gordon, 1991)

2.4.2 Improper Medical Waste Management and Analysis of Causes by WHO

Numerous causes lead to improper exposure medical wastes, some which are given below:

- Lack of awareness about the inherent hazards caused by improper management of health care wastes;
- Insufficient allocation of resources (financial and human) for the safe management of the wastes;
- Improper control of the waste management system;
- Absence of a national policy for the management of health care wastes;
- Inadequate regulatory framework;
- Insufficient evidence on the negative impact of medical wastes on certain professional groups; and
- Insufficient information on sound waste management and treatment options and their benefits.

In addition, the lack of political wills to develop and implement a proper management system plays an important role on the management of medical wastes. (source: WHO (2000b))

2.5. Technology Review

Throughout the world substantial amount of healthcare waste is still either place in open dumps or in the more scientifically designed landfill sites without treatment (Townend, 2001). The incineration has always been the favoured method of treating medical waste. However increasingly high gas emission standards required in the higher income countries has made this method more expensive. Other methods of treating medical waste have been developed over recent years and are becoming more popular. These methods includes:

- Chemical disinfection
- Dry and Wet (autoclaving) heat treatment
- Microwave Irradiation

And may include a combination of the methods. Selecting the most appropriate method of treatment and disposal is dependent on a very wide range of factors and requires a very careful evaluation of each of the factors together with expert advice before a decision is made.

Uses of medical waste treatment technology at different countries are briefly discussed below.

2.5.1 Treatment Technology at Different Countries

2.5.1.1 USA

Over 6500 incinerators were installed in the US alone in the 1980s (Agarwal, 1998). Chronic problems both relating to very high toxic levels as well as difficulties in operating a sophisticated engineering technology in a medical setting have given rise to a debate which attempts to define a clean technology for medical waste disposal. According to Hall (1989), 67 percent of hospitals incinerate their infectious waste. The EPA (1997) estimates that there are approximately 2,400 MWIs operating in the United States, which combust approximately 846 thousand tons of medical waste and medical/infectious waste annually. Most of this medical waste (85 to 90 percent or more) is simply municipal-type waste that may be recycled or disposed of without special treatment. Of the remaining 15%, 13% is infectious and requires treatment and the remainder (only about 2% of the total) is

pathological waste, which must be incinerated. Most of these incinerators are located on-site in medical facilities. Approximately 1,139 of the 2,400 incinerators are small, 692 are medium-size MWIs, and 463 are large MWIs, in addition there are 79 commercial MWIs currently in operation.

EPA has pointed out that switching to alternative waste disposal methods is significantly more economical than upgrading an incinerator. According to EPA (1997), "For many of these facilities, the economic impacts of switching to an alternative method of waste disposal are much lower than the economic impacts of choosing to install emission control equipment.

In the USA, waste generation rates for the sector have nearly doubled since 1955, due at least in part to increasing use of disposable products. Waste disposal costs per unit have escalated, and promise to continue to do so. Construction requirements for new landfills (e.g., double liners), more stringent siting requirements, community resistance and closure of existing fills all serve to increase landfill fees and transport costs. Incinerator regulations are requiring expensive retrofits of existing units, or their closure altogether. Further, medical waste has become a contentious and sensitive political issue the simple acceptance of medical waste by a landfill or incinerator often engenders substantial local resistance. The operations of medical incinerators are similarly controversial. Waste minimization and reduction of toxic substance use are preferred responses. Most healthcare wastes are burnt in hospital incinerators. Other treatment methods include steam or gas sterilization, irradiation, and chemical disinfection. The privately-owned facilities compete to handle wastes. Some new technologies, such as bio-oxidation, gas-pyrolysis, plasma-treatment technology, microwave disinfecting, and autoclaving are practiced now (WHO, 1999b).

2.5.1.2 Europe

Treatment like thermal disinfection or sterilization as well as a large scale central special waste incineration are typical methods for health care risk waste in Germany Stefan Drauschke (1999). Furthermore there is a trend in Europe in using different pretreatment systems by steam disinfection to save the valuable special-waste incineration capacities for toxic and chemical waste for which they have been designed and installed. The systems used for the disinfection of infectious waste had to be validated on the basis of a directive "Validation of Waste Disinfection Processes" which was issued by the German Health Office and the German Society for Hospital Hygiene in April 1993.

Thermal disinfection or sterilization or incineration are used as treatment methods for infectious waste. Only methods authorized by the Federal Health Office should be used for the treatment of infectious waste. Infectious waste can be disinfected with steam sterilizer (e.g. operating at 105°C with saturated steam at 1.2 bar) or transported to special treatment plants in containers as specified in the GGVS (Regulation on the Transport of Dangerous Goods).

A large number of systems are available to incinerate infectious and other hospital specific wastes. To reduce the costs and the air pollution caused by the incineration of medical wastes, incineration is becoming more and more centralized in the Federal Republic of Germany. The number of small incinerators operated by hospitals decreased from 554 plants in 1984 to 218 plants in 1987. The trend towards the shut-down of hospital-operated incinerators is continuing. At present around 10 incinerators are still used for incineration of medical waste, most equipped with a modern, very expensive flue gas-cleaning device. Several German Länder (Federal States) use central incineration plants for the thermal treatment of hospital specific waste. A special medical waste incinerator based on two-stage incineration is located at Kiel. This plant has been built to treat all hazardous medical

waste of the Schleswig-Holstein area. The municipal solid waste incinerators in Bielefeld and Coburg have special incineration units for the treatment of medical waste which are connected to the gas cleaning system of the municipal waste incinerator. In Northrhine-Westfalia, Hesse and Rhineland-Palatinate infectious waste is incinerated in rotary kilns of hazardous waste incineration plants.

Steam Disinfection, an alternate treatment system to the incineration of infectious and pathological waste is used in Berlin. Using the Drauschke System, septic waste from hospital sources is treated with saturated steam under pressure. The process was developed as an alternative technical system, which started in Berlin and has spread out to the other countries in the European Community. The Drauschke System disinfects infectious wastes, using vacuum/high pressure steam applied to the wastes in an **autoclave**. Some 10.000 tonnes of healthcare wastes have been disinfected over the last ten years in Germany. The system's owners - KEG Sonderabfall Entsorgungsgesellschaft mbH are now disposing of infectious wastes from approximately 250 hospitals containing some 100.000 beds.

So called "Dry" Infectious waste includes syringes, swabs, dressings and materials from infection wards (tuberculosis, hepatitis) isolation and dialysis wards with a unit weight of 0.1 g/cm³. This waste is collected and treated by the Autoclave with Supply-Unit. "Wet" waste is pathological waste, eg. body parts from operating theaters and large amounts of body fluids, eg. Blood-bags. Wet waste is collected in disposable polythene containers (30 or 60 liter capacity) in special vehicles and taken to the Central Stationary Autoclave with Filling Gate for disinfection.

Autoclave with Supply-Unit, the waste treatment plant consists of a semi-mobile autoclave (pressure vessel) and a stationary 'supply-unit' installed at an appropriate place. The semi-mobile autoclave is mounted on a trailer, which is moved by a commonly available truck. The maximum transport safety of the infectious wastes required under the Regulation on the Transport of Dangerous Goods by road [GGVS/ADR/RID-class 6.2 (4)] is met and the autoclave has got the permission in the whole European community. The disinfected waste finally can be taken to household incinerators or landfill.

For other hazardous waste categories: Recovery of silver from photographic developing solutions is done by commercial firms. Non-recyclable organic hazardous chemical waste is collected separately and incinerated in a regional hazardous waste incineration plant.

In the UK, 83% of industrial, commercial and domestic waste is sent to landfill, 10% is incinerated and only 5% is recycled (<http://www.he21.org.uk/wastbull.html>). In the UK, the available space for landfill is running out rapidly and the decay of waste within landfill gives rise to methane which is a global warming gas 21 times more powerful than carbon dioxide. In addition, landfill sites contaminate groundwater when leaching occurs and contaminated landfills are unsuitable for a variety of subsequent uses. Incineration also results in a number of environmental problems including emissions of PCBs and dioxins. These are complex chemicals which are notoriously difficult to monitor and their effects on human health are still unknown.

The share of different waste streams indicates different waste management options. The following figure 2.9 gives an overview about the used waste treatment methods for municipal waste in the Member States of EU in 1993 (Hempfen, 2002). The figure 2.9 illustrates that in 1993 landfill is still the preferred method of treatment followed by incineration⁵. By comparison to 1990 when 69 % of the municipal waste generated in the EU12 was landfilled this decreased to 57% in 1993. Over the same time period the share of

⁵ Please note that the given data do not differentiate between incineration with and without energy recovery.

incineration increased from 18 % in 1990 to 23 % in 1993 and recycling and composting increased by 10 %.

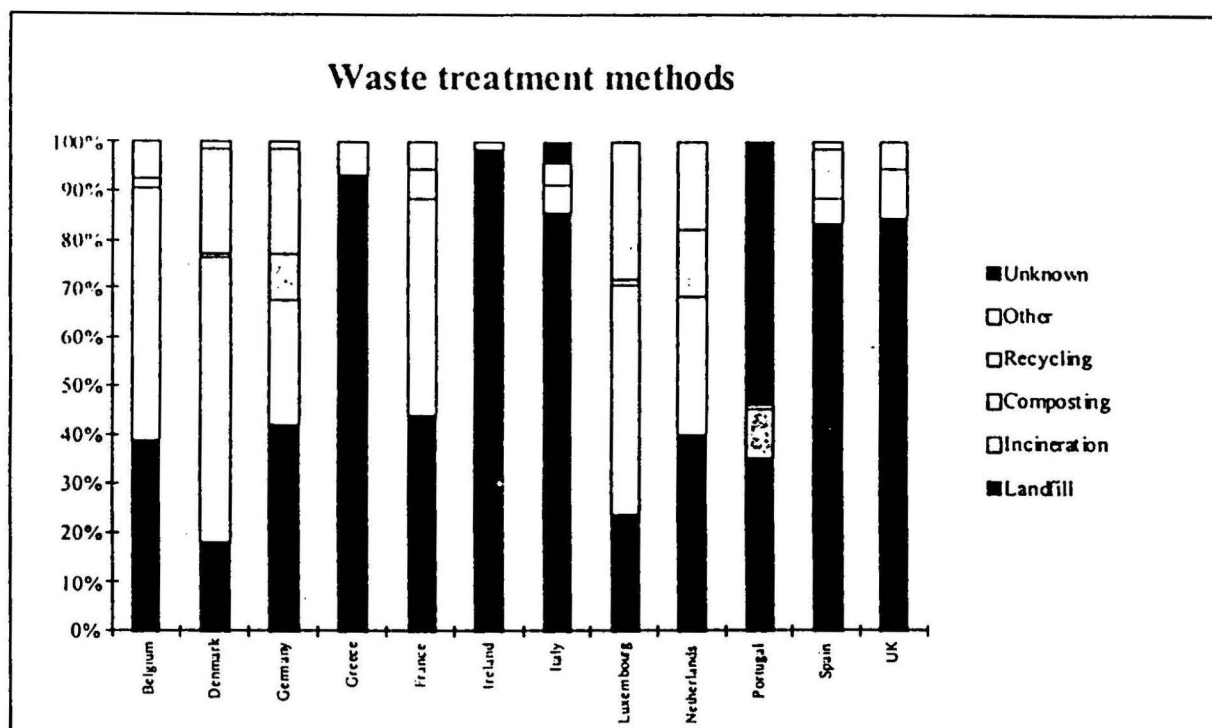


Figure 2.9 Waste Treatment Methods in the Europe

(source: Hempen, 2002).

Wastes are properly segregated at the point of generation, although the disposal is expensive. Contaminated items are incinerated at source, although new technologies, such as microwave disinfection are gaining popularity. For effective waste management, the European Commission, in 1990, under the Environmental Protection Act, imposed strict controls and instituted statutory duties. Ignorance or defiance of these can result in severe fines and custodial sanction (Nessa *et al*, 2001). In 1995, legislation on incinerator plants to integrate pollution control was introduced. After 1996, the European Commission turned their attention to waste minimization by reuse, recycling, segregation, and better management with minimum impact on the environment and ecosystem. They are imposing strict laws to manage and control hospital wastes. In the European countries, the majority of wastes are incinerated, with stringent control of air pollution. There is a move from local incineration toward regional medical waste incinerators with better air pollution-control characteristics, but concerns about compliance with respect to management and disposal, and differentiation from countries to countries persist.

2.5.1.3 Developing countries

As can be seen from the literature, there is no proper waste management system in place in most developing countries. On-site incineration, autoclaving and dematerialization are a few processes currently in use for treating very small amounts of hazardous wastes. The countries found to practice incineration is Argentina, Brazil, Thailand, Peru, India, Pakistan and Bangladesh. Clinical waste incinerators, particularly in developing and poorer countries, often operate under sub-optimal conditions. Most of the cases the percentage of incinerators that were functioning poorly or not operational (BAN & HCWH, 1999). Most medical administrations usually focus on installing disposal technologies such as

incinerators and do not implement a “practice” of waste management within the hospital. In Nigeria (Coker *et al.* 1998) practiced various methods of medical waste disposal such as land filling, open burning, incineration and open dumping.

Different methods are practiced in this region. Several studies were found in these region which mentioned and discussed about medical waste treatment technology such as; two stage constructed wetlands for treating medical wastewater and wastewater treatment plant (Laber *et al.* 1999, Shrestha *et al.* 2001; Wangsaatmaja, 1997). For infectious and solid waste technology used are autoclave, chemical disinfectant for infectious waste, as well as use of different quality incinerators, land filling (Wangsaatmaja, 1997; Paranan, 1997; Akter *et al.* 1999 & Akter, 2000).

Several authors also describe guideline and technology for medical waste treatment and management for developing countries. Land filling and waste pit construction for medical waste in small healthcare facilities was described by Jantsch & Heino (1999). Single chambered and/ or drum incinerator to burn infectious waste and small burial pit, chemical disinfection, autoclave an some other methods were described by WHO (1998, 1999) for developing countries.

2.5.2 Technology: Options and Assessment

2.5.2.1 Treatment technologies and final disposal options

Overview of treatment and disposal methods for different categories of medical waste with appropriate options proposed by WHO (1999a, 1999b) are given in Tables 2.24, 2.25 and 2.26. Table 2. 24 prescribed disposal methods of waste from in and after emergencies. Table 2. 25 prescribed disposal methods for pharmaceutical categories. Table 2. 26 prescribed disposal and treatment methods suitable for all possible categories of medical waste

Table 2. 24 Summary of Disposal Methods in and after Emergencies

Disposal methods	Types of pharmaceutical	Comments
Return to donor or manufacturer, transfrontier transfer for disposal	All bulk waste pharmaceuticals, particularly antineoplastics.	Usually not practical - transfrontier procedures may be time consuming.
High temperature incineration with temperatures greatly in excess of 1200°C	Solids, semisolids, powders, antineoplastics, controlled substances.	Expensive.
Medium temperature incineration with two-chamber incinerator with minimum temperature of 850°C. Cement kiln incineration	In the absence of high temperature incinerators, solids, semi-solids, powders. Controlled substances.	Antineoplastics best incinerated at high temperature.
Immobilization Waste encapsulation	Solids, semi-solids, powders, liquids, antineoplastics, controlled substances.	
Inertization	Solids, semi-solids, powders, antineoplastics, controlled substances.	
Landfill Highly engineered sanitary landfill	Limited quantities of untreated solids, semi-solids and powders. Disposal of waste pharmaceuticals after immobilization preferable. PVC plastics.	
Engineered landfill	Waste solids, semi-solids and powders, preferably after immobilization. PVC plastics.	
Open uncontrolled non-engineered dump	As last resort untreated solids, semi-solids, powders - must be covered immediately with municipal waste. Immobilization of solids, semi-solids, powders is preferable.	Not for untreated controlled substances.
Sewer	Diluted liquids, syrups, intravenous fluids, small quantities of diluted disinfectants (supervised).	Antineoplastics, and undiluted disinfectants and antiseptics not recommended.
Fast-flowing watercourse	Diluted liquids, syrups, intravenous fluids; small quantities of diluted disinfectants (supervised).	Antineoplastics, and undiluted disinfectants and antiseptics not recommended.
Burning in open containers	As last resort, packaging, paper, cardboard.	Not acceptable for PVC plastics or pharmaceuticals.
Chemical decomposition	Not recommended unless special chemical expertise and materials available.	Not practical for quantities over 50 kg.

Source: WHO, 1999a.

Table 2. 25 Summary of Pharmaceutical Categories and Disposal Methods in and after Emergencies

Category	Disposal methods	Comments
Solids	Landfill	No more than 1% of the daily municipal waste should be disposed of daily in an untreated form (non-immobilized) to a landfill.
Semi-solids	Waste encapsulation, Waste inertization	
Powders	Medium and high temperature incineration (cement kiln incinerator)	
Liquids	Sewer- High temperature incineration	Antineoplastics not to sewer.
Ampoules	Crush ampoules and flush diluted fluid to Sewer	Antineoplastics not to sewer.
Anti-infective drugs	Waste encapsulation Waste inertization Medium and high temperature incineration (cement kiln incinerator)	Liquid antibiotics may be diluted with water, left to stand for several weeks and discharged to a sewer.
Anti-neoplastics	Return to donor or manufacturer Waste encapsulation Waste inertization Medium and high temperature incineration (cement kiln incinerator) chemical decomposition	Not to landfill unless encapsulated. Not to sewer. No medium temperature incineration.
Controlled drugs	Waste encapsulation Waste inertization Medium and high temperature incineration (cement kiln incinerator)	Not to landfill unless encapsulated.
Aerosol canisters	Landfill Waste encapsulation	Not to be burnt: may explode.
Disinfectants	Use to sewer or fast-flowing watercourse: small quantities of diluted disinfectants (max. 50 litres per day under supervision)	No undiluted disinfectants to sewers or water courses. Maximum 50 litres per day diluted to sewer or fast-flowing watercourse. No disinfectants at all to slow moving or stagnant watercourses.
PVC plastic, glass	Landfill	Not for burning in open containers.
Paper, cardboard	Recycle, burn, landfill	

Source WHO, 1999a

Table 2. 26 Overview of Disposal and Treatment Methods Suitable for Different Categories of Medical Waste

Technology or method	Infectious waste	Anatomical waste	Sharps	Pharmaceutical waste	Cytotoxic waste	Chemical waste	Radioactive waste
Rotary kiln	Yes	Yes	Yes	Yes	Yes	Yes	Low-level infectious waste
Pyrolytic incinerator	Yes	Yes	Yes	Small quantities	No	Small quantities	Low-level infectious waste
Single-chamber incinerator	Yes	Yes	Yes	No	No	No	Low-level infectious waste
Drum or brick incinerator	Yes	Yes	Yes	No	No	No	No
Chemical disinfection	Yes	No	Yes	No	No	No	No
Wet thermal treatment	Yes	No	Yes	No	No	No	No
Microwave irradiation	Yes	No	Yes	No	No	No	No
Encapsulation	No	No	Yes	Yes	Small quantities	Small quantities	No
Safe burial on hospital premises	Yes	Yes	Yes	Small quantities	No	Small quantities	No
Sanitary landfill	Yes	No	No	Small quantities	No	No	No
Discharge to sewer	No	No	No	Small quantities	No	No	Low-level liquid waste
Inertization	No	No	No	Yes	Yes	No	No
Other methods				Return expired drugs to supplier	Return expired drugs to supplier	Return unused chemicals to supplier	Decay by storage

Source: WHO, 1999b.

2.5.2.2 Assessment

It has been found that, a variety of technologies have been developed for the storage, collection, treatment and disposal of medical wastes particularly for those wastes generated in industrialized countries. Several types of treatment and disposal processes have been applied (incineration, micro waving, chemical treatment, melting etc.), with varying degrees of safety, cost and impact on the environment. None of the available low-cost treatment devices (*i.e.* below US\$ 500) are however safe and environmentally friendly. As WHO (2000_b) mentioned that, in developing countries, a trade-off has to be made between direct health risks from absence of waste management leading to reuse of syringes, and indirect health risks created by environmental pollution (*e.g.* by production of dioxins from inadequate incineration). Progress could be made in waste minimization practices, in

particular in the development of materials and products leading to less waste, or less harmful waste when disposed off.

Nevertheless, IRPTC (1985) reported that landfilling has a striking advantage of low immediate cost and if the site is well-managed, after closure the long term cost can also be kept reasonable. Schmidt & Schmidt (1994) have noted that medical waste incineration is questionable, from the stand point of the resulting toxic emissions and ash residues, Sangodoyin and Agbawhe (1992) had suggested that the sanitary landfill could easily and properly take care of these. Sanitary landfills have found popular application for disposal of waste containing high proportions of hazardous substances from different literature (Coker, et al, 1998; Sangodoyin and Agbawhe, 1992; Schmidt & Schmidt, 1994)

These alternatives have been developed to meet the economic and environmental demands of society-. All represent different approaches to addressing the need for safe disposal of medical waste and mane seek to eliminate dioxin, mercury and other toxic emissions which impact our environment. But alternative technology development is just beginning. It needs to be implemented more widely and promoted through regulation and legislation. Despite the continued release of dioxin from medical waste incinerators, most hospitals continue to rely on them unless alternatives are provided. Therefore, without the implementation of new regulations concerning the emission standards of these medical waste incinerators, dioxin and mercury will continue to harm the environment.

Tables 2.27 and 2.28 give overview of the various technologies used for the treatment and final disposal of different categories of medical wastes. Advantages and/or disadvantages with suitable condition and influencing parameters have been discussed along with the selected technology. Information on various technologies may help to select a specific technology for each type of waste and/or each country that is suitable considering the socio-economic and environmental condition of that country.

Table 2.27 Technologies for Treatment and Final Disposal

Technology	Description	Advantages	Disadvantages	Suitable condition
Incineration	A high temperature dry oxidation process that reduces organic and combustible waste to inorganic matter. Many different types of incinerator ranging from the sophisticated to the basic; however, basic incinerators often cause serious emissions problems.	Requires no pre-treatment. Good disinfection efficiency.	If not operated effectively may pollute atmosphere High capital and operational costs. Low cost incineration is possible by using a drum or brick incinerator, however, these present large emission problems and are not as effective in the destruction of hazards.	>60% combustible Moisture content < 30%. Not suitable for pressurised gas canisters, reactive chemical waste, PVC, wastes with high heavy metal content, photographic or radiography wastes.
Chemical disinfection	Chemicals added to the waste to kill/inactivate the pathogens. Shredding is usually necessary before disinfection, as only the surface of intact solid waste will be treated. The waste is then disposed of in a conventional way, e.g. landfill.	Efficient disinfection when operated well. Some chemical disinfectants are low cost. Shredding reduces volume of waste.	Disinfectants may themselves be hazardous to operators & pose risks in the case of leakage and subsequent disposal. Needs highly trained operators. Shredder liable to mechanical failure.	Best for liquid or sewage Inadequate for pharmaceutical, chemical and some types of infectious waste.
Render inert	Mixing the waste with cement in order to prevent migration of toxic substances from waste into ground water etc.	Relatively low cost. Low-technology	Bulky and heavy final waste product to be disposed of.	Especially suitable for pharmaceuticals. Not suitable for infectious waste.
Wet thermal treatment (inc. autoclaving)	Exposure of shredded waste to high temperature, high-pressure steam. If temperature and contact time is sufficient, most micro-organisms are inactivated. Waste can subsequently be disposed of as municipal waste.	Relatively low capital and operating costs. Low environmental impact.	Shredder liable to mechanical failure. Efficiency of disinfection very sensitive to operational conditions.	Not suitable for anatomical, pharmaceutical or chemical wastes.
Microwave irradiation	Waste shredded, humidified and then irradiated by microwaves. The heat generated destroys micro-organisms.	Very efficient disinfection when operated well. Environmentally sound. Reduction in volume of waste.	Relatively high capital and operating costs. Potential operation and maintenance problems.	Not suitable for pharmaceutical or chemical wastes Not suitable for large metal objects.
Landfill (Sanitary)	Landfill isolates waste from the environment; it requires appropriate engineering preparation, staff to control operations, organized deposition and covering of waste. Waste may be pre-treated (see above). Ideally, healthcare waste is separated from municipal waste.	Simple, low cost & safe when operated properly.	If not operated properly scavengers may access the waste and it may cause pollution of environment etc.	Generally suitable
(Encapsulate)	Pre-treatment involving filling containers with waste, adding an immobilizing material and sealing the container e.g. bituminous sand, cement mortar.	Preventing access to IIC waste by scavengers. Relatively simple, low cost & safe	Not recommended as sole method for non-sharp infectious waste. Bulky and heavy final waste product to be disposed of.	Appropriate for establishments using minimal programs for disposal of sharps, chemical or pharmaceutical residue.

Source: Appleton and Ali, 2000.

Table 2.28 Hazardous Medical Waste Treatment Techniques

Parameters influencing Incineration	Advantages of Incineration	Disadvantages of Incineration
• Turbulence and mixing • Moisture content of waste • Filling of combustion chamber • Temperature and residence time • Maintenance and repair	• Reduction of waste volume, weight • Ability to make waste unrecognizable • Acceptability for all waste types • Heat recovery potential	• Public opposition • High investment, operation cost • Formation of dioxins and furans • High maintenance, testing and repair costs • Vulnerability to future restrictive emissions laws
Parameters influencing Steam Autoclave Disinfection	Advantages of Steam Autoclave Disinfection	Disadvantages of Steam Autoclave Disinfection
• Temperature and pressure • Steam penetration • Size of waste load • Length of treatment cycle • Chamber air removal	• Low investment cost • Low operation costs • Ease of biological testing • Creation of residue that is less hazardous than for incineration	• Inability to change waste appearance • Inability to change waste volume • Lack of suitability for some waste types • Production of uncharacterized air emissions
Parameters influencing Microwave Disinfection	Advantages of Microwave Disinfection	Disadvantages of Microwave Disinfection
• Waste characteristics • Moisture content of waste • Microwave source strength • Duration of microwave exposure • Extent of waste mixture	• Ability to make waste unrecognizable • Significant volume reduction • Absence of liquid discharges	• High investment cost • Increased waste weight • Lack of suitability for some waste types • Potential to expose workers to contaminated shredder • Production of uncharacterized air emissions
Parameters influencing Mechanical/Chemical Disinfection	Advantages of Mechanical/Chemical Disinfection	Disadvantages of Mechanical/Chemical Disinfection
• Chemical concentration, treatment, pH • Contact time with chemical • Waste and chemical mixing • Recirculation versus flow-through	• Significant waste volume reduction • Ability to make waste unrecognizable • Rapid processing • Waste deodorization	• High investment cost • Lack of suitability for some waste types • Production of uncharacterized air emissions • Need for chemical storage and use

Source: WHO, 1999

CHAPTER 3

Methodology

3.1 Three Phases of Research

The primary goal of this research is to formulate appropriate environmental management options of the medical waste for developing countries. The purpose is to improve the health condition of the people and environmental quality of developing country with special emphasis to Bangladesh

The study plan is categorized in to three phases. Phase one cover objective 1. Phase two cover objective 2, 3 and phase three cover objective 4.

Phase I: Background and current status

- To develop an inventory of medical waste generation in different countries- this was done by literature review and using secondary data source.
- Review of existing medical waste management and disposal practices and point source identification- using secondary data sources, field investigation, interview and questionnaire survey served this propose.
- Institutional involvement and state of legal aspects of medical waste management in Bangladesh and Thailand
- Review of HWM and legal aspect in developed/industrialized countries
- Available existing MW treatment technologies in literature

Phase II: Assessment (Management, Environment and Health)

- Screen most critical wastes based on its, disposal practices, amount produced
- Awareness level of people involved in medical waste issue at all level of management
- Overview and experience on status of medical waste management practices in both countries
- Available treatment technology in practice
- Assessment of environmental and health effects related to medical waste disposal and handling
- Laboratory analysis of waste to perceive the potential risk of improper disposal of medical waste
- Comparison of MWM in both countries
- Identified and congregate the lessons learned from different stages and activities of hospitals and projects in both countries on MWM

Phase III: Mitigation option

- Identification of weaknesses of current medical waste management system in Bangladesh and Thailand

- Find possible appropriate management and technical options for both countries
- Proposed mitigation measure with an action plan (Appropriate technological option with action plan for developing country) which would be cost effective as well as suitable for Bangladesh

Research methods with objectives are summarized in the Table 3.1.

3.2 Target Group of the Study

Study was done with the involvement of hospital management authority/administrator, divisional head/director, senior personnel of the hospital or clinics, doctors, nurses and workers related to medical waste handling and disposal, waste pickers and inhabitants around the vicinity. To review the institutional involvement, national policy, legal status, existing practices, and their understanding/ awareness about the issue of Medical waste management Ministry of Public Health, Metropolitan Administration, City corporation, Department of Environment, Directorate General of Health officials, Bangladesh Medical Association member were interviewed.

3.3 Study Design

3.3.1 Study Focus

Study mainly focused on:

- Waste inventory in different facility including 'end of pipe' waste (solid waste only)
- Emphasis on Infectious waste
- Existing waste management practices in study place (Bangladesh and Thailand)
- Policy, regulation, legislation related to Medical waste management in Bangladesh, Thailand and few examples from industrialized countries
- Public health and environmental aspects of waste handling (garbage dwellers, workers, officials, local residents)
- Public nuisance impacts
- Available treatment technology of medical waste with its advantages and disadvantages
- Treatment technologies practiced in both countries
- Possible waste reduction initiatives
- Waste picking, re-use, re-cycling
- Weaknesses of management system in both countries
- Appropriate management options for Bangladesh and Thailand

3.3.2 Research Design

Three broad categories of the design are i. Background and review, ii. Sampling and data collection, and iii. Recommendation and action plan. These are elaborated in Figure 3.1. Background and review covers preliminary study, review and study of institutes involved in medical waste management, government and private organization, and companies all are

under this section. Main part of the research is under second category 'sampling and data collection'. Based on these two categories 'recommendation and action plan' is formulated.

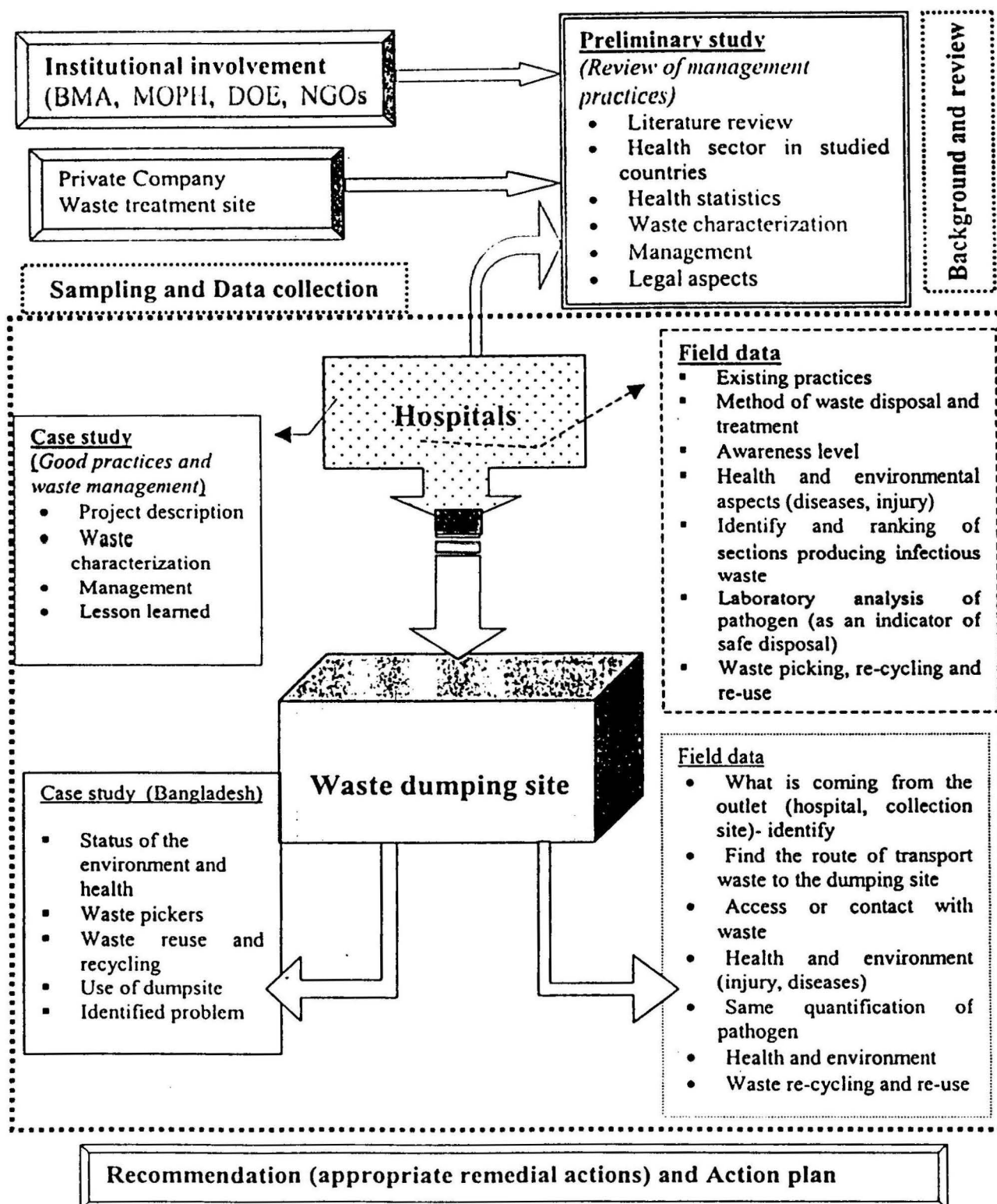


Figure 3.1 Research Design Flow Chart

Table 3.1 Summary Table of Research Method

Objective	Phase	Output	Method of experiment /data collection
1. Review the current status of Medical waste management	Phase I: Background and current status Inventory of medical waste generation in different countries Existing management practices and point source identification Institutional involvement and state of legal aspects Review of HWM and legal aspect Available technologies	- Quantity and quality of waste - Service and resources - Practices - Legal aspects, regulations, guidelines - Information from developed countries - Existing treatment technology	- literature review - secondary data - interview - field investigation - questionnaire survey - discussion
2. Compare the management techniques and practices in Thailand and Bangladesh	Phase II: Assessment (Management, Environment and Health) Screen most critical wastes Awareness level State of management practices Technology in practice Assessment of environmental and health effects Laboratory analysis of waste Comparison of MWM The lessons learned on MWM from both countries	- IW sources - Awareness level - Management and technology in practice - Health and environmental assessment - Good and bad practices - Pathogen analysis - Lesson from both countries	- literature review - secondary data - interview - field investigation - questionnaire survey - laboratory analysis - discussion - observation - case studies
3. Determine the effectiveness of infectious waste handling and disposal by testing pathogens.			
4. Recommend appropriate management options for medical waste, in developing country specifically in Thailand and Bangladesh	Phase III: Mitigation option Identified weaknesses of management system Possible appropriate management and technical options Proposed mitigation measure with an action plan	- Conclusion with identified weaknesses - Recommendation - Possible mitigation options - Action plan	Based on information collected and analysis in Phase I and II and with the help of reference literature this section was formulated

3.3.3 Sampling and Data Collection Design

Sampling procedure and data collection techniques are outlined in the following Figure 3.2. This figure showed the selection of study sites and hospitals. It also elaborated what kind of research approach applied for each section and who was involved with.

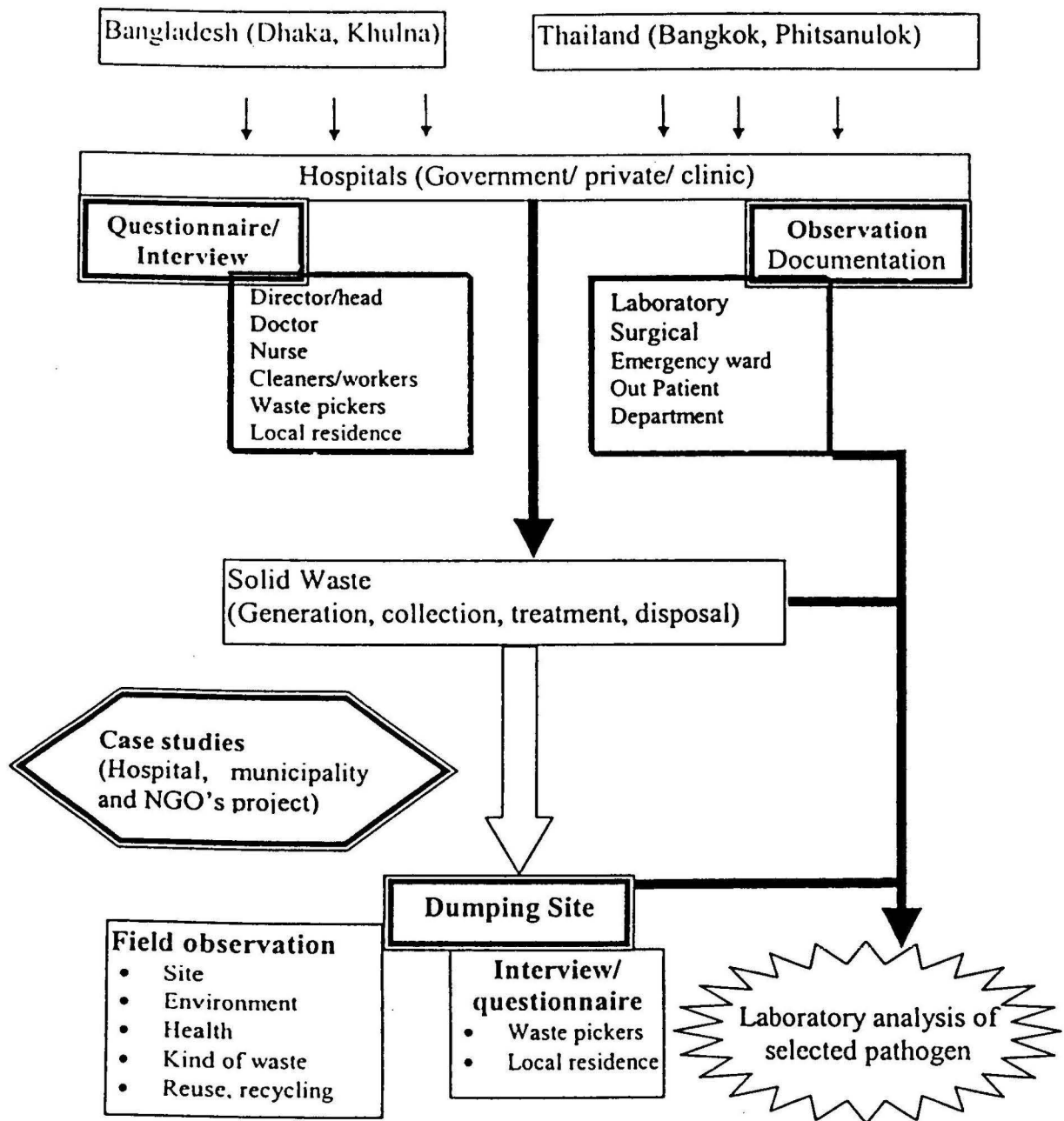


Figure 3.2 Sampling and Data Collection Design Flow Chart

3.4 Study Site Description

Dhaka and Khulna City of Bangladesh, and Bangkok Metropolitan Administrative area, Phitsanulok province of Thailand were selected for this research.

3.4.1 Hospital Selection for This Study

Hospitals were selected as large, medium, and small category considering service, number of beds and management. Different medical has different types of activities or services. Investigation area was concentrated on OPD (out patient department), Laboratory, Delivery, Surgical, Contagious disease section, normal medical ward, cabin, and waste disposal site.

Bangladesh

Study was conducted in two big cities of Bangladesh name Dhaka and Khulna. Dhaka is the capital city of Bangladesh and Khulna is the port city at southwest part of Bangladesh. There are 26 government hospitals and foundations, 133 private hospitals and clinics, and 318 diagnostic centers in Dhaka City. There are 248 health facilities in Khulna City of which 21 hospital and clinics, 12 diagnostic centers, and others are maternity center, EPI center and OPD. Except 21 hospital and clinics none has inpatient system or beds.

All together 14 hospital, clinics and diagnostic centers from Dhaka City and 7 hospital, clinics and diagnostic center from Khulna City were selected for this study (Table 3.2). Detailed are given in the appendix 1.

Table 3.2 Name of Selected Hospitals and Clinics from Bangladesh

Name of selected hospital from Dhaka	Name of selected hospital from Khulna
1. Institute of Post Graduate Medicine Research (IPGMR)	1. Khulna Medical College and Hospital
2. Dhaka Medical College Hospital (DMCH)	2. Surgical Hospital, Khulna
3. Sir Salimullah Medical Collage Hospital (SSMCH)	3. Garib Newaz Clinic, Khulna
4. Infectious Disease Hospital	4. Islami Bank Hospital, Khulna
5. National Medical Institute and Hospital	5. Pangu Hospital, Khulna
6. Ibnesina Diagnostic Center	6. Mahanagar Diagnostic Center
7. Modern Clinic	7. Bashundhara diagnostic Center
8. Medinova Diagnostic Center	
9. Holly Family	
10. Popular Diagnostic Center	
11. Delta Medical Center and Clinic	
12. Institute of Child and Mother Health (ICMH)	
13. International Center for Diarrhoeal Disease Research, Bangladesh (ICDDR,B)	
14. Combined Military Hospital (CMH)	

**. No 1-7 hospitals and centers from Dhaka were selected for questionnaire survey, including these 7 hospitals and centers all others were selected for interview and field investigation as well.*

At Dhaka four Government hospitals from different categories (these hospitals are covering 2350 beds i.e. 61% of total government hospital beds in Dhaka), one private

hospital (national institute & hospital), two private clinics and two diagnostic centers were selected to represent each categories for this study. These cover about 30% beds of total beds in Dhaka City. Selected government hospitals represent the management system of the country, as these hospitals are considered as qualifying hospitals in Bangladesh. Those hospitals were selected for the **questionnaire survey, interview, waste sampling, and field observation**. In addition to these, one health institute, one international research center, one military hospital, one clinic, and one diagnostic center from Dhaka city and four private hospital and clinics, 2 diagnostic center and one government district hospital from Khulna were selected for **interview and field observation**.

At Khulna total bed number in those 21 hospitals and clinics were around 806 of which 62% (500 beds) is belongs to 3 big hospital (one district and 2 private hospital). From these 3 hospital 2 hospitals covering 70% (350 beds) of 62% were selected for this study. Other 3 private clinics were selected from remaining 38% bed which was around 42% (130 beds) of that 38%. Therefore, total coverage for this study was 78% whole beds present in Khulna City. Prodipan (an NGO) at Khulna City and ICMH and ICDDR,B from Dhaka were selected for **case study of hospital waste management**. Selected two cities are shown in the location map of Bangladesh (Figure 3.3). Two study cities namely Dhaka and Khulna are highlighted in the figure with circle around the name.

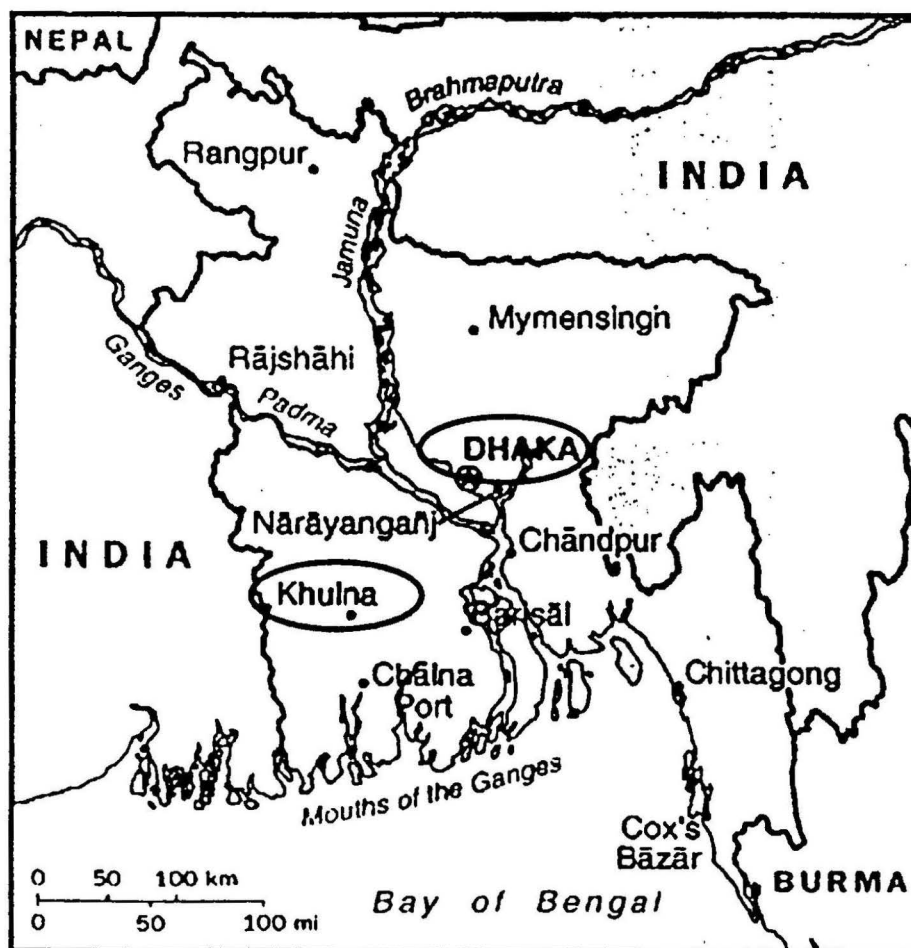


Figure 3. 3 Location Map of Study Site in Bangladesh (encircled)

Source: www.odci.gov/cia/publications/factbook/

Thailand

A total of 3,774 hospitals or medical service centers in Bangkok metropolitan area. Out of this only 361 hospitals and health service center have bed and 2744 health centers or clinics do not have inpatient system or bed. Out of 37 government hospital in Bangkok only one top most hospital and out of 143 private hospitals two private hospitals could be selected from Bangkok for the study.

There are nine government hospitals with 1270 beds under Ministry of Public Health in the province and seven private hospitals with 820 beds located only in the municipality. Buddhachinnarat government hospital is the central hospital in south part of northern Thailand. Other then this 3 military hospitals with 175 bed also in this province. A total of 189 clinics are in this province of which 115 are located in the Muang district only (appendix 2 a,b,c). It is noted that there is no bed in these private clinics. Out of these a total of 9 hospital and clinics from Phitsanulok (3 private, one central medical college and hospital, military hospital, 2 community hospital from other 2 district, and 2 clinics (no bed), public health service office were investigated for this study (Table 3.3). Both of the study area was selected for **interview, field observation, and discussion**. Moreover, Phitsanulok province and Bumrungrad hospital at Bangkok were selected for **case study**.

Table 3.3 Name of Selected Hospitals and Clinics from Thailand

Name of the hospital visited in Bangkok	Name of the hospital visited in Phitsanulok
Rajavithi Hospital	Pitsanuvej hospital:
Bamrungard hospital	Phun-lop Clinic:
Bangkok Nursing home	Noree & Sanit Clinic
	Ruampaet Hospital
	Buddhachinarat Hospital
	Wangthong Community Hospital
	Bangkratum Community Hospital
	Ratanevej Hospital
	Military hospital
	Public health service office
	Municipality

Two study areas are indicated in the location map of Thailand (Figure 3.4). Bangkok city and Phitsanulok province are shown in the figure with circle.

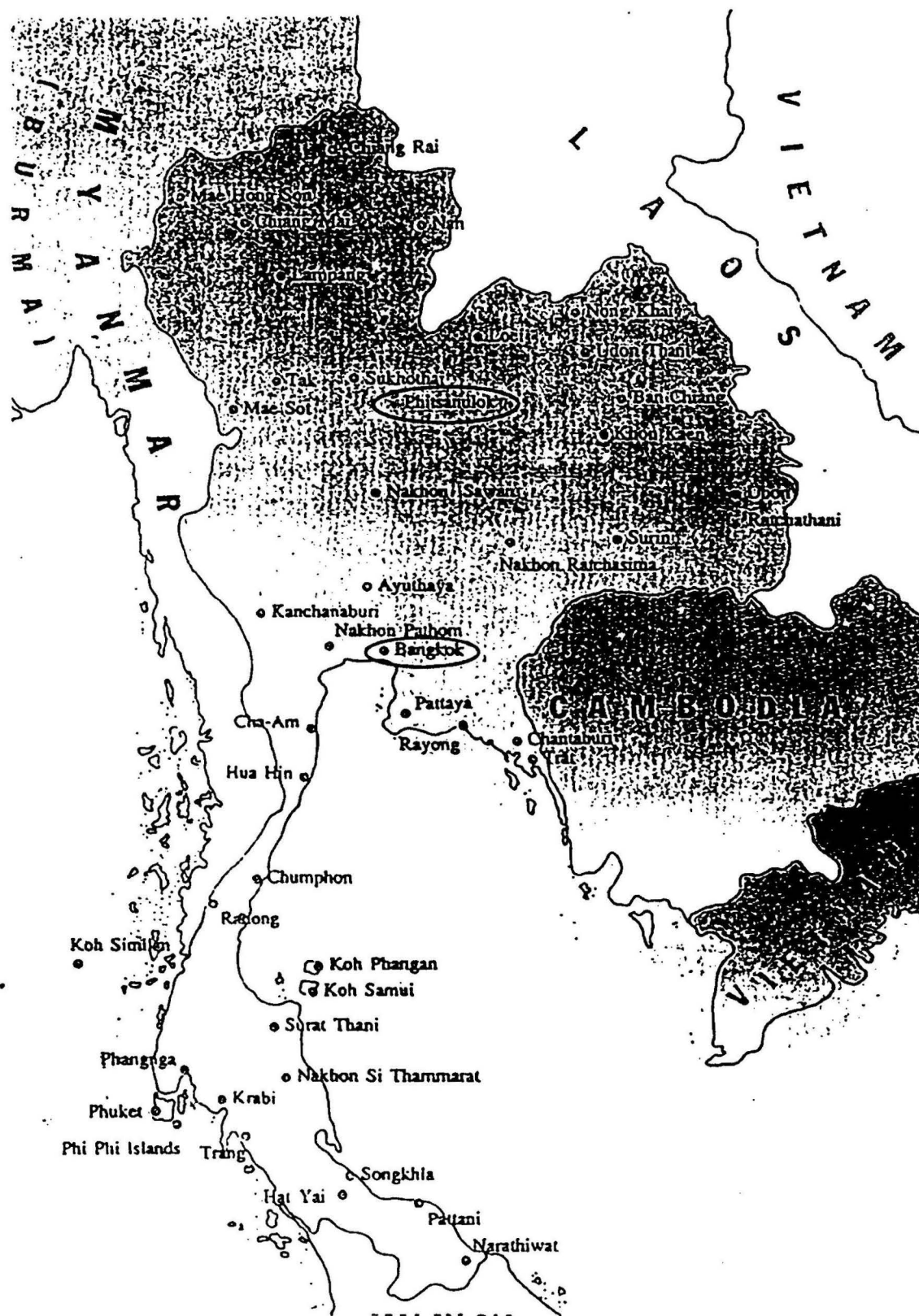


Figure 3.4 Location Map of Study Site in Thailand (encircled)

Source: www.odci.gov/cia/publications/factbook/

3.4.2 Dumping Site Selection

There were 3 dumpsites in Bangladesh (2 from Dhaka, one from Khulna) and 2 dumpsites in Thailand (one from Bangkok and one from Phitsanulok) were selected for this study.

In Bangladesh: City corporation's landfill sites/ dumpsite at Kamalapur and Matuail at Dhaka and municipal dumping site at Khulna was selected.

In Thailand: Corporation's landfill site Onnut at Bangkok and municipal dumping sites at Phitsanulok were selected

3.4.3 Disposal and Treatment Company

In Bangkok there is one private company under BMA responsible for infectious waste collection and disposal. This private company was selected for this study. In case of Bangladesh municipal authority handles all kind of wastes. Dhaka City Corporation is responsible for waste collection and disposal. Few hospitals have their own incinerator to burn infectious waste. Two of those were selected for the study namely ICDDR,B and Institute of child and Mother Health (ICMH). One NGO name Prodipan was selected as they collect and treat clinical waste in Khulna City in Bangladesh.

3.5 Case Studies

Case studies were to see the good practices of waste management and disposal in both country and draw references from those examples. A checklist was used covering different aspects of hospital waste management and treatment for this purpose. Case study includes interviewing divisional head, unit in-charge, doctors, and nurses; discussion with the group of doctors, nurses, working staff and waste handlers; field observation inside different section of hospitals, disposal practices, disposal site and treatment facility. The checklist and questionnaire used in other sections were also used for case studies.

Bangladesh

One local NGO at Khulna city name Prodipan (working in a pilot scale clinical waste management for some selected hospitals and clinic), one child and mother health institute (ICMH) at Matuail, Dhaka and one international research center (ICDDR,B) at Dhaka were visited and chosen for the case study. NGO Prodipan was selected as an example for a city and two others were selected for individual management.

Thailand

Phitsanulok municipal solid waste management project at Phitsanulok province was selected as a good example of hospital waste management in Thailand. Besides, one private hospital in Bangkok name Bumrungrad was also selected to see the management in individual level.

3.6 Field Survey and Data Collection

Data were collected from January 2000 to March 2001. The collection of data was occurred by a four pronged approach through a (i) Secondary data, (ii) field observations, (iii) interviews and questionnaire survey, and (iv) laboratory analysis.

3.6.1 Secondary Data Source

Secondary data/information were collected through literature review and as well as reports published from different institutes and register or log book of the hospitals and institutes.

Medical waste management practices of developed country; waste treatment technologies; rules, regulations and guidelines were collected by literature review. Relevant libraries were consulted for this purposes.

Information and secondary data were collected from

- Bangladesh: Ministry of Health and Family Planning, Directorate General of Health, Department of Environment, Dhaka and Khulna City Corporation, NGOs involved with waste disposal in Bangladesh.
- Thailand: Bangkok Metropolitan Administration office, district office, Ministry of public health, Department of Environment, waste treatment company in Thailand (Khrunthep Thanakom), Pollution control department, Ministry of Science, Technology and Environment (MOSTE).

Secondary information covered:

- Current practices and status in developed/industrialized countries
- Institutional involvement
- Quantity and quality of waste generated in both countries
- Legal status of Medical waste management both developed and developing countries
- Existing guidelines, policies, training manual on this issue
- Health and environmental aspects of Medical waste
- Any earlier study related to the issue of Medical waste management
- Available technologies and advantages/ disadvantages of those technologies

Checklist for secondary information is appended in **appendix 3**.

3.6.2 Field observations

Field observations were made in each location of both countries i.e. each hospital and clinics, dumpsite using a checklist (Appendix 4) that focused on potential problems posed by disposal of medical waste. Waste generation sites like wards, laboratories and waste disposal sites like waste disposal bins and dumping sites were observed. Main emphasis was given to the waste generation and disposal practice and waste disposal sites. Field observation were done using a checklist that cover waste generation and handling done inside hospital (store, OPD, patient ward, OT, pathological laboratory, kitchen), outside hospital (own dustbin and/or municipal bins in hospital premises, and road side). Observation also covered the behavior or attitude of doctors, nurses, and waste handlers (cleaners, ward boy) on the issue of waste generation and handling.

3.6.3 Interview and questionnaire survey

Interviews were conducted with the involvement of hospital management authority/administrator, divisional head/ director, senior personnel of the hospital or clinics including doctor and nurses. Director or responsible personnel in Ministry of Public Health, Metropolitan Administration, City corporation Mayor, adviser and conservancy officer, director and personnel responsible for the issue of waste management in Department of Environment, Directorate General of Health officials and director, Bangladesh Medical Association member, and personnel of NGOs dealing with waste disposal were interviewed. A checklist covering the institutional involvement or their role on this issue, national or institutional policy, legal status, existing practices, and their

understanding/ awareness about the issues of hospital waste management etc were used for the interview. Questionnaire used for hospital authorities are in appendix 5. Interviews were done in both Bangladesh and Thailand.

Questionnaire survey was conducted with people involved in providing medical services and handling and disposing medical waste. This was done only in Bangladesh. Different sets of semi structured questionnaire were used for different level of respondents. The respondents included doctors, nurses, lab assistants, cleaners and waste pickers and people around the area. The main purpose of the exercise was to assess the level of knowledge of awareness about the adverse implication of improper disposal of waste, knowledge, skill necessary for handling wastes properly and also for identifying the factors which limit proper disposal of medical wastes in Bangladesh. A statistically viable sample of respondents for survey were determined by using the following statistical formula (..i). The respondents of different categories were selected randomly.

Having a wide range of viewpoints allows for a complete picture of the issue. The questionnaire (Appendix 6) were designed and modified depending on the respondents understanding. Generally questions were geared towards the basic understanding of the respondents.

$$n = \frac{Nz^2 p(1-P)}{Nd^2 + z^2 p(1-P)} \dots\dots\dots (i)$$

When,

n = Sample size to be calculated

N = Total staff 4313

z = Confidence interval at 90%, i.e., 1.645.

p = Estimated population proportion (0.5, this maximizes the sample size)

d = Error limit of 5% (0.05).

Application of the above formula with the values specified, which in fact maximizes the sample size, yielded a total required sample of 255 considering all hospital staff as a universe/population which is 4313. This is distributed among doctors, nurses and others in the proportion as they appear in the population (Table 3.4). The collected sample size is 385 persons comprising of 55 doctors, 155 nurses and 179 others. Assuming 50% reserve (from non-response and missing staff) from the required sample size giving 383 as requirement (255 * 1.5 = 383 persons).

Table 3.4 Sample size of the interviewed hospital staff

Category of hospital staff	Total staff	Required sample size	Sampled no of staff
Doctor	616	36	55
Nurse	1653	98	155
Others (MLSS)	2044	121	179
Grand Total	4313	255	385

In addition to these 117 waste pickers/local residence and 100 waste pickers and local residence from municipal dumping site were surveyed for this study. Most of the doctors interviewed had professional experiences of 6-10 years, while most nurses interviewed

have 11 to 20 years of working experience. Most cleaners have been working for 1 to 14 years in their current jobs, while the most waste-pickers are picking waste for 1-6 years.

3.6.4 Laboratory Analysis of Medical and Municipal Waste

Solid waste and leachate from different section of hospitals, waste disposal bins, disposal sites and dumping sites were collected for pathological (microbial) analysis. Total coliform, faecal coliform, faecal streptococci, *Vibrio* spp, *Salmonella* spp, and *Shigella* spp. were analyzed using the standard methods as adopted by environment and microbiology laboratory of ICDDR,B (International Center for Diarrhoeal Disease Research, Bangladesh) shown in the Table 3.5.

Samples were collected in July 2000 and March 2001. Details of sampling site are given in the appendix 7. Sample were collected according ICDDR,B prescribed technique. Collected samples were kept in dark place and transferred to the laboratory within 5-6 hours. Solid samples were collected in polythene bag and leachate was collected in plastic bottle.

Table 3.5 Methods used for Pathogen Analysis

Pathogen	unit	Method/ref
Total coliform	No/100ml or gm	standard methods adopted by environment and microbiology laboratory of ICDDR,B
Faecal coliform	No/100ml or gm	
Faecal streptococci	No/100ml or gm	
<i>Vibrio</i> spp	No/100ml or gm	
<i>Salmonella</i> spp.	No/100ml or gm	
<i>Shigella</i> spp.	No/100ml or gm	

To select pathogen in hospital waste and relate to human disease is not a simple procedure. It requires, in fact, that all of the steps in the pathway from solid waste to human affliction be validated by unequivocal measures. This validation depends on the following points discussed by Hanks (1967) to show the solid waste/ disease relationships. It was applied in selecting pathogen in hospital waste and to identify them for this study.

1. Discovery of infectious agents or pathogen in the hospital waste, or,
2. Demonstration that such agents develop within, or in association with, the wastes
 - Done by laboratory analysis of waste from hospital, dustbin and dump site
3. Discovery of diseases or other effects among the population which may reasonably be associated with these agents/pathogen;
 - Done by interview and epidemiological study
4. Demonstration of the pathways by which the effects are accomplished;
 - Find the route of waste disposal, transport, and lifetime of microbes and waste treatment efficiency
5. Demonstration of the absence of effects following interruption of these pathways by one means or another or their absence in populations not similarly exposed.
 - This could be done by selecting a control site (waste dumping site but no Medical waste is dumped) along with experimental site. Unfortunately there was no control site in Bangladesh since all kind of solid wastes were dumped in a common dumping site.

The process flow chart of pathogen analysis in Medical waste is given in the following Figure 3.5.

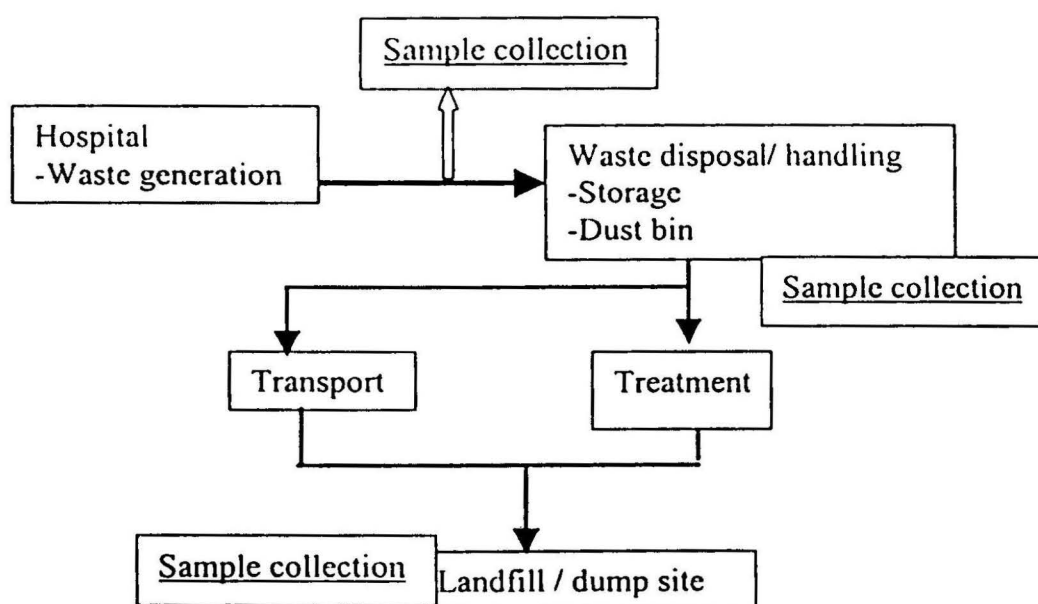


Figure 3.5 Waste Flow Chart and Sample Collection for Selected Pathogen Analysis

Those selected pathogens were analyzed from each step of waste flow chart. Infectious waste and other Medical waste and solid waste from dumpsite will be analyzed for different pathogen. Though viral infection is an important issue for Medical waste, but it would be difficult to identify or test it with this limited scope. Considering the availability of laboratory facilities, few-selected bacterial pathogens were selected for this study.

3.7 Data Analysis and Interpretation

Qualitative and quantitative data analysis were done. Mostly qualitative analysis was done for this study using information from interview, field observation, and investigation. Quantitative analysis was done only for questionnaire survey data and laboratory analysis.

Simple statistical analyses (frequency analysis, cross tab) were done for quantitative analysis of data. SPSS computer statistical package was used for the analysis.

Epidemiological approach was used for health assessment data collection and interpretation. Environmental and health impact of Medical waste was tried to identify using this approach.

Cross checking were done for health data: checking health evidence of potential problem associated with environmental exposure and occupation (interview, diagnosis, and analysis of waste sample from the site etc.).

3.8 Outline of Methodology

The following Figure 3.6 summarizes the overall metrology for this research.

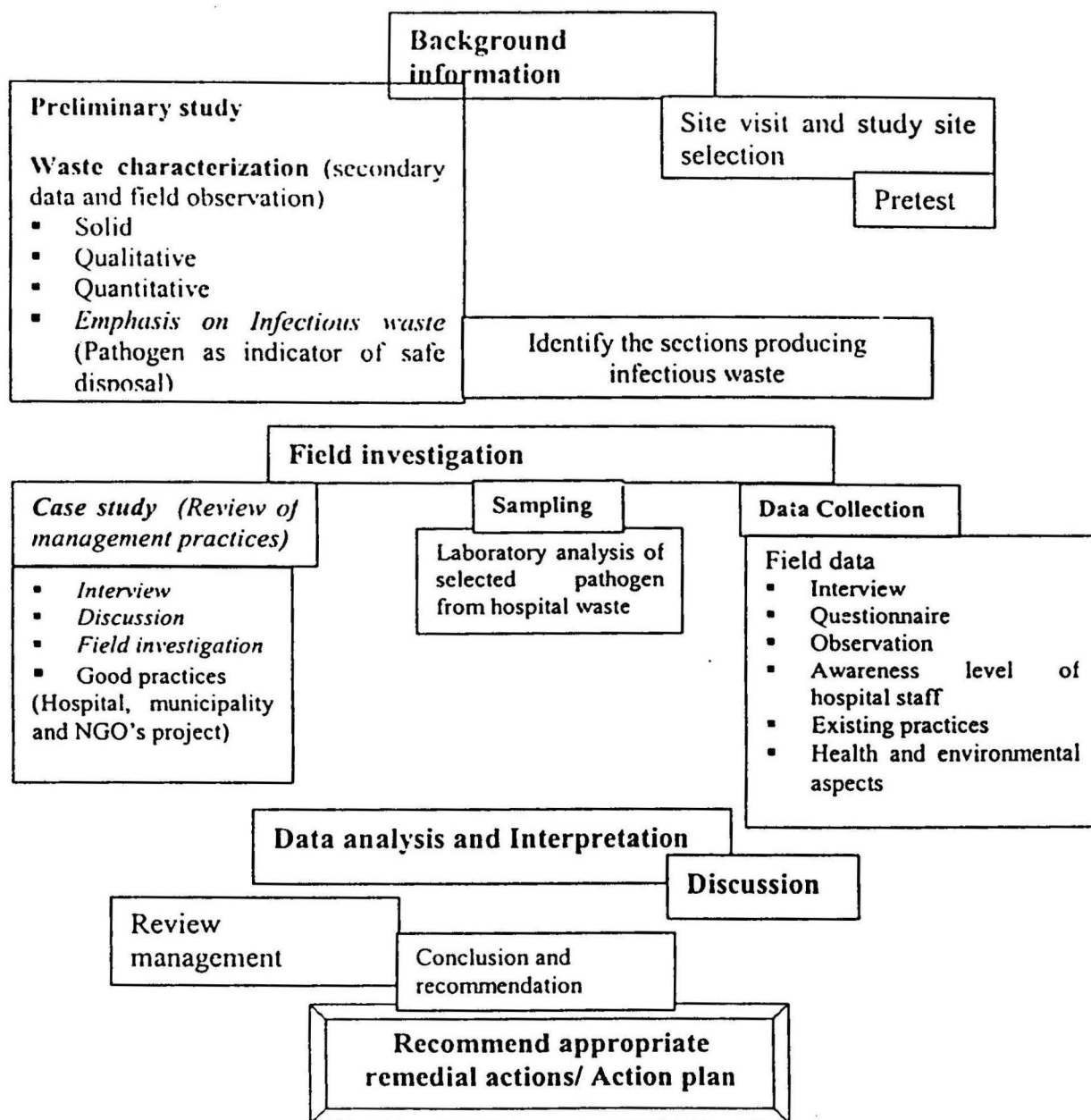


Figure 3.6 Outline of Methodology

CHAPTER 4

Organization of Medical Waste Management Situation in Bangladesh and Thailand: Extent and Analysis

4.1 Medical Waste Management in Bangladesh

4.1.1 The Health Sector in Bangladesh

Three major parties, namely, the Government, private entrepreneur and non-government organization (NGO), operate the health sector of Bangladesh. In addition, a number of bilateral and international agencies are heavily involved in the sector through their support to and influence on the government and the NGOs. NGOs are mostly involved in the provision of primary health care in both rural and urban areas. Grameen Bank, BRAC and ASA are some of the large NGOs that operate community level health clinics in the country. A significant number of tertiary hospitals are also run by NGOs, examples of these are the Holy Family Hospital (run by Bangladesh Red Crescent Society), Eye hospital (run by Lion club) and BNBS, Leprosy Hospital (run by Damien), BIRDEM by the Diabetic Foundation (a WHO collaborating center), and the Cholera Hospital (a WHO collaborating center run by ICDDR,B).

The largest service provider in the health sector is the government. The Ministry of Health and Family Welfare (MOHFW) is the main public authority responsible for providing health care to the entire population. Over the past two decades, MOHFW has established a country-wide network of physical and organizational infrastructure to plan, manage, and deliver health services.

In the private sector, there are two types of enterprises, those that are for profit and those that are for not for profit. The majority of them are for profit organizations. Examples of private not-profit organizations are Kumudini Hospital, which is run by the Kumudini Trust and the Dhaka Community Hospital. There are numerous for-profit private health facilities including National Hospital and Ibne Sina Hospitals. The private sector not only provides health services, it also provides educational and other services as laboratories and private medical colleges.

The organizational infrastructure of the health and other sectors established by the Government is quite elaborate, and is a significant vehicle for the Government to mobilize its resources for health care. At the district level, there are a number of committees, which deal with the development and management issues concerning Programs of different sectors including health. The civil surgeon who is the head of the district health system is represented on all district level committees. The District Coordination Committee chaired by the Deputy Commissioner (who is the head of the civil administration), deals with issues of coordination between different sectors. Other committees such as the District Population Committee, the MCH Committee, the Water Supply and Sanitation committee is responsible for matters relating to Health for All Strategies at the district level. NGOs and international agencies such as UNICEF also represent some of the district level committees.

Below the district level are the Thanas. The political system at the Thana level is called the Thana Parishad (Council). Presently the Thana Parishad is headed by the Thana Nirbahi Officer and is consists of the heads of various government sectors including health. The

Thana Parishad has the overall responsibility for all development programs of the Thana. There are a number of health related committees at the Thana level like the MCH services, population activities, Food for Works program, water supply and sanitation. Thana Health and Family Planning Officer (THFPO), the head of the Thana health system, is a member of all the committees and coordinates all health related activities with the other sectors.

Organization of the ministry of health and family welfare

Administratively, the country is divided into 6 divisions, 64 districts, 460 thanas (of which 397 are rural or outlying and remaining 63 are sadar) and 4403 unions (Figure 4.1). Each union has, on average three wards and four to five villages constitute a ward. A ward has an average of 7,000 population and is the lowest administrative tier of the Government. Each ward has an elected representative.

The organizational structure of the Ministry of Health and Family Welfare (MOHFW) follows general administrative rules of the country. At the national level, the ministry of MOHFW is responsible for policy, planning and decision making at macro level. Under MOHFW, there are two major implementation wings, the Directorate General of Health Services (DGHS) is responsible for implementation of all health program and providing technical guidance to the Ministry. Figure 4.2 illustrated the organo-structure of health services in Bangladesh. The Directorate of Family Planning is responsible for implementing family planning programs and providing family planning related technical assistance to the Ministry.

Separately, there are a few units/departments, which are directly under the administration of MOHFW. Examples are the Construction and Maintenance Management Unit, the Nursing Directorate, and the Drug Administration Unit.

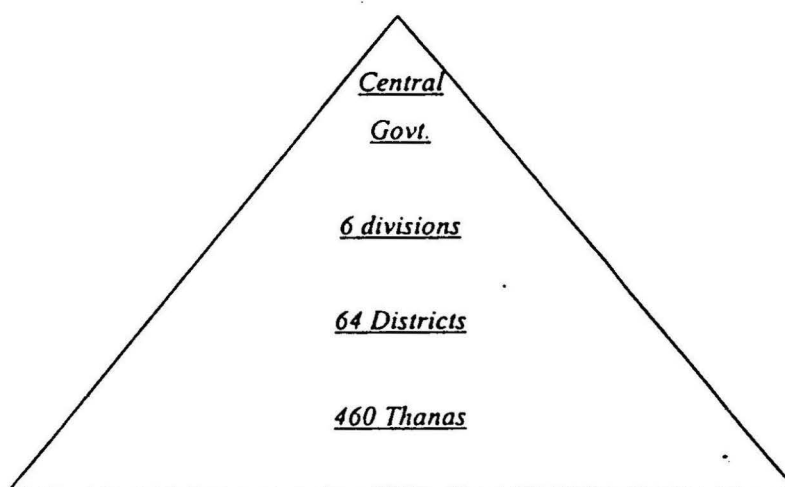


Figure 4.1 Administrative and Organizational Structure of the MOHFW of Bangladesh

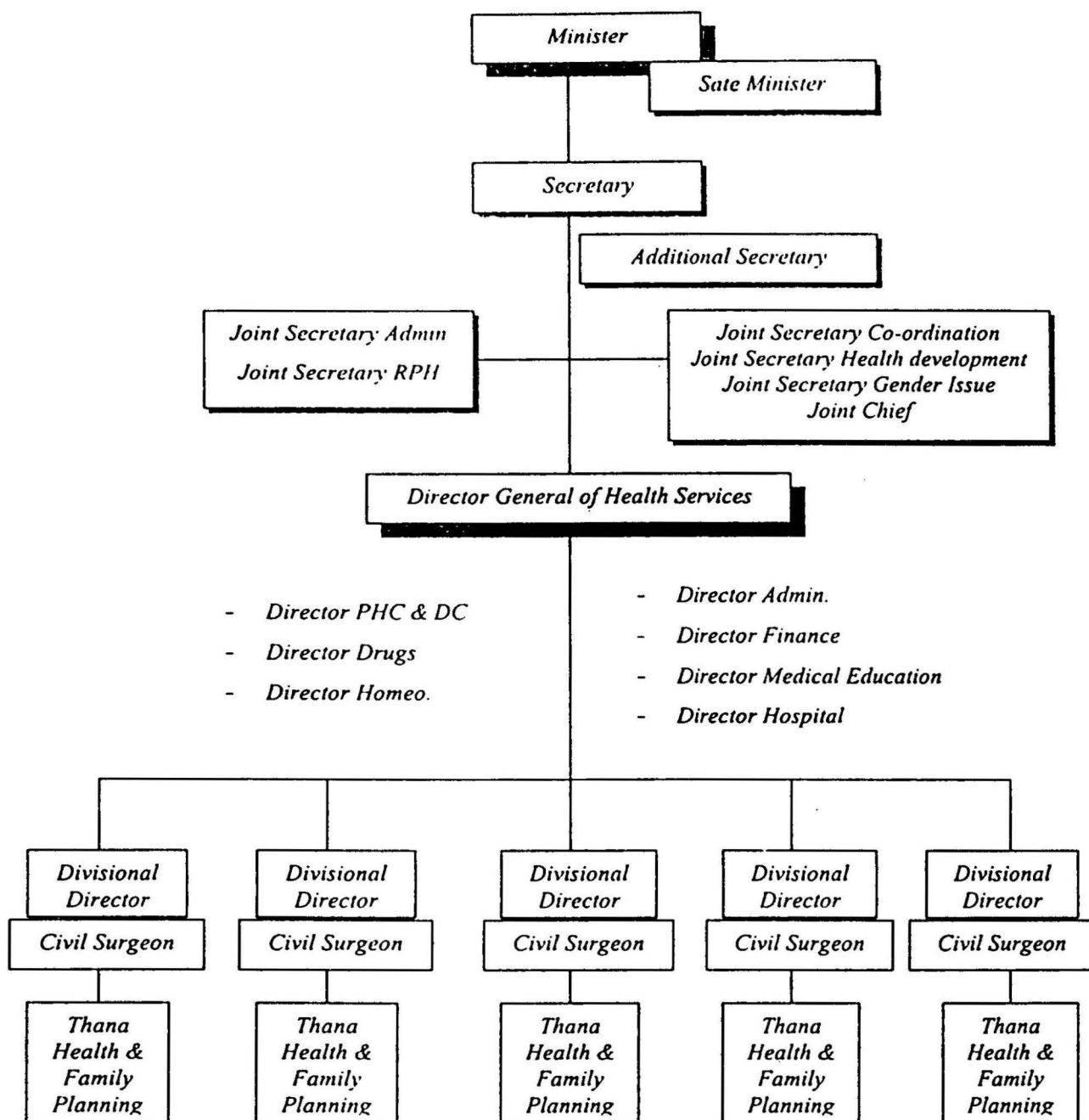


Figure 4.2 Organo-structure of Health Services in Bangladesh

4.1.2 Existing Hospitals

In Bangladesh, there are various types of hospitals with different bed capacity. At the district level, there are both 50-150-bedded and 200-250 bedded hospitals. In some district hospitals, there are also specialized hospitals. There are 500-1150-bedded specialized hospitals either as separate hospitals or are attached with medical college hospitals (Nessa et al 2001). Presently there are around 645 public and 288 private sector health care establishment (Line Director, 2000). Total number of individual hospitals in government health facilities under DGHS in Bangladesh in 1996 is 24 other than district hospitals, thana health complex (THCs) and rural health centre. These all hospitals cover 26,280 beds

all over the country. Of these about 45% are located at the thana or first referral level. Another 17% of the beds are located at the district hospitals which are the second level referral facilities. There are no cabin or paying beds in THCs and district hospitals. The remaining beds are either in large tertiary general hospitals or specialized hospitals. Out of 26,280 Government beds in the country, 2.27% (597 beds) are cabin or VIP beds while another 9.75% of them are paying beds for patients who can afford to pay to more comfort and privacy. Ninety percent (23453) of Government beds are classified as general beds. However, except for the ticket fee, the public system is in principle free of cost to the patients.

There are 96 maternity centers with a total of 748 beds are operated by DGFP. Outside MOHFW, 49 hospitals are run by different ministries. They provide about 2,297 beds. NGOs and voluntary organizations play a prominent role in the provision of health facilities to the public. There are 288 known hospital facilities run by them. Together they provide 8,025 hospital beds. If both public and private sectors (including NGOs and voluntary organizations) are counted together, a total of 37,502 hospital beds are currently available countrywide (Bangladesh Health Bulletin, 1998).

Out of 24 DGHS hospitals 11 hospitals are located in Dhaka. Including these hospitals there are 26 government hospitals and foundations (including DGFP and hospitals run by different ministries), 133 private hospitals and clinics, and 318 diagnostic centers (these are pathological laboratories, not hospital) in the Dhaka City.

Indicators of health care system in Bangladesh

Important health care system indicators of Bangladesh are shown in the following Table 4.1. The table 4.1 shows that secondary hospitals are over burden with patients more than it's capacity (111/75%).

Table 4.1 Some Basic Indicators on Health Care Delivery System in Bangladesh

Total number of Specialized hospital	05
Total number of Medical college hospital	17
Total number of District hospital	60
Total number of hospital beds	41,514
Total number of bed in non-government hospitals	11,371
Number of population per hospital bed	3,261/ 3,307*
Number of population per doctor	4,512
Household per doctor	725
Number of population per nurse	8,460
OPD bed occupancy at secondary hospital	111.75%
OPD bed occupancy at tertiary hospital	81.44%

(source: Line Director 2000; *source: HUMAN DEVELOPMENT REPORT 2001;
<http://w3.who.sea.org/eip/annex1.htm> in 2002)

4.1.3 Role of Dhaka City Corporation (DCC) and other Agencies on MWM

The City Corporation is main authority to collect and dispose all kind of waste produce in Dhaka City. There is no separate provision of medical waste collection or disposal. Medical wastes are collected, transport and disposed along with other solid waste. The solid wastes in Dhaka City are generated mainly from domestic, trade, industrial and commercial sources. According to Dhaka City Corporation (DCC), solid waste generated per day is estimated between 2000 to 3000 tons. Usually 2000 to 2500 tons of waste is generated daily during dry season and 2500 to 3000 tons of garbage per day during rainy season, increasing enormously during festivals. About 1800 tons or little over 50% of solid waste is collected and dumped at the disposal sites daily. About 900 tons go to backyard and landfill site, 400 tons remains on the road side and open space, 300 tons are recycled by waste pickers and 100 tons are recycled at the generation point. DCC has taken up a program for disposing off solid waste by sanitary landfill with Asian Development Bank/World Bank assistance. DCC also introducing some new waste management methods e.g. a) Utilization of bio-gas and fertilizer, b) Recycling or recovery. These are still under pilot project.

Solid waste generation from different sources in Dhaka (DCC, estimate) are as follows (Rahman & Ali, 2000):

Residential	: 49% (1718 tons/day)
Commercial	: 21% (722 tons/day)
Industrial	: 24% (835 tons/day)
Hospital & clinic	: 7% (255 tons/day)

There is no data on the coverage of hospitals and clinics under DCC collection system. No separate system or vehicle to collect hospital waste only. However, local city corporation or municipality is responsible for collection and disposal of hospital waste in the district level. Recently few projects on hospital waste management are going on in collaboration with WHO, WB and local municipality and local NGOs. These kinds of projects are running at Khulna, Sylhet and Rajshahi district.

Department of Environment (DOE) has made a report to find out environment friendly techniques for clinic establishment and clinical waste disposal/management in Dhaka city (7 September 2000). In this report DOE committee has recommended guidelines/rules to include environmental aspect in the "Ministry of Health and Family Planning Clinic Act 1999". Other then this DOE provide certificates for medical establishment according to Environment Protection Act 1995, and Environment Conservation rule 1997 (Bangladesh Gazette, 1997, Farooque & Hasan, 1996). Nevertheless, there is no specification for hospital or medical establishment or waste disposal and management.

Collection and disposal

Out of 297 trucks, the city council is maintaining an average of 250 collection vehicles per day due to technical defects and non availability of spare parts. Each truck has an assigned area and makes more than one trip to the land fill area per day. The trucks collect the generated waste and transport to final disposal sites in two shifts. Day shift starts from 5 A.M. and continues up to 2 P.M.; the night shift is from 8.30 P.M. up to 2 A.M. In addition some special trips are provided on VIP roads from 1 A.M. to 8 P.M. On an average, vehicles of different capacity make 600 trips everyday. Some times trips increase due to seasonal variation and festival time.

DCC employs about 6000 conservancy staff for waste-disposal, augmented by another 500 in monsoon. In addition 135 conservancy inspectors and supervising inspectors look after the works of them. There are only 1.2 workers per thousand people for solid waste management in Dhaka City. They have to manage an area of 360 sq km of DCC that has been given municipality status out of 1528 sq km of the city (The Daily Star, 2000). During the same collecting time and vehicle collects medical waste as well and disposed to the same place. There is no separate disposal or collection system for medical waste.

It occasionally appears that these arrangements and the management itself are inadequate for timely or rapid removal of waste from bins. The number of vehicle is 1 for 27000 people and it is clear that some places of the allotted zones are unattended for more than 5 days. There are some local NGOs taking role on collection of solid waste from door to door and disposed to municipal bins. The DCC budget in the recent years has declined notably. While the 1996-97 fiscal year DCC budget was of Tk 950 million, it came down to Tk. 180 million in the 98-99 fiscal (The Daily Star, 2000).

Solid wastes are disposed to the landfill sites. Crude and uncontrolled dumping methods are used in Dhaka though every such uncontrolled land filling is an environmental disaster causing health risk through vectors, air pollution and water pollution through leaching by rainfall. However, since open dumping is the cheapest, it is preferred by DCC. There is no written document on collection and disposal coverage of medical waste by DCC or local municipality. Nevertheless it is assumed DCC collection system covers all hospital and institute found in the City.

4.1.4 Medical Waste Management in Bangladesh: Situation Analysis

Background

Composition and generation of medical waste varied depending on several factors in Bangladesh such as kind of services, size of facilities, housekeeping practices etc. There are several studies showed different rates of medical waste generation in Bangladesh. One study (Rabbani, et al., 1997) showed total generation of solid waste in Dhaka City is 1.00kg/bed/day. Mubarak (1998) conducted a study that showed 0.55kg/bed/day waste generation and the percentage of hazardous waste was 27% of total volume. A research has done by Shehab (1999) on medical waste management at Dhaka City. Research finding was waste generation rate 1.1.kg/bed/day with 0.169 kg/bed/day hazardous waste. The contribution of infectious, sharps and pathological waste are about 10.5%, 3.5% and 1.5% respectively in Dhaka City.

With rapid increase in number of clinics and hospitals in the country the generation of medical wastes have been increasing considerably. But most of the hospitals do not have the provision of safe disposal of medical waste. Waste is collected from a small bowl (plastic or metal) or plastic bin provided for each bed in a hospital or clinic and put them either in a larger size plastic bag or bucket (plastic or metal). These plastic bags or waste from buckets are then put in a pushcart and carried to the nearest municipal bins for dumping. Sometimes the buckets or bags are directly carried to the bin. The municipal bins are placed either in hospital premises or outside the hospital. In Dhaka all kind of waste from hospitals including clinical wastes, syringes, needles are dumped in the municipal bin indiscriminately (ADB, 1998).

Use of incinerator or any alternative methods for safe disposal of waste is almost absent in hospitals. There are few hospitals and clinics, which have onsite waste management system such as combusting, burial, autoclaving, and waste segregation. Otherwise all hospital

waste are dumped together in a common bin and carried by municipal trucks to the landfill sites.

A significant number of the urban poor in Bangladesh rely on the collection of secondary materials for their primary source of income. The wastes pickers (scavengers) sort through waste at site, usually open dumps, and sell anything that can be recycled to agents of industry. The waste pickers have no special protection for sorting through wastes and are in danger of becoming seriously injured or sick. Though large scale recycling occurs for both medical and non-medical wastes, waste collectors are in constant danger of becoming contaminated and injured. So, it is most likely that the waste pickers, neighbors, and people will be infected from these materials. Moreover, municipal dustbins of Dhaka City are usually open. Government hospitals place all wastes in open dustbins and the wastes are left in the open for one to two days. Other hospitals leave their wastes outside in open dustbins for two to three days at a time before a municipal truck would remove them. Parts of human bodies were found in dustbins as well (Rashid, 1996; ADB, 1998). Therefore, spread of infectious organisms through various means from medical waste pollute the environment and increase the risk of silent epidemics of infectious diseases like Viral Hepatitis, Typhoid, Pneumonia, Gangrene, AIDs etc. (ADB, 1998).

BRAC's Environment Group has conducted a study on medical waste disposal at BRAC Health Centre (Akter et al., 1998). At the same time they have visited some government and private clinic at Mymensingh and Bogra. The overall findings of this study indicate that there is a lack of awareness, concern, and knowledge of appropriate handling and disposal methods of medical waste. The waste disposal systems in both the government hospitals and private clinics were severely lacking.

Method of disposal

A variety of methods were used by the medical facilities to dispose of waste. These included incineration, open burning, burial, selling, dumping, reuse and removal by municipal bins. Akter et al (1999), Figure 4.3 below shows common modes of medical waste disposal and table 4.2 below is the summary of waste disposal practices at Government hospitals and clinics, private clinics and laboratories. There has been no proper disposal system for particular things in a particular way. Most hospitals have collected and dumped all wastes together in public places. Those places were roadside, hospital surroundings, dustbin of city corporation, Corporation's drum. Waste is placed in dustbin, re-sold or poured down drain to the main sewer. It was also found that revenue was generated by medical staff through the sell of medical wastes. Syringes and other medical wastes were re-sold for 20Tk/kg (e.g. saline bag).

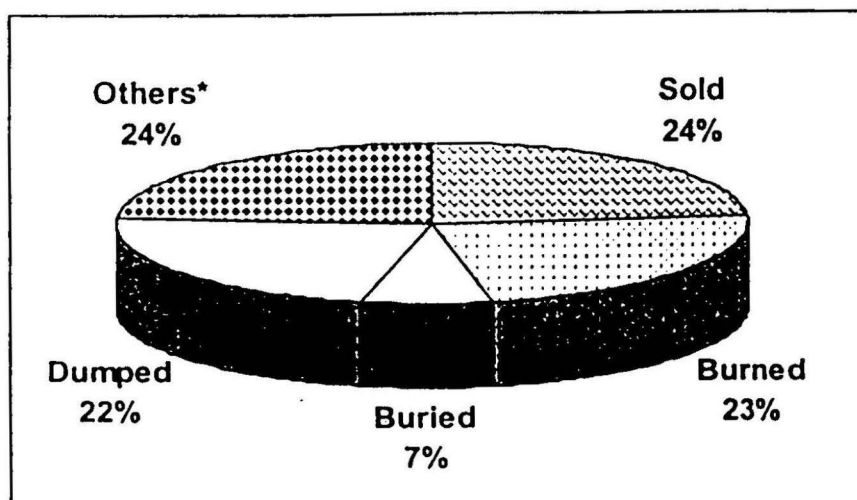


Figure 4.3 Mode of Medical Waste Disposal Mentioned by Respondents

(source: Akter et al, 1999)

*Others as mentioned in the figure means collected in an open place, roof of the building, drum or bucket which was taken by van or sweeper to dump in a municipal bin; saline bag re-used for urination, laboratory waste burn with acid, autoclave the waste before disposal, chemical waste thrown in to the basin.

Table 4.2 Item Disposed by Different Disposal System

Disposal system	Medical waste items
Sold	Container, Syringe, Saline bag, D/Syringe, Bucket, Saline set, Needle, X-ray water, Plastic bottle, ampoules, vials
Burned	Clothes, Gauze, Cotton, Mattress, Bandage, AIDS clothes, Rabies clothe, Paper, Gloves, Saline bag, Saline set, X-ray film, Needle, Syringe, Blood bag, Plaster of Paris, Apron, D/ syringe, Plastic, Sputum pot, TB slide, Blood, Urine, Stool, Bed sheet
Buried	Common waste, Needle, Syringe, Blood lancets, Specimen collection pot, Blood, Urine, Stool, Sputum, Saline bag, Damaged body part, Placenta, Slides, cotton
Dumped	D/syringe, Saline bag set, Gloves, Needle, Cotton, Gauze, Bandage, Pad, Paper, Plastic, TB slide, Sputum, Polythene, Blood sample, Tissue paper, Common wastes, Dressing, Stool, Urine, Broken tube, Acid, bottle, Syringe, Paper, packet, Placenta
Container/ Basin	Tips, Reagent, Chemicals, Blood, Urine, Stool, Sputum, D/syringe, Needle, Gloves, Slide, Broken glass
Dematerialized by acid/ Autoclave	Cotton, Needle, Syringe, TB slides, Sputum pot, Tested sample's, vials

(source: Akter et al, 1999)

There were several mode of waste transport. Mostly waste were carried by open bucket as respondent mentioned (44.38%) and plastic bowl (23.86%). The medical waste were disposed in several places: Corporation's dustbin (DCC); Pit near hospital (dig a hole); Open field / roadway / by the roadside; Canal water/ river/lake/ditch; Own net house / closed house/ own closed dustbin (Figure 4.4). It is found that most waste were disposed in municipal bin (59%) without any treatment or separation.

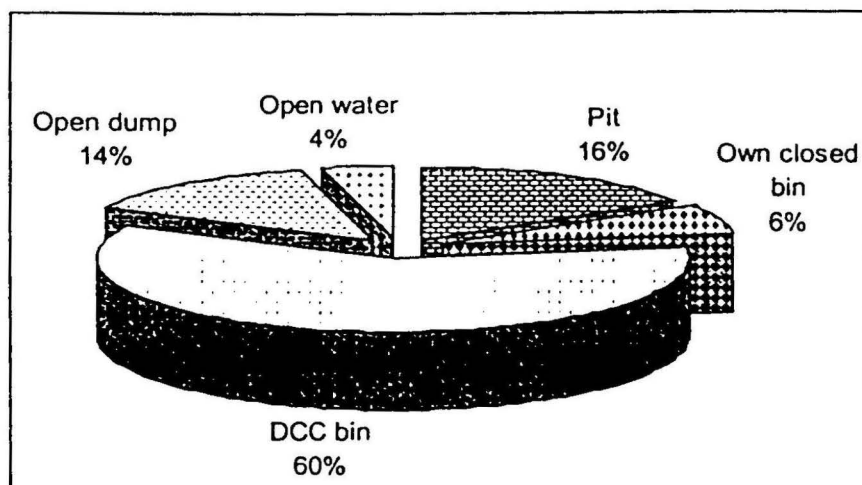


Figure 4.4 Places of Medical Wastes Disposed off Mentioned by Respondents

(source: Akter et al, 1999)

It was found those saline bags, x-ray water, syringes, vials, slides, empty packets and bottles were collected and sold. Medical waste like used disposable syringes and saline bags supplied from hospital store was collected by hospital authority, other then these all medical supplies provided by patients or outside hospital was recollected by waste pickers (tokai), cleaners and sell to whole seller, hawkers.

Identified problems related to medical waste management

Problems or limitations of City Corporation related to waste management were discussed before. During field visit it was observed that there are problem in hospital itself to managing waste properly. Usually hospitals have patients more then its capacity. Therefore, 3 or 4 patients share one dustbin under the bed. Cockroach and rats are moving around inside ward. Toilets are very dirty and unhygienic. There is no awareness of patients, they throw their garbage through the window. Sometimes garbage kept in the dustbin for 3 or 4 days, but the City Corporation does not clean it. Very often there is no water supply in the basin, therefore nurse or doctor cannot wash/clean their hand even after dealing patient with infectious disease. Some wards have same toilet for patients and nurse, there of possibilities of infection from the patients.

Nevertheless, Interview and questionnaire survey of doctors and management personnel in this study the following results obtained (Table 4.3). It is quite clear from their responses that authority is not much aware about proper handling and disposal of waste (21%) that is mostly related to inadequate system or resource availability (Table 4.3). Government is also not giving importance of this issue hence there is no intensive law and enforcement as well as monitoring authority to look after this matter. Other study related to medical waste management in Dhaka City identified some kind of problems (Hadi 1999), these are shown in Table 4.4. The most important problem found was lack of supervision and monitoring (56.67%). Nevertheless, this is also related to the second identified problem of missing resources. As it can be said that all of these are interrelated and lack of awareness regarding this issue is an unavoidable cause of these results.

Table 4.3 Problem of MWM in Bangladesh Identified by Respondents

Problem identified by respondents	% of total responses
Negligence of the authority	21
Lack of sufficient infrastructure	18
Lack of cooperation from Governments	13
Lack of public awareness	13
Lack of trained/ experienced manpower	13
Irresponsibility of the worker	11
No chain of command	7
Lack of monitoring	3
Weakness of law enforcement authority	1

Source: primary field data

Table 4.4 Problems of HWM in Dhaka City

Identified problems	% of total responses	% of total respondents
1. Lack of supervision of administration	19.54	56.67
2. Lack of resources (waste container, incinerator, modern technology)	17.24	50
3. Open dumping	16.09	46.67
4. Lack of modern disposal system	12.64	36.67
5. No waste segregation system	10.34	30.00
6. Lack of health education	8.05	23.33
7. Human behavior/attitude	8.05	23.33
8. Lack of efficient manpower	5.75	16.67
9. Improper reuse of waste	2.3	6.67

(Source: Hadi, 1999)

Possible solution for improvement

Respondents also provided their opinion to improve the situation of MWM during this study (Table 4.5). Awareness got top priority among all responses (24.7%). They also pointed out the job distribution (responsible to the job), supervision and monitoring of activities in and outside hospital (City Corporation's duty, privatization). Trained manpower, budget allocation, appropriate technology, low enforcement were some aspects should be taken into account for proper MWM system.

BCAS (1997) provided some suggestions for different respondents in relation to proper Medical waste management (Table 4.6). Hospital staff identified that training is needed for cleaners or others on waste disposal and management. Almost all respondents mentioned about the need of proper techniques for waste handling and treatment. They also suggested several options for waste treatment and disposal.

Table 4.5 Suggestions for Improvement of MWM Situation in Bangladesh by Respondents

Suggestion provided by respondents	% of responses
Awareness through mass media, seminar, and training	24.7
Job distribution, responsibility, supervision and monitoring	23.7
Trained manpower	12.4
Increase government budget in health sector	11.3
Incinerator or improved technology	10.3
Appropriate guideline	7.2
Chain of command should be maintained	7.2
Law enforcement authority should be sincere to their job	3.1
Proper place for waste disposal	1

(Source: field data)

Table: 4.6 Suggestions on Medical Waste Management by Hospital Staff, Neighbors and Waste Collectors

Category or respondents	Suggestions
Hospital staffs	1. Implementation of short term training for cleaners 2. Some waste need to be burned and some waste should be covered for subsequent and rapid disposal by the City Corporation. The covered waste must have to be kept outside the clinic. 3. Waste need to be categorized into three different groups and should be kept in different containers. 4. Waste after being covered should be taken away far from the clinic and to be burned off. 5. Specific waste should be thrown to specific places. 6. Medical waste needs to be destroyed by chemical treatment. 7. Waste need to be burned by electricity 8. Basic training for safe waste disposal for every body.
Neighbors	1. Medical waste needs to be burned in specific places. 2. Waste needs to be buried under the soil. 3. Waste should be thrown directly into the City Corporation dustbin and they should dispose them safely to specific places, which should be far from the hospital and preferably from outside the City. 4. Waste must have to be kept in a container with lid and should be cleaned by the city corporation. 5. Medical waste should be burned in the specific place. 6. City Corporation should clean these wastes twice in a day.
Waste collectors	1. Medical waste should be burned in specific place. 2. The hazardous wastes need to be buried under soil far from the hospital. 3. Use of plastic drum with lid for in-house waste collection and to clean it within a short time. 4. Waste should be thrown to specific place and need to be disinfected by any process.

(Source: BCAS, 1997).

According to the DG Health report (Line director, 2000), Medical waste flow and management system in Bangladesh is shown in the figure below (Figure 4.5).

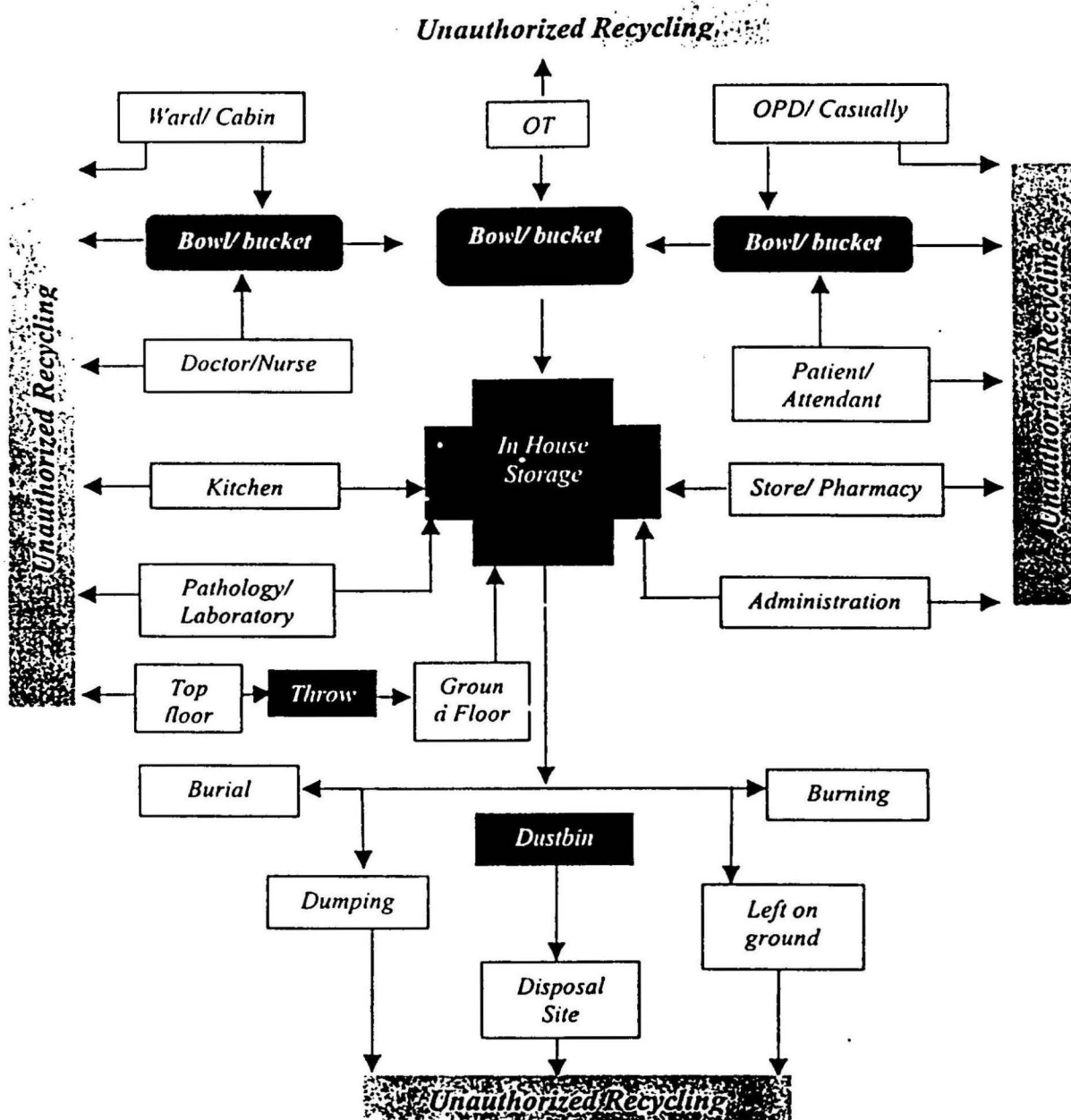


Figure 4.5 Medical Waste Flow Chart in Bangladesh

(source: Line director, 2000)

4.2 Medical Waste Management in Thailand

4.2.1 Health Sector in Thailand

Health resources are distributed to various agencies implementing health program activities including those both in the public and the private sector. The Ministry of Public Health (MOPH) is the principal agency in health system and is supported by public sector agencies namely Bangkok Metropolitan Administration, Ministry of University Affairs, the Ministry of the Interior, and the Ministry of Defense. Further health related issues the Ministries of Industry, Science, Technology and Environment, Labor and Social Welfare, and the Ministry of Education implement activities.

About 375 health-related non-profit, non-governmental organizations are registered with the Ministry of Education and/or the Ministry of Interior. For the past several years NGOs have helped in numerous projects and received partial funding of the MOPH. In the most recent years NGOs activities are associated with HIV prevention and general health services. NGOs run several hospitals that are included in the private sector. The private sector has played an important role in the provision of services at hospitals and clinics. With government's investment privileges, private hospitals have been expanded and albeit their capacity by beds is around 30 to 35% of the public sector their capability is at least equivalent to that of public hospitals. They are highly esteemed by the people and who ever can afford will consult a private facility. Private hospitals and clinics are under the control of the Medical Registration Division (Permanent Secretary) of the MOPH. Health resources are distributed to various agencies implementing health program activities including those both in the public and the private sector. The private hospitals and clinics are organized within "The Private Hospital Association of Thailand".

As been mentioned the MOPH is the core agency in the Thai public health system. It holds a 60% share of health facilities, most of which are in the rural areas. The MOPH has authority and functions related to medical care, public health, health promotion and development, food and drug control, anything toxic or hazardous to the public health, and the Red Cross supervision and support according to the Ministry and Department Reorganization Act of 1991. MOPH's major functions include the promotion and support, control and co-ordination of all activities related to physical and mental health including well-being of the people, and the provision of health services.

Organization of the Ministry of Public Health

The administrative structure of the MOPH is divided into 2 parts: Central Administration and Provincial Administration. The Central Administration is composed of the Office of the Permanent Secretary, the Office of the Minister's Secretary and six Departments. Structure of the central administration and provincial administration are given below in Figure 4.6 and Figure 4.7.

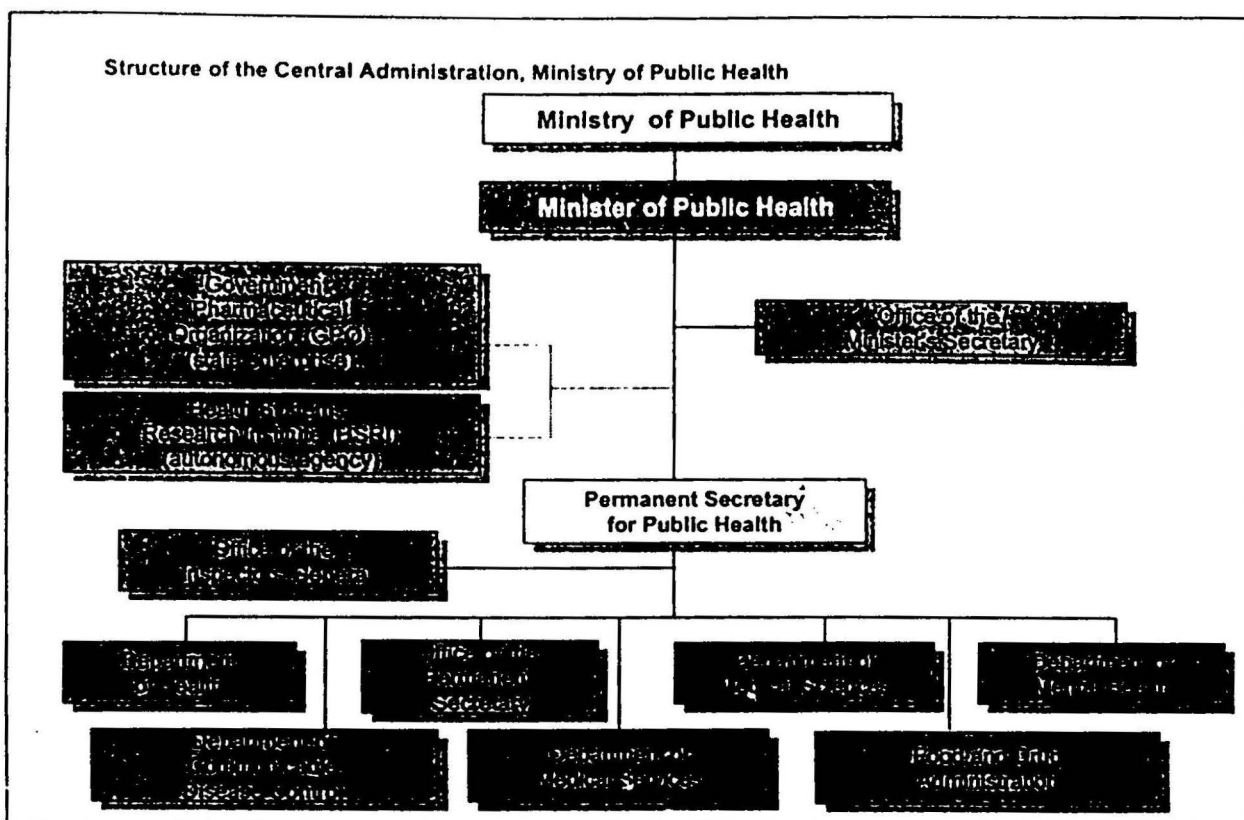


Figure 4.6 Structure of the Central Administration MOPH

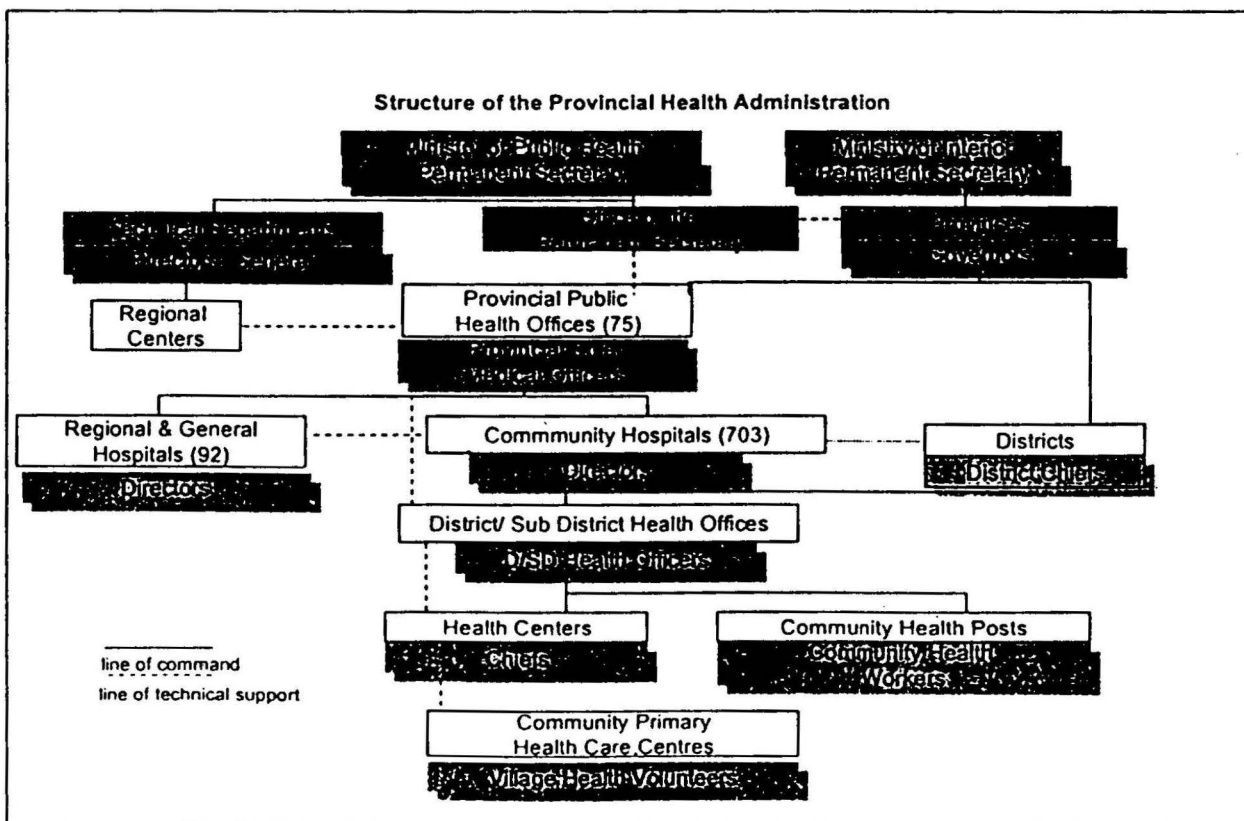


Figure 4.7 Structure of the Provincial Health Administration

The Provincial Administration is under the supervision of the Office of the Permanent Secretary for Public Health. The Permanent Secretary is in charge of controlling and monitoring all provincial level health activities to ensure they are implemented in accordance with MOPH's policies and programs. Agencies under the provincial health administration are Provincial Public Health Offices, District Health Offices and Health Centers. Normally they are affiliate with the Provincial Government. Additionally 12 regional health centers are established to provide technical services to the region.

Within the MOPH the Department of Health is the one to deal among others with all environmental issues. In the following the objectives and responsibilities are reviewed. The Department of Health undertakes legal actions pursuant to public health and other related laws as given below:

- Conduct research and development on state of the art and alternative approaches for health service delivery, to set appropriate standards of health promotion, health behavioral development, sanitation, industrial and environmental health in an effort to achieve an balanced physical, mental and social development.
- Disseminate information and transfer technologies in health promotion, disease prevention, and environmental control and health behavioral development to all concerned divisions both within and outside the MOPH including the general public.
- Promote, support and demonstrate responsible services pertaining to health promotion, disease prevention and health behavioral development.
- Recommend ideas for consideration in formulating health policies and master plans.
- Formulate and correlate the departmental plan of action in line with ministerial policy and master plan. Formulate corresponding programs and projects for funding, resource allocation and technology transfer in support of health services. Projects to include health promotion, disease prevention, environmental surveillance and control including health behavioral development undertaken by its institutions both at the central and rural levels.
- Co-ordinate and co-operate with both government agencies and NGO's in health promotion, disease prevention and environmental development.
- Fulfil other functions as stipulated by law to be the responsibility of the department, or those assigned by the ministry or the cabinet.

The Bureau of Environmental Health is within the Department of Health an entity, which covers the following duties:

- Develop appropriate technologies, establish standards and guidelines, models, systems and methodologies for environmental health quality control and standardization contributing to the prevention and solving of environmental health problems.
- Develop an environmental quality surveillance system, to monitor and analyze environmental quality, which may affect human health.
- Enhance, support, and transfer technical knowledge and expertise relating to environmental health prevention and control to other concerned agencies.

The Bureau of Environmental Health structure is organized into 9 units, which are

1. The General Administration Section
2. The Planning and Evaluation Division

3. The Environmental Technology Division
4. The Environmental Quality Surveillance Division
5. The Environmental Quality Analysis Division
6. The Environmental Engineering Division
7. The Environmental Health Promotion and Development Division
8. The Environmental Health Regional Center Support Division
9. The Environmental Health Communities Development Section

Aside of the MOPH that rules the related hospitals there are hospitals under the supervision of the Ministry of the Defense and the Ministry of the Interior. Furthermore there are state-owned hospitals of Thailand's railway and Bangkok Metropolitan Administration operates their own hospitals.

4.2.2 Existing and Planned Hospitals

The health service system in Thailand has evolved from self-reliance Health service facilities, which at all levels have been upgraded and improved in terms of their quality and efficiency. The health care industry is predominantly by numbers controlled by the government. The public sector functions as a regulator and operator of roughly 70 percent of Thailand's hospitals and as a promoter of investments. Of the 1,301 hospitals in 1997 operating throughout the country, 943 of them were public hospitals with 102,100 beds. Under MOPH are about 90% of the hospitals and 82% of the beds, respectively. Military hospitals cover with 63 facilities and an estimated 15,000 beds proportion of the rest. There are 358 privately run hospital with 35,052 beds. Extension of beds from 1981-1999 in different sectors are shown in Figure 4.8. Between 1994 and 1997 the total number of hospitals increased at an average rate of seven percent, while the number of beds increased at eight percent.

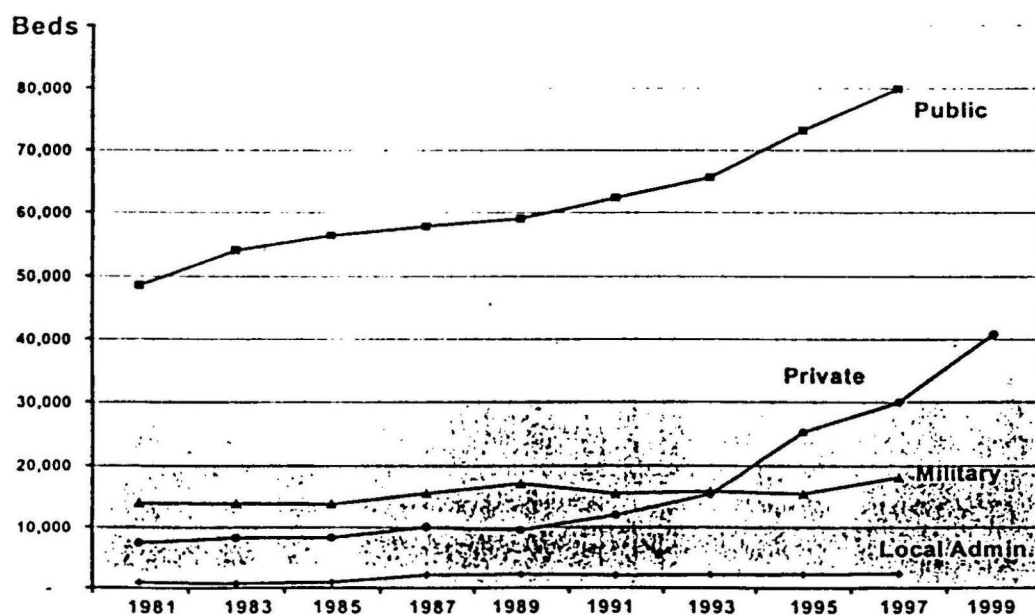


Figure 4.8 Extension of Beds from 1981-1999

(Source: Department of Health, MOPH)

In addition to the number of private and public hospitals, there are also over 9,689 health centers and over 12,206 private clinics established throughout Thailand. In the sub-district level health centers have been built to cover all villages throughout the country during the last decade. In 1998, roughly 706 community hospitals were covering 89.6% of all districts and 9,689 health centers on Tambon (an association of up to 10 villages). The ratio of people per health center improved drastically during the last decade. Although many health centers are clustered in the central region, regional disparities have declined a little.

Indicators of health care system in Thailand

Some statistics of basic health system indicators are given in this section. Ratio between population and bed for general health services are shown in Table 4.7. Population bed ratio showed decreasing trend that reveals the improvement of health care system. Situation in Bangkok and Central part is far better than other part of the country.

Table 4.7 Ratio Between Population and Beds for General Services, Bangkok Metropolis and Other Provinces, 1991-1997

	1991	1993	1995	1997
Number of persons per hospital bed				
Whole Country	604	579	500	457
Bangkok Metropolitan Area	257	266	221	205
Central	506	468	395	374
North	682	637	568	465
South	603	616	530	492
Northeast	1,074	1,071	875	813

Source: MOPH, 2000

The same inequity can be observed if the total number of private hospitals and clinics (less than 30 beds) are assessed. The majority of private hospitals are concentrate in the Bangkok metropolitan area and in the Central Plains (Table 4.8).

Table 4.8 Number of Private Hospitals and Beds in Thailand 1997– 1999

	1997		1998		1999	
	No.	Beds	No.	Beds	No.	Beds
Whole Country	491	38,375	473	40,253	471	40,852
Bangkok Metropolitan Area	143	15,641	131	16,536	129	16,396
Central	164	11,144	168	11,522	167	11,939
North	70	5,268	64	5,604	65	5,786
South	58	2,806	52	2,784	53	2,756
Northeast	56	3,696	58	3,807	57	3,975

Source: Private Hospital Association

According to the MOPH, Thailand's public medical sector employed about 17,300 physicians, 3,700 dentists, 6,100 pharmacists and 95,000 nurses in 1996. The average ratios of health personnel to people have improved considerably over the past two decades.

The number of people per physician dropped from about 8.466:1 in 1975 to 4.180:1 in 1996. The same accounts for the ratio people per dentists (20.363:1 in 1996 down from 65.018:1 in 1975) and people per nurse (1.092:1 in 1996 down from 3.349:1 in 1975). Overall, for most Thais the access to health care services has improved substantially. Table 4.9 illustrated the ratio between population and personnel for different part of Thailand.

Table 4.9 Ratio Between Population and Personnel, Bangkok Metropolis and Other Provinces, 1991-1997

	1991	1993	1995	1997
Number of doctors per population				
Whole Country	4,426	4,297	4,180	3,649
Bangkok Metropolitan Area	958	1,045	999	720
Central	5,805	5,180	4,091	4,506
North	6,317	6,117	5,844	5,791
South	6,079	6,257	5,591	5,216
Northeast	10,970	10,851	10,936	9,951
Number of nurses per population				
Whole Country	1,255	1,255	1,092	1,073
Bangkok Metropolitan Area	413	432	347	368
Central	1,470	1,230	1,022	1,004
North	1,635	1,425	1,270	1,188
South	1,463	1,400	1,178	1,080
Northeast	2,964	2,621	2,273	2,133

Source: Department of Health, MOPH

4.2.3 Role of Bangkok Metropolitan Administration (BMA) in MWM

In Thailand Bangkok Metropolis, the Department of Public Cleansing (DPC) is an important local government sector under the Bangkok Metropolitan Administration (BMA). According to Article 89 of the Bangkok Metropolitan Administration Act 1985, and under other related laws, the BMA has been authorized to perform some principal functions within its jurisdictional area.

BMA's function also include the followings along with other functions:

- Maintaining cleanliness and orderliness of the city.
- Environmental development and conservation
- Provision of public health, family hygiene and medical services

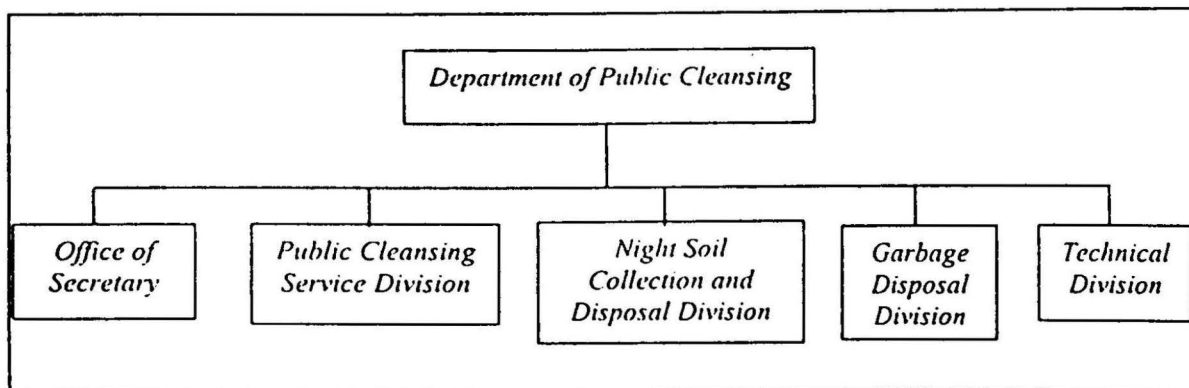


Figure 4.9 The Organizational Chart of the Department of Public Cleansing

Department of Public Cleansing (DPC) is responsible for planning and implementing the work of public sanitation and disposing of garbage and night soil including the provision and maintenance of mobile lavatories. The organizational chart of DPC is shown in Figure 4.9. Public cleansing and garbage disposal division is responsible for collecting and disposal of solid waste. However, there is no specific function related to Medical waste, since they collect Medical waste along with other waste and send those to the treatment site (incinerator). As it is found in the leaflet of DPC that they incinerate the part of refuse rejected from the compost process and infectious wastes collected from hospitals in Bangkok only, because the refuse fed into incinerator have high moisture content and the incinerator has low efficiency. So incinerators require fuels of heavy oil and firewood to assist them and needed heavy expenses while the efficiency is not as good as expected.

Collection and disposal

In Bangkok metropolitan area Medical waste collected by DPC of BMA central office. DPC office of BMA is responsible for infectious waste disposal and management. There are 27 officers, 57 vehicles and 107 collector (cleaners) work for all kind of solid waste collection from the city. BMA has divided it's area into three sections for Medical waste collection. Each area has 20 trucks to collect Medical waste. The trucks spend time about 4-6 hours every day. Working hour of the collection truck is from 6 pm to 6 am to avoid the traffic jam. The truck has the system to keep infectious waste with in controlled temperature of 15⁰C, thus prevent the possibility of infection. Then infectious waste is sent to the treatment site at On-Nooch for incineration.

DPC has facilities to collect waste from hospitals (government, state enterprise and private sector), public health service centers and private clinics in BMA area. Since 1988, DPC separate infectious waste from municipal waste during the process of collection, transportation and disposal. BMA employed one private company name Krungthep Thanakom for Infectious waste collection and treatment. A total of 3774 hospitals or medical service centers (including 2640 clinics and 853 public health center) in Bangkok metropolitan area out of this only 579 hospitals and health service center are under BMA service for waste collection and disposal (Table 4.10). It was noted that BMA service covers all publics or government facilities and a little number of private clinic and hospitals. It is also noted that private clinics and health center in Thailand provide only out door services, they do not have any bed. Therefore, they send their waste to the municipal bin. Nevertheless, if exclude the small health service as private clinic, BMA service covered all government and private hospitals waste collection and disposal. Besides

infectious waste all other Medical waste are collected and disposed off along with municipal waste by BMA.

Table 4.10 Number of Hospital under BMA (Krungthep Thanakom) Services for Infectious Waste Collection in 2001

Name and type of facilities	Total number	Number under collection	Percentage coverage
1. Hospitals	133	133	100
2. Clinics	2,640	248	9.39
3. Public health service center	148	148	100
4. Other public health center (private)	853	50	5.86
Total	3,774	579	15.34

source: Krungthep Thanakom, 2001 (in Thai)

4.2.4 Medical Waste Management in Thailand: Situation Analysis

Background

The composition of both general waste and infectious waste underlies a great variation depending on the alignment and various other factors. A recent survey (Asia Invest, 2000) throughout Thailand found that in hospitals waste is produced in a range of 1.12 –2.79 kg/bed day. For infectious waste a range of 0.26 –0.38 kg/ bed-day is reported. Another source of data shows the rate of total Medical waste generation in Thailand is 0.23-0.46kg/capita/day (Table 4.11). In Bangkok Medical waste ranges between 0.22-6.45 kg/bed/day, where the infectious waste ranges 0.06-0.59 kg/bed/day (Table 4.12). Therefore, the percentage of infectious waste in Bangkok is 12.67%.

Table 4.11 Rate of Waste Generation at Different Sources in Thailand

Source	Waste generation rate
Residential areas	
-municipalities	0.8 kg/capita/day
-sanitary areas	0.6 kg/capita/day
-outside of municipalities and sanitary areas	0.4 kg/capita/day
Households	0.2-0.3 kg/capita/day
<u>Hospitals and medical centers</u>	<u>0.24-0.46 kg/capita/day</u>
Industry	18 kg/rai of operation area
Travelling sources	
-non-dwelling groups	0.02-0.66 kg/capita/day
-dwelling groups	0.06-0.45 kg/capita/day

(source: PCD, 2000 in Matrix, 2001)

Table 4.12 Rate of Waste Generation in Bangkok from Different Sources

Sources	Range of waste generation	Rate of waste generation (average)
Housing	0.33-1.54 kg/person/day	0.721 kg/person/day
Flat, apartment	0.20-1.15 "	0.571 " (1.087 kg/room/day)
Townhouse	0.23-1.09 "	0.705 kg/person/day (1.568 kg/room/day)
Hotel	0.10-1.58 "	0.490 kg/person/day (1.830 kg/room/day)
Hospital		
- General waste	0.22-6.45 kg/bed/day	2.034 kg/bed/day
- Infectious waste	0.06-0.59 "	0.295 kg/bed/day
Office	0.01-0.22 kg/m ² /day 0.13-0.44 kg/person/day	0.038 kg/m ² /day (0.251 kg/person/day)
Department store	0.04-0.24 kg/m ² /day 0.03-0.62 kg/person/day	0.053 kg/m ² /day (0.288 kg/person/day)
Market	0.25-1.00 kg/m ² /day	0.618 kg/m ² /day
Industry	0.025-5.155 kg/person/day	1.056 kg/person/day (0.058 kg/m ² /day)
Academic institute	0.02-0.57 kg/person/day	0.289 kg/person/day

Source: surveyed by Team Consulting Engineer Ltd., and Quality Team Consultant Ltd. (August-October, 1999)

In 1996 (Paranan, E. 1997) Rajavithi hospital (one of the biggest government hospital) produced 3000kg general waste per day while 1200-kg infectious waste, which is around 29% of total Medical waste. Few more hospital's data are given in Table 4.13. The percentage of infectious waste from four institutes was 28.47%, which is much higher than the data above. This is because of these selected hospitals are situated in Bangkok City and quite big and kind of service they provide generates more infectious waste. Moreover, all waste coming out from emergency ward is considered as infectious waste without any separation that increased the quantity of infectious waste as well.

Table 4.13 Solid Waste of Five Institutes in 1996

Institute	Infectious waste kg/day	General waste kg/day	Total waste kg/day	% of infectious waste
Rajavithi Hospital	1200	3000	4200	28.57%
Children's Hospital	200	500	700	28.57%
Pathology Institute	22	20	42	52.38%
Dermatology Institute	3	60	63	4.76%
Total Kg/day	1425	3580	5005	28.47%

(secondary data: Paranan, 1997)

Medical waste collection in Bangkok

Hospital Infectious waste (IW) generation become 4.3 times higher from 1986 to 2000 (from in 1986 86,674 ton/year to 200,699 ton/year in 2000). It can be assumed from following data from different year (Appendix 8). Total Medical waste collected by BMA and infectious waste collected by BMA assigned company during the year 1999 to 2001 are given in Figure 4.10 and Figure 4.11.

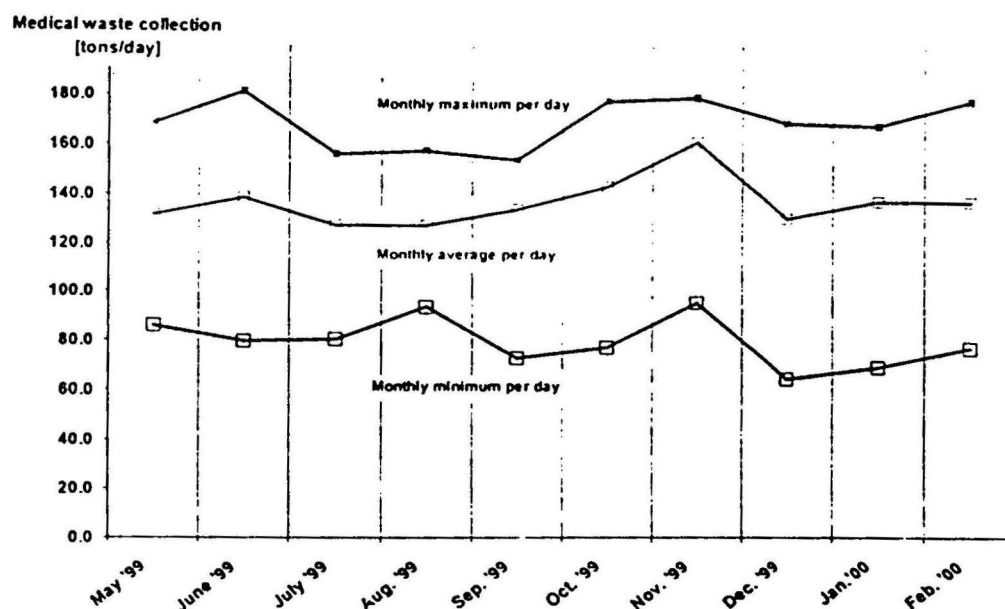


Figure 4.10 Medical Waste Collection in Bangkok

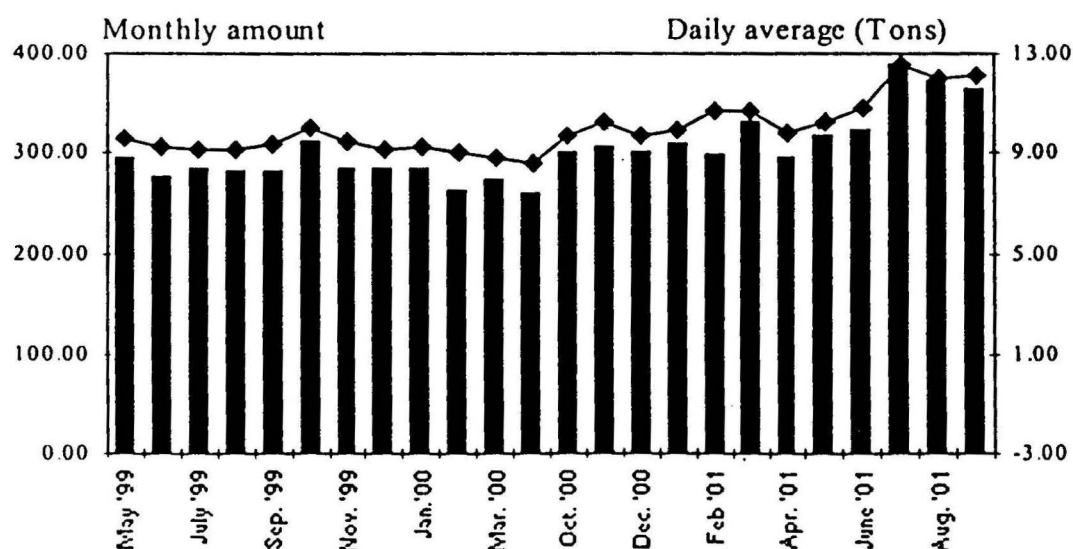


Figure 4.11 Infectious Waste Collection and Incineration in Bangkok

Source: primary data from BMA and Krungthep Thanakom company

Nevertheless, the infectious waste collection shows fluctuation on a daily level whereas the monthly amount remains nearly constant. Compared on a daily basis the amount of infectious waste accounts for 6-7% of the total health care waste (Appendix 9). This

amount is small compare to other developing countries. This is because most of the big hospitals in BMA area have their own incinerator, so they do not send their infectious waste to DPC.

Method of disposal

Other than infectious waste, all medical waste is collected along with municipal solid waste. These wastes are then sent to the municipal landfill site. Some private and big hospital incinerate almost all medical waste together since the capacity of incinerator is higher than the infectious waste produce in the hospital as well as all wastes are not properly segregated. Therefore, incineration, open burning (few), landfill are common mode of waste disposal in Thailand.

It is noted that recently all infectious waste generated in BMA area by the hospitals which does not have incinerator supposed to be collected by one private company (Krungthep Thanakom). The infectious waste is sent to the private driven Krungthep Thanakom company (Thai Australian joint venture). That private enterprise is operating a 2-line incinerator (capacity 20 tons/day) since June 1999. This company incinerates 10-ton waste per day. Other waste are sent to the land fill site along with municipal solid waste. There is no clear definition of infectious and normal waste. Recently BMA is employing another private contractor for waste haulage and disposal by sanitary landfill in there own land outside Bangkok area.

Problem, prefix and solutions of medical waste management

BMA found some difficulties in collecting and managing Medical waste properly. These problem and possible solutions are summarized in the table below (Table 4.14).

Table 4.14 The Problem, Prefix and Solutions Provided by BMA for Infectious Waste Management in BMA is as Follows

The problem and prefix	The solution
1. General waste mixes with infectious waste. It increases the volume/ amount of waste to incinerate which increases the cost of management as well (the cost of collection and incineration of infectious waste is about 8000 baht/ton). 2. Problem of collection and disposal of infectious waste. The amounts become large while waiting for the collection truck. This cause uncomfortable situation sometimes. 3. Improper packing of infectious wastes also a problem. Such as over loaded in the bag, tears off bags, leave sharps thing and not tie the bag. Therefore, the staffs handling that waste are in risk of infection.	• Advice hospital staff and officers about the consequences of improper handling of infectious waste and how to manage infectious waste correctly. • Seminar on effective manage of infectious waste from hospitals may organize. Representative from hospitals should attend it. For example in 2nd October 1997, there was one seminar on " The increasing effective to manage the infectious waste from the nursing home" and 500 persons from different hospitals participated on that seminar. • The officer should follow the timing of waste collection and allocate specific area to keep the infectious waste away. • Keep record of weight and amount of infectious waste. Advise hospital to follow the proper infectious waste management system.
4. BMA does not have enough officers and the small trucks (1 ton) to collect infectious waste. Therefore, the waste increases in the hospitals.	• Keep few reserve officers and purchase 5 trucks for infectious waste collection (2 tons each in 1997).
5. There is a risk of infection to the person who handles infectious waste. 6. The problem (to keep the waste at day and collect at night) of timing in collection. It should be at night to avoid traffic jam.	• Training to the truck officer, the officers who collect waste and incinerate. • Moreover, to make officer and hospital staff aware about infectious waste. As well as the officers at incinerator site.
7. The communication problem between hospitals and the collection officer and incineration site. Some small hospitals do not destroy/burn the waste in correct way. The officer should take care about it.	• BMA control the collection center where people send the waste. The people collect the waste at night from the bin. They got permission to do this from BMA. BMA looks over that collection center and controls the processing unit. • Ministry of Public Health works with BMA to solve the legislation of act 1993. The hospitals must separate the waste (infectious waste) for incineration. A ministry must control these things.

(source: BMA Annual report 1998)

Based on field investigation, literature, discussion and interview, the Medical waste flow and management is sketched down in the Figure 4.12 below.

Hospital/ Waste generation site

*Diff. colored bag for
diff. Waste
Disinfectant of IW
Separate diff categories*

*Separate items for
Reuse
Recycle/sale*

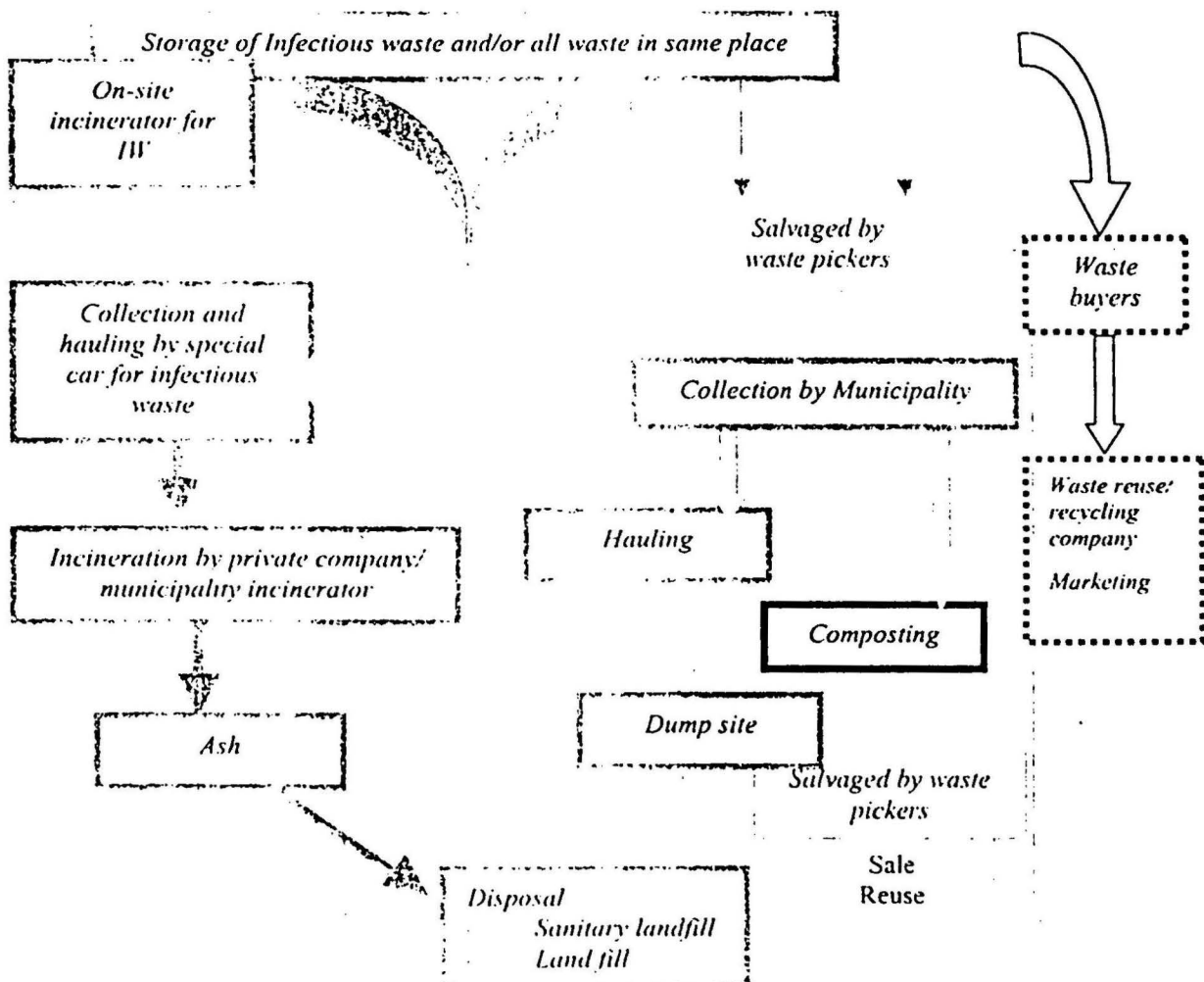


Figure 4.12 Medical Waste Flow in Thailand

4.3 Synopsis

4.3.1 The Case of Bangladesh

The health sector of Bangladesh is mainly operated by the Government, private entrepreneur and non-government organization. The Ministry of Health and Family Welfare (MOHFW) is the main public authority responsible for providing health care to the entire population. The City Corporation and municipality perform the role of waste collection and disposal in Bangladesh. City Corporation or municipalities do not have separate system for medical waste or infectious waste collection. There are few initiatives taken by local NGOs for medical waste collection, disposal and training for hospital staff. Dhaka City Corporation (DCC) has the capacity only to collect 50% of waste generated each day in the city. A variety of methods were used by the medical facilities for medical waste disposal. These included open burning, burial, incineration, dumping, and removal by municipal bins. Municipality has the system of land filling and open dumping of waste only. The hospital authority has not adequate awareness of proper handling and disposal of waste, at the same time government places little importance on this issue resulting in no intensive law and enforcement. Awareness has prioritized atop among all responses to improve the situation of MWM. In addition, job distribution, supervision and monitoring of activities in and outside hospital and adequate budget allocation in health sector are some of the issues identified by respondents. Hospital staff also mentioned that training is needed for cleaners or others and appropriate options for waste treatment and disposal is needed to improve medical waste situation in Bangladesh.

There is no well-established solid waste management system in the country, hence. Overall situation analysis showed the evidence of lack of resources (trained manpower, logistics, waste transportation cars, treatment facilities, adequate budget); population pressure; absence of training, monitoring, evaluation and regular reporting; and lacking in adequate law and law enforcement authority in proper medical waste management situation in Bangladesh.

4.3.2 The Case of Thailand

The Ministry of Public Health (MOPH) is the core agency in the Thai public health system. Within the MOPH, the Department of Health is the one to deal among others with all environmental issues. The private sector has played an important role in the provision of services at hospitals and clinics. Public sector agencies namely Bangkok Metropolitan Administration (BMA), Provincial municipality, local NGOs are involved in waste management. In Thailand, Bangkok Metropolis, the Department of Public Cleansing (DPC) is an important local government sector under the Bangkok Metropolitan Administration to look after medical waste management. Infectious wastes from hospitals are collected by BMA appointed Private Incineration Company in Bangkok. Local municipalities are responsible for medical waste collection along with other solid waste at provincial level. Other than infectious wastes, all medical waste is collected along with municipal solid waste. These wastes are then sent to the municipal landfill site. Incineration, open burning (few), landfill and sanitary landfill are common mode of waste disposal in Thailand. It was found that general waste mixes with infectious waste without proper segregation increased the amount of waste to incinerate which increases the cost of

management as well. Improper packing, availability of collection trucks, lack of trained manpower, timing of collection, and health risk are some identified problem of medical waste management in Thailand. Training, seminar, awareness building were emphasized to improve the situation.

Medical waste management is a part of municipal solid waste management system. Medical waste management situation analysis in Thailand indicated that hospital authority gave little attention on proper MWM; negligence in implementation, enforcement, and monitoring of existing law; lack of resource availability (trained manpower, improved technology, collection vehicle); and absence of specific law or regulation on medical waste management. Despite the situation is better than Bangladesh still needs improvement.

CHAPTER 5

Assessment: Existing Practice and Organization of Medical Waste Management

5.1 Status in Case of Bangladesh

5.1.1 Existing Practices of Medical Waste Management in Bangladesh

There were 51 doctors and 140 nurses were interviewed to get an idea about medical waste management practices in Bangladesh. These doctors and nurses were selected randomly from selected hospital and clinics; selection also done based on the total number of doctors and nurses in selected hospital i.e. small number were selected from small facilities and big number from large facilities. Different variables were used to determine waste management practices in the hospital along with the observation checklist. These variables were the way of medical waste dispose from this hospital (MWD_H); waste segregation before disposal of waste (WSBD); use of separate bag or bin for different kind of waste (BAG); method of waste disposal (MWD), place of medical wastes disposal (WMD); available waste treatment system (WTS). It was found that most hospitals had no waste management system in place. Municipal bins and dumping grounds were often used for disposal. Hospital authorities were found less concerned about proper disposal of medical waste.

It was found that most hospitals had no waste management system in place. During the study, a conclusion was reached that hospital authorities did not give a high priority to the proper disposal of medical waste. This finding was also corroborated from the interviews of doctors and nurses.

5.1.1.1 State of legislation in Bangladesh

Bangladesh lacks both effective waste management facilities and relevant government policy to guide health providers and punish offenders. Written waste management guideline/ procedure and rules/ regulations are lacking. Method for qualifying the waste generated, separating the waste before disposal, handling unexpected hazardous waste situation, and protecting cleaners/ others from infectious or potentially dangerous waste products are not well defined.

The earliest legislation (Bangladesh Gazette, 2000) in this country can be tracked back to the "Fatal accident Act 1855" passed by the British colonial government. To protect the people from health risks and to promote public health, health legislation in Bangladesh can be divided into six groups, namely (1) Vital registration, (2) Communicable diseases control, (3) Food and drug control, (4) Medical education, (5) Health practice, and (6) Environmental health.

This law does not say anything about the empowerment of the supervising authority. Moreover there is no indication about the status of the waste of the hospital. GOB has no written legislation, guideline, plan, or policy neither for the health care workers nor on HWM.

The Bangladeshi Government's Environmental Policy 1992 (Farooque & Hasan, 1996), has six general aims which have been further detailed into priority objectives for different sectors. Applicable to medical waste disposal practices is the objectives under the Health and Sanitation Category.

These objectives are as follows:

- 3.3.1. Prevent activities which are harmful to public health in all spheres, including development activities in the country
- 3.3.2. Integrate environmental concerns into the National Health Policy
- 3.3.3. Incorporate environmental issues in Health Education Curriculum
- 3.3.4. Ensure a healthy workplace for workers

Improper handling and disposal of medical wastes will undoubtedly not ensure a healthy workplace for workers, as well these activities also are harmful to public health.

The Bangladesh Environment Protection Act 1995, defines pollution as “contamination or alteration of the physical, chemical or biological properties of air, water, or soil, including the change in temperature, taste, turbidity, odor or any other characteristics of these or such discharge of any liquid, gaseous, solid and radioactive substance, the discharge, disposal and dumping of which may cause adverse/negative changes of the environment.” There is no specific legislation pertaining directly to the handling, transportation or disposal of medical waste in Bangladesh’s Environmental Protection Act 1995. However, medical waste can be classified under Section 2 (1) which defines waste as “any liquid, solid and radioactive substance that is discharged, disposed, or dumped which may cause adverse/negative change to the environment”.

In Bangladesh there are some laws (Bangladesh Gazette, 1997, Danna, 1999a, b, Farooque & Hasan, 1996), which have rarely influences on HWM system, these are:

- a) The Environment conservation rules 1997 –partly regulates waste management and disposal facilities. These rules classified polluting industries into four categories, such as
 - Green
 - Orange-A
 - Orange-A: includes pathological clinics
 - Red- includes Hospital
- b) import and export of hazardous wastes is regulated by the Import and export control Act 1950 (as amended) or Customs Act 1969, controlled by shipping ordinance 1979.
- c) Custom Act 1965.
- d) Environment Management Plan.
- e) Pollution effect abatement plan.
- f) Emergency plan for adverse environmental impact.
- g) Environment impact assessment plans (ELA).

Law number d, e, f and g have to be full fill on establishing new clinics / pathological center. However these rules does not indicate about the status, their standard and monitoring system of the hospital / clinic / laboratories. There are other laws, say

- a) Transport action may be controlled by Inland shipping Ordinance, 1979 or by Merchant Shipping Ordinance, 1983 or by Port Rules, 1967.
- b) The City Corporation Act still not covers medical waste treatment and disposal.

According to Environment Conservation Rules, Section 7(6) (c) and Ministry of Environment and Forestry to establish a clinic or hospital the following must be submitted:

- (a) Feasibility report of the project

- (b) Initial environment examination report (IEE). – Lay out plan, flow diagram
- (c) Effluent treatment plant (ETP)
- (d) No objection certificate from the local authority
- (e) Pollution effect abatement plan along with Emergency plan for adverse environment impact
- (f) Other necessary information's (where applicable)
- (g) Environment Impact Assessment (EIA)
- (h) Ministry of Environment and Forestry: clinic should be in non-residential areas.

According to Environment Protection Act 1995, and Environment Conservation rule 1997, all establishments must get certificate from DOE, even the old one. There is no specification for hospital, but to get a certificate from DOE (e.g. for gas line or electricity connection) they need to follow DOE's guideline. There is emission standard for industrial waste disposal, which may partly apply for medical waste disposal still it does not cover all aspects of medial waste. But there is no specific law or even guideline to regulate the waste management process of the hospitals, clinics or pathological laboratories.

However there is no indication about the standard of the clinic or hospital before the law came into force. The Directorate of Health Services issues "registrations" for the clinics, but they have few old fashioned criteria for registration and the criteria are ill defined with a number of black holes (Line Director, 2000).

Very recently the Directorate General of Health Service under the Ministry of Health and Family Welfare has published a manual for medical waste management that might have influence on improving the waste management in hospitals (Line Director, 2001). However, it has not been put to practice yet.

Regulations covering disposal of medical waste

At present there is no law or regulation that specifically regulates medical waste generation and its management in medical establishments. The government has no written legislation, guideline, plan or policy for medical waste management and/or for the protection of health care workers. Very recently the Directorate General of Health Service under the Ministry of Health and Family Welfare has published a manual (Line Director, 2001) for medical waste management that might have influence on improving the waste management in hospitals. However, it has not been put to practice yet. Without effective laws or regulations hospitals may be reluctant to follow the instructions mentioned in this manual.

In September 2000 Department of Environment (DOE) committee has recommended guidelines/rules to include environmental aspect in the "Ministry of Health and Family Planning Clinic Act 1999". This is to find out environment friendly techniques for clinic establishment and clinical waste disposal/management in Dhaka City. Title of the proposed draft for medical waste management guideline/rules is "Bio medical waste management and process guideline/rules (2000.2001)".

This draft included:

- Definition (authorization, authorized person, bio-medical waste treatment facility, occupier, operator of bio-medical waste facility)
- Duty of occupier
- Treatment and disposal

- Segregation, packaging, transportation and storage
- Authorization (committee)
- Advisory committee
- Annual report
- Maintenance of record
- Appeal
- Categories of bio-medical waste (1-9)

According to environmental law 1995, and guideline 1997, all establishments must get certificate from DOE, even the old one. There is no specification for hospital, but to get a certificate from DOE (e.g. for gas line or electricity connection) they need to follow DOE's guideline.

5.1.1.2 Waste segregation before disposal

Segregation of waste before disposal, except for syringes and needles, was not practiced by the sampled hospitals for questionnaire survey. Ninety percent of doctors and 64% of nurses mentioned that there was no waste segregation before disposal (Figure 5.1). Only 3 doctors from private clinic mentioned about segregation, though 35.3% nurses mentioned about it but that is not in practice in their hospital. As is the normal practice, waste pickers or cleaners sort out this waste and separated items that can be sold again. Since separate bags are not used (Figure 5.2) for different types of waste, these workers sort through all types of hazardous *and* non-hazardous material. Only in a small number of private hospitals and research centers, infectious waste⁶ was kept separately in red bags or buckets.

Proper separation of waste has been introduced in some larger hospitals and some private clinics. Such as IMCH separate sharps, needles, glass, clinical and food waste in separate waste bin or box. ICDDR,B separates laboratory culture and waste, needles, and glasses. Some other hospital and clinics also practice separating needles, syringes and infectious waste. These have a slightly superior practice of HWM. In general, however, there is no system for segregating the waste before disposal and no mechanism for handling hazardous waste. Nevertheless most of the hospitals separates needles and syringes those are then sent to the central store for getting new supplies.

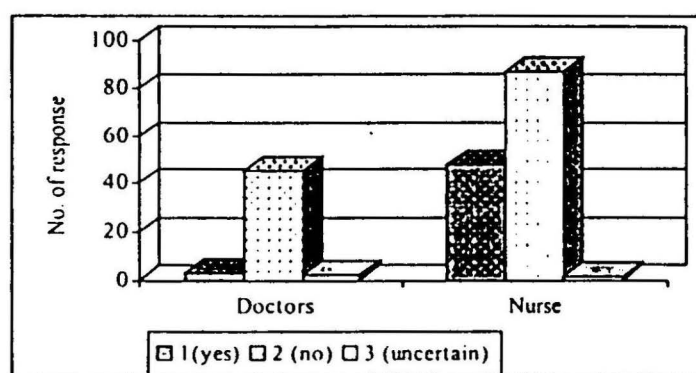


Figure 5.1 Waste Segregation before Disposal

⁶ Infectious waste: No clear definition by them. This includes body fluid, drainage bags, blood collection tubes, culture, gauze, bandages or any other materials that were in contact with infectious agents or blood, pathological waste including organs, body parts, tissues.

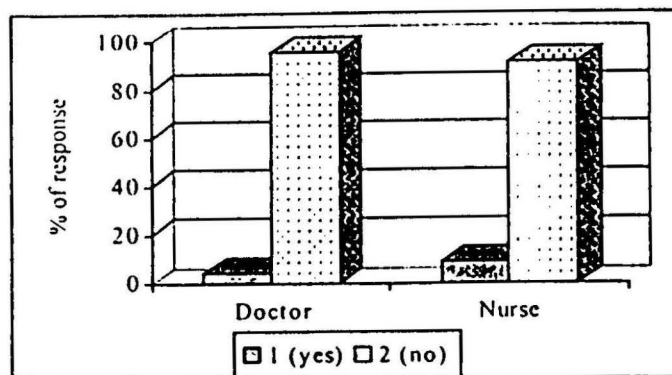
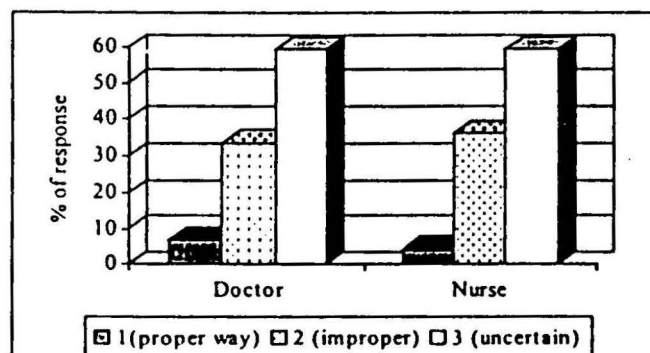


Figure 5.2 Use of Different Bag for Different Kind of Waste

5.1.1.3 Place and method of medical waste disposal

A large number of hospitals dump their waste in common places like public garbage disposal bins, sides of roads, surroundings of hospitals, or City Corporation's waste collection sites. Medical waste could be found in rivers or canals near some bigger hospitals, though a few hospitals store their waste within their own net house or in closed dustbins before sending to the City Corporations' bins. The hospitals, clinics and diagnostic centers used different methods to dispose of waste. Generally solid waste were disposed from hospitals in improper way with few exception (6.98% doctors and 4.41% nurses). Third category of disposal (uncertain) also falls into improper way as well (Figure 5.3).



1. Proper way: Covered bucket, cartoon, plastic bag, burn, and cart/ trolley.
2. Improper: dustbin, basket, open place, river, and dumping.
3. Uncertain: Selling (maximum), carried by plastic bowl, drum, taken by social welfare association and ward master/ boy.

Figure 5.3 Way of Medical Waste Disposal from Hospital

In the absence of an appropriate system, a variety of methods were used for the disposal of waste. These included incineration, open burning, burial, selling, dumping, reuse and removal by City Corporation trucks. Waste is collected informally mostly by waste pickers, cleaners and *ayas* (*women health workers*), and is then sold to hawkers and small traders. It was found that syringes, vials, slides, empty packets, bottles and saline bags, used X-ray film developing chemicals, were some of the items collected un-safely and re-sold. But the respondents were reluctant to mention about it.

In most cases, there is no facility or specifically assigned site for burning medical waste. The burning takes place in open fields and pavements near hospitals and clinics with the help of cleaners. Though 21% doctors and 18% nurses mentioned burning as a process of disposal, it was found that few understood that selected solid waste should be burnt e.g.

Sputum from TB patients, tested slides, spoiled bed-sheet, mattresses. Other infectious waste was also disposed by burning. Some items are also buried near the medical facilities (11%) or within the hospital compound (3%). In some hospitals, cleaners buried fetuses and placenta in the soil near the rivers or the morgues.

Most medical wastes dumped together in a common place like roadside, hospital surrounding, and municipal dustbins. 64% doctors and 76% nurses were agreed about it. Similar result was found also in asking about the place of waste disposal from hospital. 72% nurses said that waste was dumped in a common place The doctors interviewed (43%) said that disposal of selected solid waste such as placenta, syringes, TB slides or sputum in a 'proper place' takes place. When asked to mention what constitutes 'proper place' for disposal, the respondents listed (open) burning grounds, burial under the soil (indiscriminately), or closed dustbins within the hospital boundary. Figure 5.4 and Figure 5.5 illustrated the result of method and place of waste disposal from hospital.

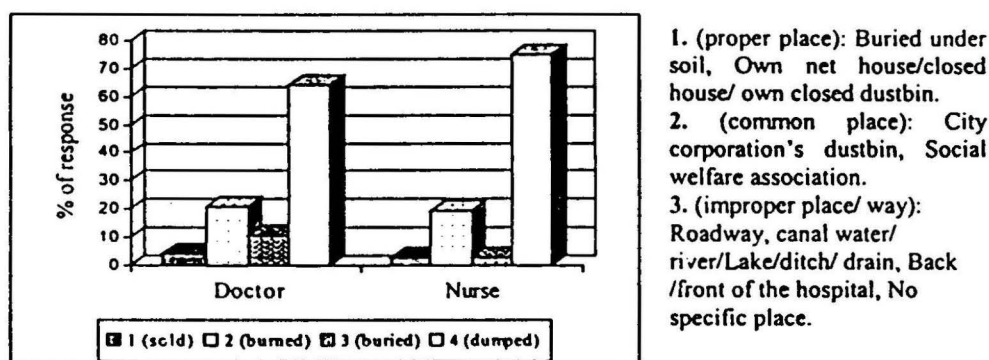


Figure 5.4 Method of Waste Disposal from Hospital

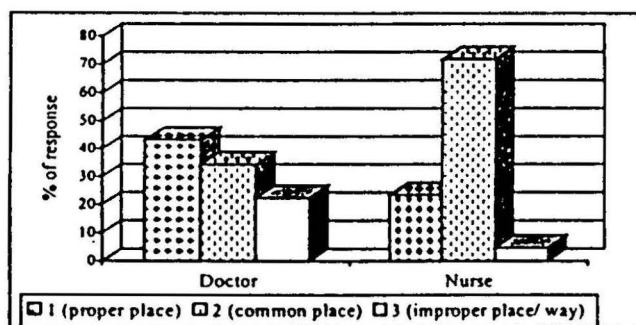


Figure 5.5 Place of Waste Disposal from Hospital

5.1.1.4 Awareness

Awareness level of hospital staff (doctors and nurses)

Some selected questions were asked to doctors and nurses to determine their knowledge on medical waste or to know the level of awareness about it. Selected questions included number of years in this service (NOYR); Kinds of waste as they know (KDW); Quantity of waste if they were aware about it (QNWS); If anyone voice concerned about disposal of medical wastes (VOIC); Toxic/hazardous elements in HW as they know (TXE); Knowledge on waste dangerous for health (DNGH); Knowledge on environmental impact of improper disposal (ENV); Kind of waste recycled from hospital as they know (REW); and knowledge about harmful impact of recycling (HIR). Work experience of doctors interviewed were ranges from one year to 17 years of services. Most of them were 6 to 10

years in their job (47.5%), only 6 respondents have 11 to 17 years of experience in their job. Contrarily, most of nurses have 11 to 20 years of working experience though nurses were more or less equally distributed in different years of experience group (Table 5.1). There were only 4 nurses have more than 20 years experience.

Table 5.1 No of Year in Medical Service

Years	Doctors		Nurse	
	Respondent	Percent	Respondent	Percent
1 to 5 yrs	16	38.1	51	32.9
6 to 10 yrs	20	47.5	49	31.6
11 to 20	6	14.4	51	32.9
Above 20 yrs			4	2.6

Doctors and nurses are responsible for generating a significant part of medical waste. Some examples include syringes, needles, waste from emergency wards, OT, and OPD (including blood, body fluids etc.). Each visit to a patient generates some kind of waste. Hence, their awareness of the disposal methods is crucial, lest it seriously harms waste handlers and other members of the public.

The results from some specific questions that were asked to doctors and nurses to determine their knowledge about medical wastes and the adverse impact it may have unless properly disposed are summarized in Figure 5.6. Please note that waste handlers knew nothing about the medical waste issue, therefore, their survey was discarded from this section.

Knowledge on the composition of medical waste among doctors and nurses

There was insufficient awareness about the issue of medical waste among the respondents at both levels. Through medical college education and by handling medical substances while in the hospital, doctors and nurses ought to know the composition of medical waste and hence its harmfulness when not disposed properly. They were requested to name the composition of some medical waste. From their responses, it was clear that the level of awareness was low. Sixty nine percent of the doctors and 92% of the nurses sampled described medical waste as general waste. The very small remaining number considered that blood, urine, stool, sputum, chemicals, infectious waste, and body parts as medical waste. It seems that most respondents were not aware what to be considered as medical waste. Still, doctors (64%) were more aware of the toxic elements in medical wastes; such as pathogens, as compared with nurses, who were less conscious about it (46%). However, 98% of doctors and 95% of nurses were able to recognize the health risk associated with toxic medical waste. Seventy seven percent of nurses were aware of the *quantity* of waste generated from their hospitals while the doctors (44%) had less information on it. These doctors had a working experience of five to ten years. Fifty four percent nurses were uncertain about the presence of harmful elements in medical waste even 35% doctors were not aware about that. They could just mention that there might be something toxic or hazardous but they could not explain or mention those things. The respondents, who were aware about it, they mentioned that pathogens present in medical waste might be hazardous to human health. Some of them also explained the hazardous elements of medical waste and the source of those elements. It was found that nurses were less aware about the harmful elements in medical waste then doctors. This is likely due to the lack of awareness

among the respondents and negligence of the authority of the hospitals to treat medical waste as a special waste.

Awareness about the environmental impact of improper disposal

It was quite impressive to see that 98% doctor and 94% nurses were able to recognize the risk associate with medical waste on health. A few respondents said that poisonous chemicals or pathogens could be transmitted to human body from medical waste. With regard to the environmental impact of medical waste, 90% doctors and 87% nurses were aware about environmental impacts of medical waste. Although a minority of those questioned were not aware of the presence of toxic elements in medical waste, they were able to explain how the burning of toxic elements, such as plastic, affect the human health and environment. Most of them knew how it is harmful to health and environment when plastic or infectious waste is burned and how infectious waste can affect human health. This is because of education level of both groups and their experience in the job.

Knowledge on kind of waste recycled from hospital and its harmful impact

Most of the respondents did not have any idea (no idea or uncertain) about recycling of medical waste, since they did not deal the disposal of waste. But they knew or were aware about the harmful impacts of recycling (Table 5.2). In this regards doctors (86%) had better idea than nurses (70%). All of the respondents explain the harmful impacts of recycling as infection. It seems that they did not have enough knowledge on recycling of medical waste, though most of the items are recycled from the medical waste.

Table 5.2 Knowledge on Recycled Items from HW and Harmfulness of Recycling

	Doctors Percent		Nurse Percent	
Items recycled				
1. all plastic items	10	12.82	13	6.50
2. no idea	9	11.54	27	13.50
3. uncertain	59	75.64	162	81.00
Harmfulness of recycling				
1. no idea	7	13.7	47	29.94
2. infection	44	86.3	110	70.06

Voice concern about medical waste management

Although doctors and nurses get little training on waste management as the college medical curriculum has no specific topics that relate to *waste* generation, they can still influence the hospital authorities with regards a proper disposal of waste. Seventy one percent of nurses seemed to be aware of the current waste disposal practices such as dumping in a common place. Still, it is increasingly difficult to influence higher authorities since nurses, lab technicians, and health workers receive no training, formal or informal, on the handling and disposal procedures and have no direct say in the matter. Fifteen percent of doctors and 27% of nurses said that they learned about waste disposal from someone outside of the hospital, or from the mass media. Although 75% of doctors and 58% of nurses also mentioned textbooks as a source of knowledge, the information was not specifically on the *handling* and *disposing* of medical waste. There are a few NGOs that have developed

training manuals for HWM and have started providing training for hospital staff. These are still in its initial stages and are applied only in small clinics.

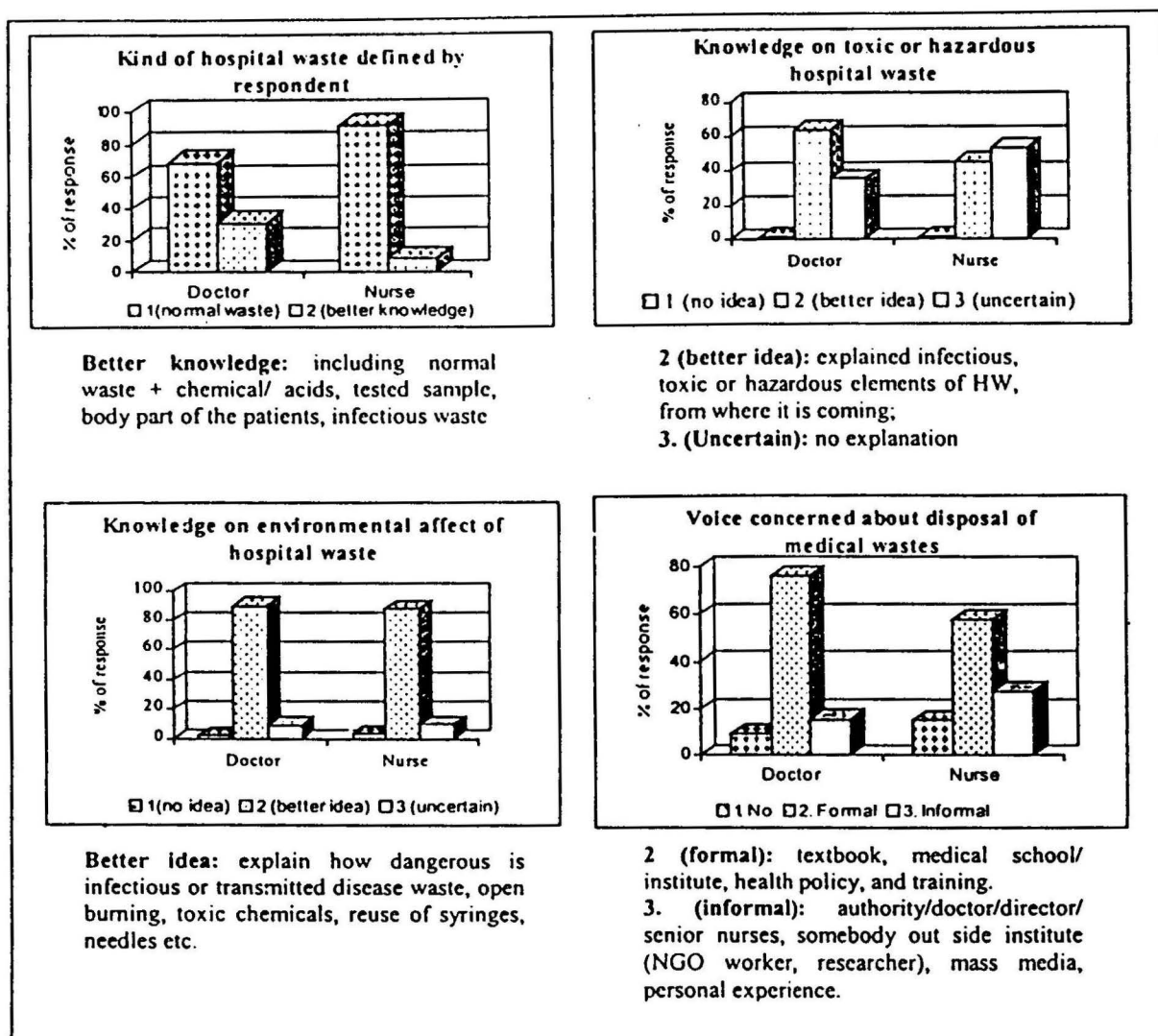


Figure 5.6 Awareness Levels of Hospital Staff

There was a general lack of knowledge and interest in safe waste disposal amongst those interviewed. A study by Akter *et al.* (1999) showed that, there was insufficient awareness about the magnitude and importance of safe disposal of medical waste across the board from hospital administrators down to waste pickers. Nevertheless, the doctors and nurses questioned seemed sensitive to the improper reuse or recycling of medical waste, even though they stressed that waste handling is not their duty. They (hospital authority, management personnel, doctors and nurses) recognized medical waste management as a problem but they seem to put the problem at low priority or overlook it.

Director, divisional heads, hospital authorities, and management personnel interviewed seem to be aware of the issue of medical waste even though they did not express much concern about its safe disposal during the survey. In government hospitals respondents were straightforward in their response to the question on waste disposal. However, private clinics and hospitals were found to avoid responding to some questions and seem to hide the improper disposal practices in their hospital. Some of them think that they are handling it properly, and it was found that they only separate used syringes and needles, which are

then burned in open places. Similarly Dana (1999) referred to a director's view that, medical waste do not require any segregation or separation and what happen to the waste after it disposed off it is not hospital or director's concern. It is city corporations' responsibility as one director mentioned (Dana, 1999). During the survey, no director or authority was able to show any guideline on medical waste management except in the case of an autonomous medical institute. Many respondents pointed out that there is lack of availability of funds for effectively implementing safe waste disposal. They also pointed out that there is a lack of initiative from the government to ensure safe disposal of medical waste and hence, an absence of laws. Since there is no authority/watchdog, and no legal binding, little trouble is taken to follow the correct procedures which involves some costs. It was also clearly stated by some, that before implementing any policies or regulations, the government must provide facilities and solutions to dispose the waste properly. During the survey, most of the directors did not agree to pay extra service fee for medical waste treatment as they said that government should take care of medical waste issue and provide the facilities for waste disposal and treatment. Another study on medical waste management at Dhaka city (Rashid, 1996) also concluded that there is a lack of knowledge and interest in safe waste disposal by most health workers and an absence of a budget to effectively implement safe waste disposal.

NGOs like BCAS⁷ and BRAC⁸ have recently started awareness building or training on medical waste management for selected small hospitals or clinics and among NGO officials. DGHS published a manual (Line director, 2001) for hospital waste management in Bangladesh and several training manual. All of these are in experimental or pilot phase.

5.1.2 Institutional Involvement

In Bangladesh, there is no identified or responsible institute that should take care of medical waste. At the national level, the Ministry of Health and Family welfare (MOHFW) is responsible for policy, planning and decision making at macro level. Directorate General of Health Services under the Ministry of Health and Family Welfare is taking care of the health issue. As a part of their responsibility they have just started an exploratory work on medical waste management (line director, 2000) and came up with a manual (Line Director, 2001) on medical waste management. In general City Corporation is involved in collecting and disposal of medical waste along with other municipal waste. Department of Environment under the Ministry of Environment and Forest is trying to set criteria, definition and guideline for different kind of medical waste. There are some local level NGOs in collaboration with City Corporation and donor agencies involved in medical waste management as a part of their municipal waste collection projects.

5.1.3 Statistics on Waste Recycling and Reuse

To know about the use of medical waste, hospital cleaners, workers, and waste pickers were interviewed. Results are shown in the Table 5.3. As their response 55% of medical waste are reused or recycled, of which 28% are plastic bags, 30% are saline set/bag/rice or urinal pipe, and 42% are glass and paper made things. Purpose of use of medical waste are categorized as selling (23%), as fuel (7.5%), reuse as container, wrapping (9%), and 60% were as dumped or store in storehouse considering all medical waste. Sources of those wastes are inside hospital (89%), 10% from dustbin. Most of the garbage used as waste pickers/ local residence mentioned (52%) was saline set, syringes, vial etc. Twenty six percent mentioned about plastic items mostly plastic bags, only 22% mentioned about

⁷ Bangladesh Center for Advanced Studies

⁸ A national development NGO

paper box and paper items use. Eighty five percent respondents said that the reusable garbage are sold, only 14% used as fuel and 9% said about reuse as container, wrapping. Most of the respondents said that the source of garbage was inside hospital and 27% mentioned the source as dustbin near hospital.

Table 5.3 Items Collected by Cleaners and Waste Pickers, Purpose of Use and Source of Medical Waste

Collected items	Cleaner	W/pickers
1. plastic bag	15.32	26.36
2. Saline set/ bag/rice tube/ urinal pipe	16.67	51.94
3. Glass/Papers/ box/ bottle	23.12	21.71
5. Useless	44.89	
Purpose of use		
1. Sell	23.13	85.5
2. Fuel	7.5	13.6
3. Reuse	9.38	8.6
4. Other	60	3.5
Source of garbage		
1. Dustbin	9.85	27.4
2. Inside hospital	88.64	72.6
3. Visitors	1.52	

Combination of reusable item was different in the dumping site (Table 5.4), as all waste from the city was dumped there not only medical waste. There was only 1% medical waste was collected from dumpsite those were saline set, syringes, vials, medicine bottle. But still it can be noticed that saline set or syringes are reused or recycled from dumpsite even. Most of the items collected from dumpsite were plastics (33%) and metal/glass (32%) and others were brick, stone, bone, paper and wood. Items collected from dumpsite were sold (53%), used as fuel (18%), though 28% respondents did not say anything about it.

Table 5.4 Combination and Uses of Waste Collected by Waste Pickers from Hospital and Municipal Dumpsite (% of responses)

Items collected			
Hospital site		Municipal dumpsite	
1. Plastic	26.36	1. Plastics.	33.42
2. Saline set/syringe/vial	51.94	2. Hospital waste (syringes, saline bag, pipe, vials)	1.03
3. Paper, box	21.71	3. Paper/wood	19.03
		4. Metal/glass	32.39
		5. Brick/stone/bone	14.14
Purpose of use			
1. sell	76.92	1. Sell	52.63
2. Fuel	12.31	2. Fuel	18.42
3. Reuse	7.69	3. Reuse	0.88
4. Uncertain	3.08	4. Other/ no answer	28.07

5.1.4 Health Effect of Medical Waste and Solid Waste

Medical waste is a source of contamination and pollution to both humans and the environment. Medical waste is capable of causing diseases and illnesses to people, either through direct contact or indirectly by contaminating soil, groundwater, surface water and air. Wind from these dumps can also carry pathogens and hazardous materials. Where domestic animals are allowed to graze in open dumps, there is a risk of reintroducing pathogenic microorganisms into human body through food chain. Medical waste therefore, poses a risk to individuals, communities, and the environment if not carefully handled. Waste disposed from medical was analyzed and discussed in section 5.1.4.1.

Those handling the medical waste were often cleaners, sweepers, ward boys, *ayas*, and laboratory assistants. In addition, waste pickers and people living near hospitals or disposal bins also come in contact. Since nurses are always dealing with patients they are also exposed to the waste generated from the hospital ward or laboratory. Respondents from all these groups were interviewed to determine whether they are suffering from any diseases and if so, whether these diseases are linked with the exposure to medical waste. Results are discussed in section 5.1.4.2.

5.1.4.1 Pathological analysis indicating the improper disposal of medical waste

Samples from disposed medical waste were analyzed to ascertain if they contain any harmful pathogen. Detail of the collection and results are shown in the appendix 10. The presence of few selected pathogens in medical waste indicates the un-safe disposal of infectious waste without any treatment.

Pathogens found in the waste samples are responsible for different kind of bacterial diseases. Such as, tuberculosis, leprosy caused by *Mycobacteria*, typhoid and para-typhoid caused by *Samonella*, *Shigella spp.* Different kind of fever, sore throat caused by *fecal streptococci*, dysentery by *Amoeba* and cholera or diarrhoeal disease caused by *Vibrio spp* / *Aeromonas spp.* Presence of coliform and fecal coliform in any waste sample indicate the presence of other pathogenic organisms as well as absence of sterilization or any treatment of waste. The presence of above-mentioned pathogens in the analyzed medical waste provides a clear indication that the wastes have not been disposed properly. Both humans and animals have the potential of being exposed to severe health risks. As Colgate (2001) mentioned, bacteria are the most successful living organisms on this planet and many can be hazardous or even fatal to humans. The highest concentration of such organisms can be found in hospitals and consequently medical waste poses a potential risk for staff, patients and operators responsible for its eventual disposal. History of diseases in the respondents of this study may support the aforementioned findings of pathological analysis of waste (next section). Though it was not possible to analyze all pathogens responsible for infectious diseases found with the respondents because of limitations of technical and laboratory facilities in Bangladesh, the presence of some infectious microorganisms in the waste sample directly collected from hospital indicates that there might be some other infectious agents also present in the waste. Some selected pathogens present in laboratory analysis indicate it's potential adverse effect on health.

5.1.4.2 Exposure to the diseases

Disease within 15 days of contact

A survey was done to determine the prevalence of diseases within 15 days before the survey was carried out. It was found that 41% of the nurses interviewed were suffering from diseases contracted within the 15 days. Similarly, 60% of the cleaners and *ayas*, and 57% of waste pickers and local residents (wp-lr) were also suffering. From municipal

dumpsite (dump), 85% had some kind of diseases within 15 days. Apart from that, 11% of nurses and cleaners, 19% of waste pickers and local residents, and 7% residence in municipal dumping site had infectious diseases. Disease occurrence and type of diseases are shown in Figure 5.7. *The infectious diseases contracted within 15 days of exposure were skin diseases, allergy, hepatitis B/ C, diarrhea and dysentery.* The majority of those infected consulted physicians and showed their prescription to the interviewer. The lists of diseases found during interview are added in the appendix 11.

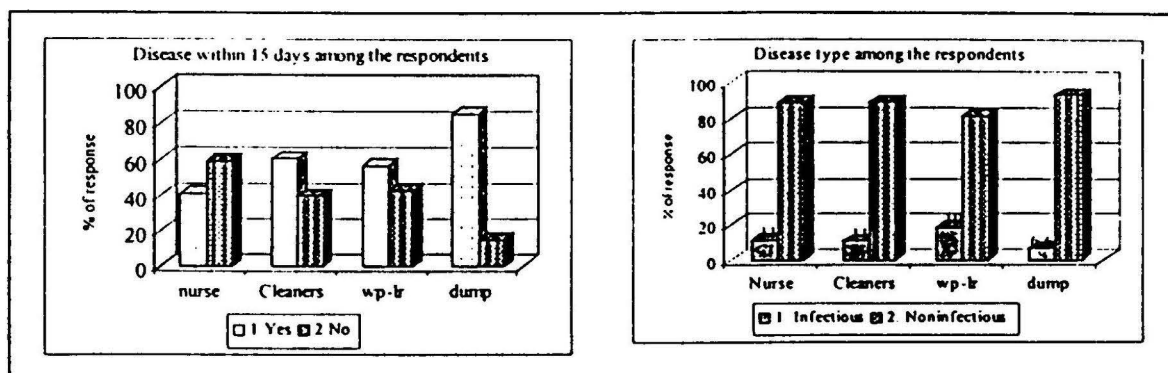


Figure 5.7 Disease Occurrences and Type of Diseases Among Respondents

Chronic diseases

Chronic diseases were assessed within the sample population. Figure 5.8 illustrated the findings. Forty seven percent of the nurses were suffering from chronic diseases, out of which 13.38% were infectious, and some of which were existing for approximately a year (45%). Thirty seven percent of the diseases were clearly stated to be job related, although 48% of respondents were reluctant to speculate the source. About 89% of the respondents consulted physicians. According to them most infectious diseases was job related. As they mentioned there was lack of facilities to disinfect hands or instruments after dealing with patients. Furthermore, hospitals are overcrowded with patients and they are forced to work far beyond their capacity. Therefore, it is difficult for them to handle all patients with proper care and precaution. Some of respondents had more than one disease suffering for longtime, none of those were infectious in sample population.

Among the cleaners and workers, 64% had chronic diseases of which 39% were infectious. Fifty five percent of them were suffering for up to one year. Forty one percent mentioned that hard work and care for patients resulted in contacting these diseases. Infection might come from the patients as they mentioned (job related). Twenty eight percent did not give any clear answer as to how they contracted the disease. Fifty five percent of waste pickers and local residents were also sufferings from longtime diseases (2 to 5 years) during the investigation, of which 41% were infectious. A small number (7%) had more than one infectious disease. Twenty six percent stated that this was due to the handling of waste and the unhygienic environment in which they live. Many were unaware of the cause of the diseases (57%), and hence 77% percent went to see a physician. Few respondents had more than one (4%) infectious diseases, but 77% diseases were not categorized as infectious or non-infectious diseases, such as complicated disease, respiratory problem, some kind of tumor etc.

From dumping site interview, it was found that 83% of respondents had long time diseases of which 24% was infectious diseases, 40% were suffering for up to one year and 35% for up to 5 years. Most of them (61%) mentioned that they got the diseases because of

garbage handling/ working near garbage, infection from food near dumping, problem from water and dirty environment. Only 51% of them went to see doctor and 92% were able to show their prescription. 23% of the respondents had more than one disease that was infectious and 77% were non-infectious diseases.

Longtime infectious diseases were Hepatitis B/ C, typhoid, skin disease/ allergy, diarrhea, dysentery, TB, and malaria.

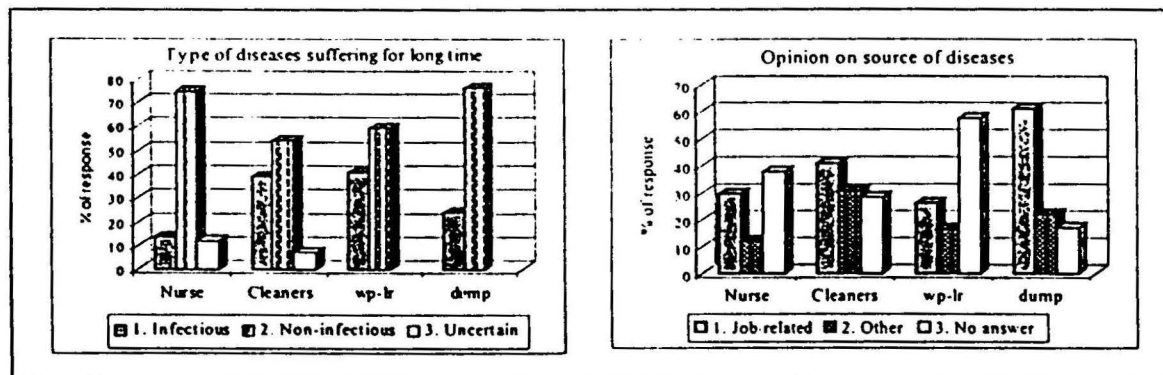


Figure 5.8 Chronic Diseases and Source of Diseases as Respondent's Opinion

It was reported, "Solid waste pollution is causing the spread of at least forty-nine vector-borne diseases like typhoid, dengue, diarrhoea etc in the capital city Dhaka of Bangladesh (The Daily Star, 2000). According to Gleis (1997), wastes arise in the following diseases: cholera, leprosy, anthrax, paratyphoid A, B,C; pestilence, smallpox, poliomyelitis, dysentery (bacterial), rabies, tularemia, typhus abdominalis, virus-induced hemorrhagic fever, brucellosis, diphtheria, meningitis/encephalitis, Q-fever, glanders, tuberculosis (active form) and virus hepatitis need for taking additional measures (e.g. separate collection, disinfection). Results from the type of pathogens concerned involved (especially their risk of communicating diseases and their viability), the route of transmission, the extent and type of contamination, and the waste quantity.

5.1.4.3 Injury/ accident

Information was collected from cleaners, waste pickers and local residents in and around the dumping sites. There were several incidents of injury due to the handling of solid waste inside or outside hospital premises. These injuries occurred from broken glass, needles, and other metals present in the waste. Some examples include the following:

- Hands/ legs cut due to handling of broken glasses, sharps, metals
- Fingers permanently damaged/curved, and/or legs, hands, fingers paralyzed due to injury by needles
- Puss due to injury
- Ulcers on legs
- Skin diseases on legs and hands (a minority-2%)

About 67% cleaners and 68% of waste pickers and local residents mentioned about injury caused by exposure of medical waste. Among them 99% and 91% respectively listed cuts and some paralyse as main types of injuries. Residence or waste pickers in dumping site also experienced the same accidents from solid waste dumping site, 95% of them mentioned about cuts/injury/paralyse and 5% mentioned about skin disease and ulcer on hand or legs.

5.1.5 Available Treatment Technology and Practices in Bangladesh

Mostly used infectious waste treatment techniques are **autoclaving, closed or open burning, and incineration**. However, the respondents from selected hospitals, 78% doctors & 69% nurses, pointed out that there are no waste treatment systems in hospitals except boiling or autoclave. In a few places, selected wastes like microbial culture, slides were autoclaved. 22% of doctors and 31% of nurses were aware of the autoclaving practices (Figure 5.9). The autoclave, however, is performed before any laboratory analysis or testing of infectious samples takes place. Hence, at the end, all these tested samples and microbial cultures are dumped together with other waste. Body parts, fetus are buried under soil.

It was noted that very few hospitals and research centers have incinerator to burn clinical or infectious waste e.g. IMCH, CMH, ICDDR,B. In the majority of hospitals there is no incinerator or an alternative. It was noticed that some private hospitals or clinics send their infectious waste to ICDDR,B incinerator. There was a central low cost incinerator operating in Khulna district to burn infectious waste. There are some good quality incinerators installed in big hospitals like Dhaka Medical College Hospital but because of environmental problem that may occur due to air emission DOE did not give permission to use those incinerator. However, they did not suggest any alternative options for infectious waste treatment.

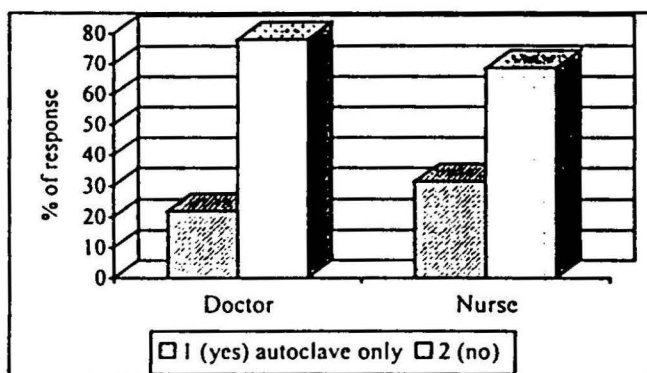


Figure 5.9 Waste Treatments before Disposal from Hospital

5.2 Status in Case of Thailand

5.2.1 Existing Practice of Medical Waste Management in Thai Hospitals

Results for this section were done through interview and discussion with key informant such as manager, in-charge, supervisor, divisional head, director and managing director as well as interview with doctor and nurses. At the same time secondary data from literature and direct sources were used to analyze the situation. Few secondary analysis were done using data from Paranan's (1997) questionnaire survey where 22 doctors, 83 nurses, 68 cleaners and collectors were selected.

5.2.1.1 State of legislation in Thailand

In Thailand, Department of Health, a sector under Ministry of Public Health, is the government sector that has responsibility in the scheme of infectious waste management according to the Act of Legislation of Public Health 1992. As of 1992 the ministerial regulatory scheme of infectious waste management and control there are certain

requirements to collect, transfer and disposal of infectious waste. Department of Health has appointed the working group to establish the definition of infectious waste and the infectious waste management guideline. This working group has finished this work and has offered the draft final ministerial regulation to ministry of Public Health to make decision. This draft will declare to enforce in the near future. Nevertheless, There are ministerial requirements about the collection, specific container, storage, and transport, of health care waste are determined. It has also detailed explanation and guidelines on how to deal with infectious waste e.g. collection transport and treatment (Appendix 12). During the year 1998 the MOPH published several manuals on the health care waste management in hospitals above 100 beds and for smaller size hospitals (30 to 100 beds). For hospitals above 100 beds it is obligatory to operate a furnace for the incineration of infectious waste. Basic disinfection is supposed to be carried out where hospitals in provincial areas do not have on-site incinerators. Besides these outlines all kind of facilities treating waste have to fulfil the emission standards for air and liquid discharge, but it is not specified for hospitals (Appendix 13).

In Thailand, various laws and organizations are involved with solid waste management. None of these laws provide guidelines, criteria, or regulations for waste separation, collection, transportation, disposal and monitoring. Nowadays, Thailand has no intensive law to enforce in medical waste management. There are some laws, which indirectly influence medical waste those are related with hazardous waste management. Hazardous waste management is implemented in several organizations (Ministry of Science, Technology and Environment, Ministry of Public Health, Ministry of Industry, Ministry of Communication and Ministry of Agriculture and Cooperatives). However there are no specific laws which control hazardous waste at source. As a result, various laws and implemented organizations are involved with hazardous waste management. Organizations in the Ministry of Science, Technology and Environment, and Ministry of Public Health are responsible for the management of hazardous wastes.

Since the early '90s, Thai officials have recognised the environmental impact that unprecedented growth has had, particularly in the Bangkok Metropolitan Area (BMA) and Eastern Seaboard (ESB). Attempting to balance its overarching economic ambitions with the search for solutions to environmental degradation led to a major revision of important laws affecting the environment. Those are shown in Figure 5.10. These Acts and the Labour Relation Act of 1977 have enacted various announcements, notifications, standards and regulations as well as enforced the requirements regarding the environmental impact assessment.

Two direct laws that control each type of hazardous waste are the Hazardous Substances Act of 1992 and the Enhancement and Conservation of National Environmental Quality Act of 1992. None of these laws mentioned anything about medical waste or infectious waste. At present, indirect laws related to hazardous waste management is only The Public Health Act of 1992. Other than these, the Pollution Control Department, Ministry of Science, Technology and Environment, proposed a Master plan for management of municipal hazardous waste. This plan consists of 11 operating plans covering development of laws and other regulations such as determining sources, separation, storage, collection, transportation, treatment and disposal of municipal hazardous waste. The operating plans included incinerator for infectious waste and hospitals under its' waste minimization for target sources.

After reviewing the laws and legislation, it was found that, various laws and organizations are involved with solid waste management. None of these laws provide guidelines, criteria, or regulations for waste separation, collection, transportation, disposal and monitoring.

There is problem of law enforcement, current laws and regulations are not updated to present situations. Therefore it is difficult to change and improve them.

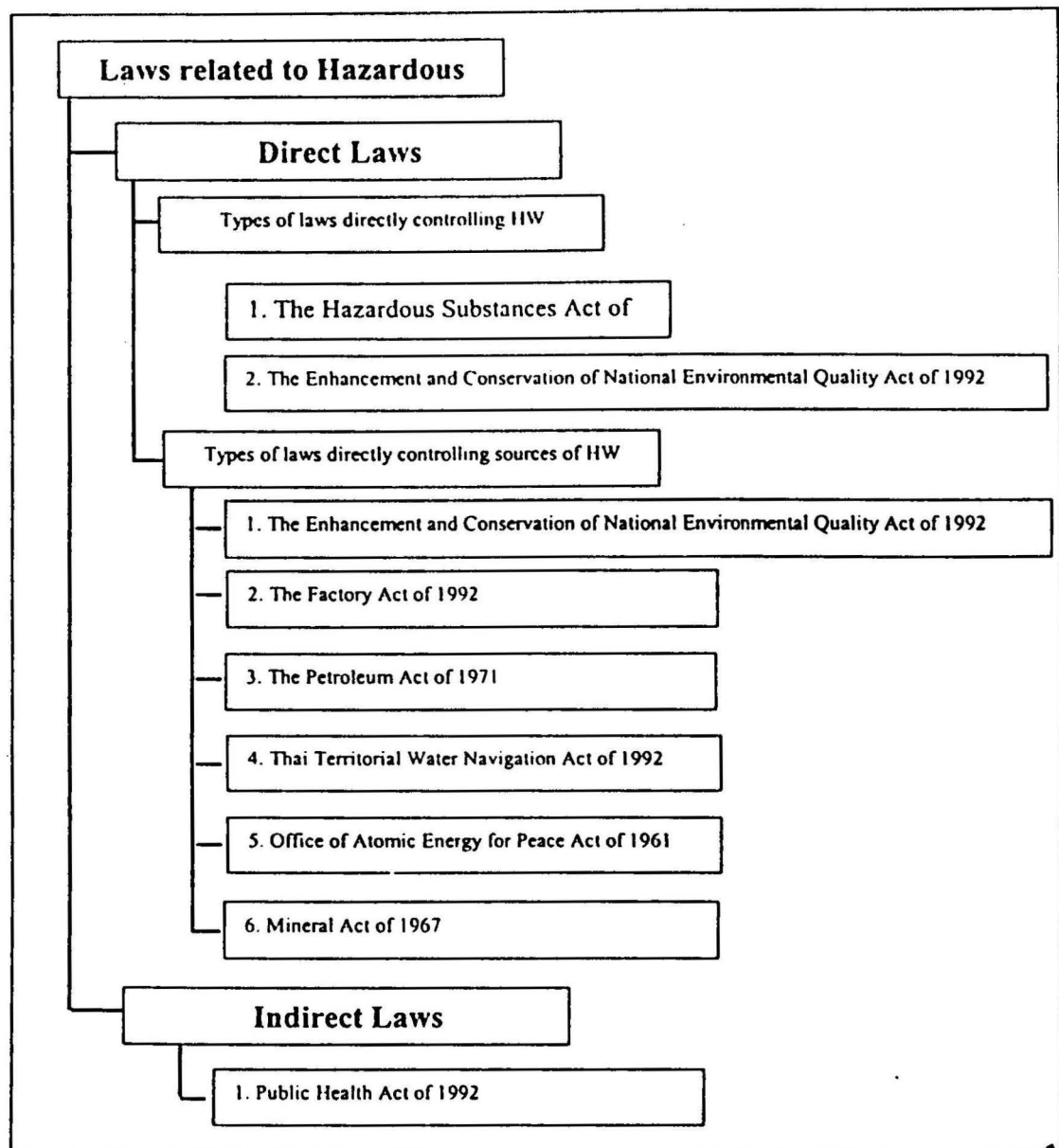


Figure 5.10 Laws Related to Hazardous Waste Management
(source: Matrix Associates, 2001)

5.2.1.2 Waste segregation, disposal, and practice

There are two major category of medical waste separated in most of the hospital visited and interviewing with the hospital and management personnel. Officially also there were only two categories was found in the BMA collection record book. These two categories are (i) infectious waste and (ii) general medical waste. Other than these sharp (needles) are also considered as infectious or hazardous waste and kept in hard container. Infectious wastes are kept in red plastic bag and other wastes are in black plastic bag. All waste coming out from emergency ward is considered as infectious waste. There was waste segregation were done centrally in almost all section of patients ward and it was situated at the side where all nurses and health workers sits (newly introduced). Generally waste

coming out from patient ward are considered as normal waste except syringes, needles are kept in special plastic box or normal plastic box or bottle or saline bag used for keeping needles. Some portion of waste from OPD, specialized section, OT, laboratory also considered as infectious waste and kept in red bag.

Hospitals may use different kind of waste bin to dispose different kind of waste as it was found in some leaflet of DPC. For example; plastic, sharps, papers etc. it was not found in practice during field visit except black and red bin. Situation is quite better in private hospital since they are dealing with patients from higher economy group and foreigner. Even then they have also just introduced the waste management system (Guide line/policy), still it was not fully in practice.

Bumrungrad hospital has adopted an environmental policy (as a part of ISO 14000) for the hospital that include infectious waste and wastewater management only. They have also hospital administration policy (Appendix 14) part of that deals with waste management. That policy classified medical waste in 4 broad categories such as: general waste (white bag), infectious waste (red bag), poisonous (Gray bag) and recycle waste (green bag) and container for sharps (needles). Nevertheless, there were only two categories (general and infectious) found during the field investigation.

Bumrungrad private hospital is a big investor in health service of Thailand. This hospital has 14,00 full time staff including nurses. There are 600 register doctors, and 120 full time doctors and 600 nurses in this hospital. 140 cleaners supplied by from subcontracts. Number of inpatients 250-290/day and out patients 2000/day. They generate 800-kg waste per day of which 250kg/day considered as infectious.

It was found from the company visited and hospitals that, almost all waste related to patient are considered as infectious waste, which could be further segregated. Since it is complicated and still the cost for sending IW to the Incineration Company is not much expensive, they give almost all waste to the company without proper segregation. Paran (1997) also found that studied hospital could not segregate infectious and general waste properly, some infectious waste would mix with municipal waste.

5.2.1.3 Method of waste disposal

All infectious waste suppose to be disinfected by chemical disinfectant before placing to the red bag, though 70% nurses said that it was not followed (secondary data from Pran, 1997). Red bag waste/ infectious waste and general medical waste are packed separately and carried by cleaners with pushed car or trolley. These are then kept in waste store room or outside hospital building. In some hospitals red bag waste and other waste kept separately but most hospitals kept those all in same place sometimes in different time i.e. after one waste take away put another waste. There was no temperature controlled room observed for infectious waste in the visited hospital except one big private hospital (Bumrungrad) in Bangkok. They kept all waste in that cool room in different big containers before taking away by municipal car. Municipal trucks carry all waste generated by the hospital. And BMA has special vehicle to carry infectious waste. Most of the big hospitals have their own incinerator. There was no well-established storeroom observed for infectious waste in any of private or government hospital visited except Bumrungrad private hospital.

There was no probation of recycle or selling of waste from big hospital. As some small health facilities mentioned that they give their recyclable waste (glass bottle, vials) to big government hospital and they may use those for specimen collection. Other than this all waste are thrown to the bin. Sometime small hospitals collect papers and plastics (saline bag) and give to the waste pickers free of cost. It was also observed that after throwing all general waste in the municipal bin those bags were opened by municipal workers to find some valuable or saleable items. Hospital staff and directors also agree on this. All private well-established hospital did not care about recycle or reusable item. Nevertheless some big government hospitals trying to separate those valuable items like glassware, saline bag, syringes, and papers. Those suppose to be sold later as it was observed only in display room did not seem to be common practice. Hospital staff (Nurse, doctors, and head) also mentioned that they just introduced this system. Almost all hospital sell their developer and fixer from X-ray room.

Waste are carried separately (general and infectious waste) or together and place in a common place or separate place in the hospital premises, which was then collected by municipal cars or sent for burning. Normally general wastes are collected by municipal cars once a day. Big hospital burns their waste once a day or sometimes every alternate day. Storage places were open with brick wall, close and locked room, net house or sometimes just open place.

Cleaners or waste handler suppose to ware gloves, musk, covered shoes during waste collection and transport. Most hospital workers follow this with some exception. It was impressive to observe separate elevator used for carrying waste from the hospital to disposal site or bin in one big government hospital in Phitsanulok.

However, data from BMA annual report (BMA, 1998) mentioned different improper mode of infectious waste packaging. There are 261069-kg infectious waste collected in average every month (1997 data) in 57332 bags. The percentage of proper packed and improper packed are has shown in Figure 5.11. Though it did not mention what are the proper packaging systems.

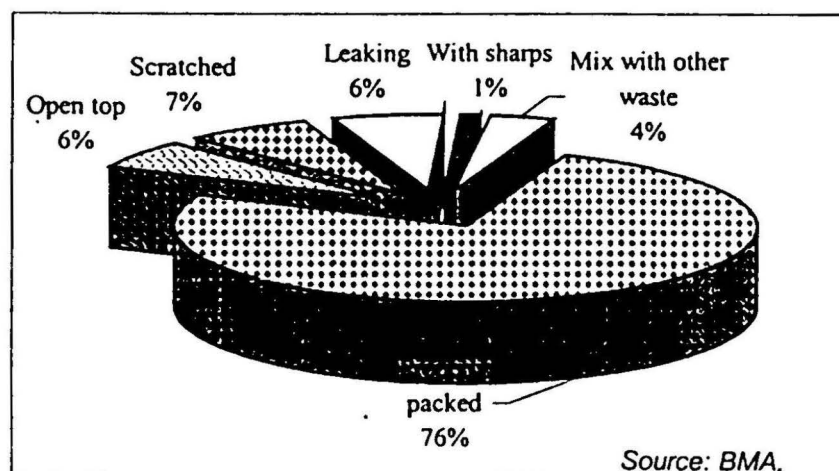


Figure 5.11 Infectious Waste Disposal Practice in Fiscal Year 1997

According to the ministerial requirement, all hospital having 30 beds must have incinerator to burn their infectious waste, though the quality of incinerator is not specified. Therefore, most of the hospitals operate brick made single burner or drum incinerator (like oven) without following any standard. Nevertheless, almost all infectious waste generated in

Bangkok City are collected and incinerated by private company owned by BMA, this company is fully subsidized by BMA, and still there is no service charge introduced in to the hospital for collection and burning their infectious waste. This might be the one reason of not practicing good separation before disposal medical waste, since they do not pay for any amount of infectious waste. Some big and private hospital have their own incinerator, though private hospital in Bangkok do not use their incinerator, since they can send their waste to the company free of cost. Big government hospital e.g. Rajabithi hospital has a good incinerator run by hospital, this is subsidized by DOE. This hospital accepts and burns the infectious waste from some other government hospital nearby. Still the capacity is not fully used by their waste. Some private hospital in Phitsanulok operates their incinerator most of those do not follow any standard, and there is no required (controlled temperature) storage room for infectious waste before burning or storing in the hospital.

5.2.1.4 Awareness

In Thailand MOPH has a unit to provide regular training (once a year) on how to handle medical waste. Chief trainer (chief of sanitary section) and/or Infection Control unit nurse of government hospital including all community hospitals receive this training from MOPH. MOPH also provide guideline/manual to the community hospitals about medical waste management. This chief of sanitary section and Infection Control (IC) unit nurse provides training for workers in the hospital who deals with waste. There is regular evaluation for the staff carried out every 3 months using a questionnaire. In big hospital IC unit nurses act as supervisor to train other nurses who are related with waste.

From secondary data source (Paranan, 1997) it was found that awareness level of hospital staff is quite low. Only 41% doctor and 51% nurses could mention what constitute infectious waste, though people from other profession had better understanding (60%). Among the nurses 64% were not able to differentiate infectious and general waste. Nevertheless 81% doctor and 100% nurses were agree that infectious waste should be kept in red plastic bags. It was also clear that they are not much aware about who is responsible for waste disposal (31% doctor and 36% nurses mentioned about BMA). Sixty three percent doctors and 61% nurses were not aware how the general wastes are disposed off from hospital, some of them (22% doctors and 26% nurses) said that general waste should be incinerated. Even they did not know how the infectious waste disposed off, only 23% doctors and 35% nurses could mention about incinerator though other hospital staff could (58%) mention about incinerator for infectious waste destruction. Nevertheless, 98.7% hospital staffs interviewed have the opinion that the collector should have training in solid waste collection and the procedure to clean the infectious waste and spilling off during the way (Paranan, 1997).

Medical waste management issue is not included in the course curriculum of medical study. Ministry of Public Health is responsible for providing training on waste management for hospital staff. Nurses or staff dealing with waste or infectious disease unit seem more aware about the issue since they get direct training on this. There is routine evaluation of their performance done by MoPH. System and regulation make them aware about medical waste management. Staffs, doctors, or nurses of other section were not much aware, as they are not responsible to do so. Director or divisional heads seem to conscious because of the ministerial regulation, they are more aware about to follow the regulation but not much concern about the properness of disposal. It was found that they do not concern about the storage of infectious waste, emission standard, proper segregation etc. But most of the places visited separate infectious waste and they seem to be much aware about this infectious waste only. The diseases prevalence (AIDS) might be the reason of making them aware. Big hospitals kept the regular data of infectious waste, as it was found

from BMA data and some hospital personnel could show the data during field investigation.

There are seminar, poster, leaflets distributed and display by MOPH, BMA or municipality to raise the awareness. BMA's one slogan is 'waste segregation at sources', but it is not effective since there is no extra charge for the hospital to collect and treat infectious waste by BMA subsidized company.

Few private hospitals have their own guideline to comply with ISO 1400, though it is not much in practice except infectious waste separation. Almost all hospitals mentioned that they are to implement the guideline soon. Nevertheless, they have well-established demonstration of waste management (as a model of proper waste segregation) that is just introduced not yet in use. That was found in Bangkok and Phitsanulok as well. It seemed that there was no evaluation or monitoring from the government or implementing authority though it is written in ministerial guideline.

5.2.2 Institutional Involvement

Department of Health, a sector under Ministry of Public Health, is the government sector that has responsibility in the scheme of infectious waste management according to the Act of Legislation of Public Health 1992. Department of Health has appointed the working group to establish the definition of infectious waste and the infectious waste management guideline. This working group has finished this work and has offered the draft final ministerial regulation to ministry of Public Health to make decision. This draft will declare to enforce nearly in the future. Thus, nowadays, Thailand has no intensive law to enforce in medical waste management.

Different government agencies such as MOSTE, MOPH, DOE, PCD, local government are involved with medical waste management. They are involved in formulating guidelines, emission standard, training, oversee the management quality. Nevertheless, BMA and municipalities are directly dealing with the medical waste collection, disposal, and treatment. In Bangkok metropolitan area medical waste collected by DPC of BMA central office. DPC office of BMA is responsible for infectious waste disposal and management. Other than these private sector has some co-operation in the infectious waste management such as using red plastic bag, plastic box for sharps, bin for waste separating, push-cart and also providing services such as transferring service. In future, there shall be a waste management center managed by the private sector. This center will provide full option services systems with high technology. Not only the private health facilities and clinics, which are target groups of the center but also the government health facilities will use the services. The possibility to have these systems depends on the law regulation and policy of government.

Thailand is going to change the policy of individual incinerator system. They are planning to establish centralized incineration system for infectious waste at different provinces and municipalities (source: environmental engineering section of Department of Health under MOPH). Under this new policy each province will have one central incinerator in local municipality. Therefore, there would be 7 central incinerators in seven municipalities. Other than this 25 existing incinerators at different government hospital also will be used as central system. Another 46 central system will be built in the remote area that would be smaller than provincial system. This central system may allow the use of incinerator in full capacity, which would be cost effective. Hospital will be charged according to the amount of waste generated. The MOPH also is planning to set up the emission standard for hospital waste incineration.

5.2.3 Information on Waste Recycling and Reuse

There was no formal recycling or reuse done in most of the hospital visited. There is no legal requirement in Thailand for reduction, recycling of medical waste stream. From an interview with nurses, it was found that 72% mentioned about the recycling of saline bottle of which 47% were glass saline bottle (secondary data from Paranan, 1997). Some hospitals collect recyclable items and give it to the waste pickers free of charge. Glass syringes, needles used for medicine mixing are reused in community hospital. Few glass vials and bottles are also used for specimen collection in small hospitals. Though some small hospitals and clinics mentioned about sending re-usable items to the government hospital but government hospital did not agree on it. In fact there was no existing system for recycling or re-use of selected waste. This is newly introduced system in some big government hospital just for demonstration. Saline bag, disposable syringes, glass bottles, official papers were found in displayed waste bin for recycling and re-use in some big hospital.

Recycling accounts for only 7-8% of municipal waste stream (Hazardous waste and waste management division, 1993). It was observed in the municipal landfill site at Onnut and Phitsanulok that there are some registered waste pickers collecting recyclable waste from dumpsite. Recyclable items were different kind of plastic bags, hardboard, paper box, metal, glass, can etc.

5.2.4 Health Issue Related to Medical Waste

From secondary data source (Paranan, 1997) it was found that (Interviewing hospital staff, doctors and nurses) 64% doctors, 77% nurses and 66% staffs could identified Aids, hepatitis, and tetanus as the major diseases caused by infectious sharps. It was also noticeable that the risk persons are nurse, hospital staff dealing with waste, laboratory technicians who are highly vulnerable to infectious diseases caused by sharp injury from Aids, hepatitis or tetanus infected persons. It was found that 28.9% nurses interviewed had accident causing by medical sharps while 8% of cleaner or waste collectors interviewed in a children hospital have had accident caused by infectious sharps.

Kungskulniti (1991 in Paranan, 1997) indicated the problem of health risk and adverse environmental effects that cause by mismanagement of medical waste in Thailand. That study investigated the solid waste scavenger at On-Nooch dumping site in Bangkok for the purpose to identify the dimensions of the public health risk. In that study it was found that, six cases from 109 male scavengers at dump site was positive for HIV (5%), and 20 cases (18%) were positive for the hepatitis B virus. This study pointed out that there was increasing number of HIV and hepatitis infections resulting from accident involving the handling of clinical waste (predominantly caused by infectious sharps). Nevertheless, the relation with HIV and clinical waste is not clearly explained. There is no supportive information and data about the evidence of this conclusion. It needs further clarification.

Nevertheless, it was mention by respondents during field visit that there is routine checkup and vaccine given to the workers and waste pickers in government and private hospitals, private company and municipality dumpsite.

5.2.5 Available Treatment Technology and Practices in Thailand

Hospital supposed to use chemical disinfectants before disposing infectious waste. Only few pathological laboratories in government hospital autoclave their discarded microbial culture dishes and sample before disposal to the red bin. Other hospital just places those in red bag directly without any sterilization or autoclaving. Those are then sent to the

incinerator. Body parts or fetus are sent for cremation in the temple as some respondent mentioned.

All hospitals in Thailand have to separate infectious wastes from domestic waste and provide a suitable and appropriate waste treatment facilities. Generally speaking, most of the hospitals apply a simple incinerator technique, which was designed by the DoPH and blueprints supplied to the hospitals.

Most of hospitals under MOPH have incinerators. At present, MOPH installed incinerators in all big hospitals and almost all community hospitals. Figure 5.12 and Figure 5.13 showed the number of installed incinerator from 1988 to 1998 and distribution by capacity and region. Installation of incinerator by MOPH has been increased in 1996, and most of the incinerators are in medium capacity i.e. 50 kg/hr (Figure 5.13). The amount of installed incinerators can provide the service for 87% of 862 hospitals under MOPH. The health facilities that have no incinerators may only do the primary septic technique and then transfer the waste to municipality and sanitary.

Recently MOPH has taken an initiative to establish a centralized incineration system for infectious waste burning. Under this system the incinerators already existed in big hospital will serve as a central system for that particular area, and all provincial are there will be one central incinerator. Other then these 46 incinerators will be installed in the remote area as well.

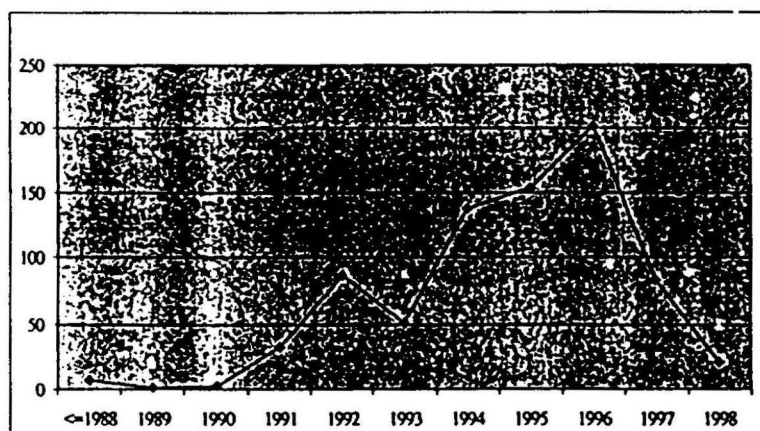


Figure 5.12 Number of Installed Incinerator by MOPH since 1988

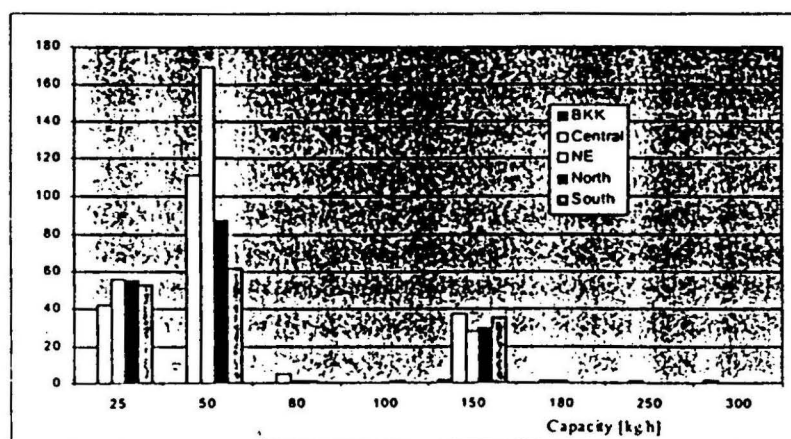


Figure 5.13 Number and Distribution of Incinerators by Capacity and Region

Source: Ministry of Public Health, DoPH

5.3 Case Studies: Example of Good Practices

5.3.1 Prodipan a Case Study

Prodipan, a community based local non-government organization working in Khulna City of Bangladesh. Khulna is the third largest city of Bangladesh and is located in the southwest part of the country. It has a population of 1.2 million in 45.65 square kilometer City Corporation areas. Detail description of Prodipan is given in the appendix 15.

Medical waste management under the Municipal solid waste management project of Prodipan:

Prodipan has been active in solid waste management in Khulna City since 1997. As a part of its program, the organization has undertaken a pilot project that involves the collection and disposal of medical waste from 20 healthcare establishments in the city. Khulna City Corporation (KCC), the Hospital and Clinics Owner's Association (HCOA) of Khulna City, the Bangladesh Medical Association (BMA), and representatives of local people were the principal stakeholders of the program. It was noted that, this is the first time in the country that there has been a medical waste management project of this type (Kazi, 2000).

The pilot project started operating in February 2000. Integration different stakeholders at different stages of project cycle, and consideration of the various potential impacts have been identified as the key factors in the success of the project. The case study demonstrates how an integrated approach can lead to a sustainable waste management project in cities of low-income countries.

Activities:

Prodipan's activities included awareness, training, collection bin supply to the hospitals, collection of waste with special vehicle, simple sanitary landfill and central incinerator.

Prodipan has set up the following **categories of waste** for all hospitals to separate under the project.

1. needle/ sharps (in plastic bottle)
2. syringes and saline set (plastic bow/bucket)
3. food waste (drum/bucket)
4. all other medical waste from all sections (gauge, bandage, cotton, paper, plastics, blood products, specimen) (in plastic bowl/bucket)
5. body parts goes to other place (not taken by the project)

It was found that all waste are kept in a bowl under the bed, then cleaners separate those in above mentioned category and kept in different bin/bowl provided by Prodipan. Food waste sent to the municipal bin. Some clinics have separate system to drain out food waste from the clinics. None of the diagnostic center or clinic autoclave their specimen or tested sample before disposal. Collected waste kept in an open place inside clinic's premises before it collected by Prodipan's car.

Prodipan's collection car collect waste from hospital once a day and Prodipan assigned cleaner collect each waste in different kind of plastic bag from the bin or bowl. These bags are kept in separate box or bin placed inside the car. Medical waste disposal site is in the municipal dumpsite area about 10 km far from the city.

Management system at dumpsite were as follows:

1. Concrete pit for syringes, needle and saline set – yet to decide the final disposal/treatment
2. Clay layered pit for other medical waste storage - burn
3. Incinerator to burn those waste from second pit

Construction cost of the incinerator (burner with 15ft stack) was 35000 BDT, capacity 80 kg per 35-40 minutes. No energy is required except a little amount of kerosene to initiate fire. Prodiplan get a minimal service charge from hospitals for training, supplies, collection, and treatment of medical waste.

Institute of Child and Mother Health (ICMH), Matuail, Dhaka

- An autonomous institute.
- Health service provided to mother and child only with 60 beds.
- Segregation of waste: needle, syringe, plastics, food waste, and saline bag (sell) (Laboratory, general ward, surgical ward, and operative room)
- Incinerator to burn all except food waste, 1200 °C installed in 1998 (use of gas and electricity)
- Installation cost ~20million BDT
- Operation cost (one cleaner is paid 1000Tk/month to collect and burn), gas and electric bill subsidized
- Operate twice a week (40kg+40kg)
- Capacity of the incinerator is 130 kg/hr.

May share the incinerator with other hospitals to use the optimum capacity and recover the installation and operating cost.

International Center for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) Dhaka:

- Service for diarrhoeal disease only with 250-300 beds.
- Waste coming from hospital ward, research laboratory (animal/ microbial/ environmental/ pathology)
- Waste segregation: research laboratory waste (maintain universal precaution), sharps and needle sent to the incinerator, all other waste to the municipal bin.
- Incinerator (1000-1200 °C), 2 chambered 3 burners, use gas as fuel.
- Installation cost 56,000 USD (in 1995), fuel cost 1 USD/kg.
- Capacity 50 kg/time burn (1 hr.), every alternate day, and mostly animal carcass with IW, sharps and needle.
- Hospital keeps sharps/needle in storeroom for 20-25 day to become 50-60 kg.
- Other clinic e.g. Medinova a private clinic sent sharps/needle (4-5 kg daily), CARE sent needle used for AIDS programme. Those wastes kept in storeroom before burning.
- Service charge for others was 50TK/kg.
- Ash (~5%) goes to municipal dustbin.

May reduce the service charges and accept IW from more hospitals or clinics.

5.3.2 Phitsanulok a Case Study

Phitsanulok province is located in the northern part of Thailand. The total area is about 10,896.05 square kilometers with a population of 863,451. There are nine districts under this province. Three districts were visited for the study namely Muang, Bang Krathum and Wang Thong district. More detail about Phitsanulok and the project is appended in appendix 16.

Municipal solid waste management project of Phitsanulok province:

Hospital solid waste management was a part of municipal solid waste management project of Phitsanulok province funded by GTZ. Phitsanulok municipality has done several studies on hospital waste inventory and existing situation at the province. Phitsanulok province is a model of solid waste management in Thailand. Some selected government and private hospital clinics in the city and some district hospitals were visited to get an overview of the medical waste management in Phitsanulok.

Almost all hospital in Phitsanulok separates their waste at least in three categories namely:

1. General waste in black bag (collected by municipal collection car)
2. Infectious waste in red bag for incineration
3. Sharps in hard box or bottle for incineration

Management system for hospital waste:

- Collection of general waste and kept in net house near roadside in hospital premises. These are then carried by municipal truck
- Collection of infectious and sharp waste (with or without chemical disinfectant), kept in net house or storeroom near incinerator, and burn once a day or every alternate day.
- Food waste used as fish feed or sent to piggery farm.
- Worker in works for incineration uses special dress, gloves, mask, and boot as safety measure.
- All hospital sent their incinerator ash to the municipality.
- Municipality dumps all waste in a sanitary landfill site.
- Provide training for the staff dealing with waste.

Field experience

Small clinics (out patient only) and hospitals separate only sharps and needles. Municipality takes care of clinic's waste. Most private hospital do not segregate waste properly and incinerate almost all waste since the capacity of incinerator is higher than the actual amount of infectious waste. Except infectious waste and sharps almost all waste kept together in black bag for municipal truck to transfer. Municipal workers open the black bags for collecting recyclable items as respondent mentioned and was observed during field visit. Few out patient clinics separate re-usable items and those are then given to the garbage collector for selling. Some hospital reused bottles/ glasses.

From field investigation, interview and discussion with the health workers, hospital staff, authority, heads, municipal office staff and personnel, it was found that, every hospitals and community hospitals (30 beds) at Phitsanulok have incinerator according to MOPH regulation. Though those incinerators did not maintain standard and cannot burn well. Most of the times it is just a burner with chimney. Some hospital has separate incinerator for general waste burning also.

All government hospital get training once a year for chief trainer (chief of sanitary section) and guideline from MOPH. This trainer provides training for workers who deal with waste and IC nurse. Evaluation is done every 3 months using a questionnaire. IC nurses provides training for all other nurses. Hospitals have their own guideline for waste management.

All most all hospitals have wastewater treatment plant.

Buddhachinarat Hospital, Phitsanulok

This is the biggest government hospital and college in Phitsanulok province. Hospital has 1000 beds, 700 nurses and 700 doctors. Infectious Control unit, female ward, children ward, chemotherapy unit, pathological laboratory, waste disposal site, incinerator, and wastewater treatment plant were visited. Nurses and doctors involved with the activities were interviewed.

Good separation of waste just introduced. (Recyclable, disposable, reusable, selling, etc.).

- red bag for IW
- blue bag or bucket for hazardous
- green or bucket for recycle/plastic
- wooden box for glassware/cloth reuse
- plastic sharp box for needle (incinerate)
- black or bucket for general waste

It seemed that these different categories are kept in display place only for training and demonstration. Otherwise only red and black bags and sharp box were found to be in regular practice. Paper waste are recycled, glass syringes are reused after sterilization. All kind of waste from patients before identifying the disease considered as IW. Normally waste under bed considered as general waste. Hospital generates 100kg IW/day, weighing before burning only.

Waste management: All waste from intensive care unit and emergency room are treated as IW. Wastes are collected by their own truck around hospital. Infectious waste and body part or organ is burned in own incinerator, general waste collected by municipal car. There was no treatment system for chemotherapy waste, this waste sent back to the company. Wastewater treated and use for watering plant and sludge sent to the municipality to use for composting. X-ray fixer solution is sold but developer is sent to the WWTP. This is the only hospital found to use separate lift for waste transport.

Infection Control (IC) department nurse takes care of waste management in the hospital. They provide training for staff and other nurses on waste handling and disposal. IC nurses as supervisor train other nurses who are related with waste.

Buddhachinarat government hospital is a good example of proper waste management in Thailand, among the hospital visited in Thailand. Medical waste management practices is newly introduced in this hospital.

It was understood from the discussion that even they have required facilities prescribed by MOPH, but most of hospital or clinics does not use those. In some hospital no one is sure when they use the incinerator for infectious waste burning even they have it, may be this is just to fulfill the regulation. According to municipal landfill project personnel, lots of sharps and needles were found in landfill site, which should not be there if all hospital following the regulation. From some respondents it was found that there is a limitation of fund to run incinerator. Therefore, they prefer to send their waste to the municipal bin.

Compare to Bangkok Phitsanulok has better situation in medical waste management. This is might be due to some waste management projects are running over there and Phitsanulok is used as a model for proper waste management. Figure 5.14 showed the medical waste disposal system in most government hospital at Phitsanulok.

5.4 Synopsis

5.4.1 Bangladesh

Bangladesh lacks both effective waste management facilities and relevant government policy to guide health providers and punish offenders. Waste management guideline/procedure and rules/regulations are lacking. Method for qualifying the waste generated, separating the waste before disposal, handling unexpected hazardous waste situation, and protecting cleaners/others from infectious or potentially dangerous waste products are not well defined.

Proper segregation of waste has recently been introduced in some tertiary hospitals and some private clinics. In general, however, there is no system for segregating the waste before disposal and no mechanism for handling hazardous waste. Nevertheless most of the hospitals separate needles and syringes those are then sent to the central store for getting new supplies. Small number of private hospitals and research centers separate infectious waste and kept in red bags or buckets.

Medical waste management system in both the government hospitals and private clinics were severely lacking in Bangladesh. In most government hospitals, private laboratories, and clinics waste was disposed in municipal bins without proper regard to the harmful effects they may pose to human health and environment. Methods of disposal medical waste included incineration, open burning, burial, selling, dumping, reuse and removal by municipal trucks. Syringes, vials, slides, empty packets, bottles and saline bags, used X-ray film developing chemicals, were some of the items collected un-safely and re-sold.

There has been no formal training of staff on handling procedures and disposal methods of medical wastes. There is a lack of knowledge and interest in safe waste disposal amongst those interviewed. They recognized medical waste management as a problem but they seem to put the problem at low priority or overlook it. Similar attitude was observed also in Thailand. Few NGOs have recently programs for awareness building and training on medical waste management for selected small hospitals or clinics and among NGO officials. DGHS published a manual for hospital waste management in Bangladesh and several training manuals.

In Bangladesh, there is no identified or responsible institute that should take care of medical waste. The Ministry of Health and Family Welfare and DOE is working separately in this issue. There were few local initiatives taken by some NGOs in a pilot scale.

Some selected pathogens present in laboratory analysis indicated un-safe disposal of waste in to the municipal bins. Some infectious diseases were reported during the survey among nurses, cleaners and waste pickers. Infection, injury and accident among hospital staff, waste pickers were reported due to the handling of infectious and sharp waste improperly. Mostly used infectious waste treatment techniques were (a) autoclaving, (b) closed or open burning, and (c) incineration.

5.3.2 Thailand

Various laws and organizations are involved with solid waste management in Thailand. None of these laws provide guidelines, criteria, or regulations for waste separation, collection, transportation, disposal, and monitoring. There is problem of law enforcement current laws and regulations are not updated to present situations. Therefore it is difficult to

change and improve them. Medical waste is an integral part of solid waste management in Thailand. Still there is no separate laws or legislation to deal with medical waste only.

There are two major categories namely (a) infectious and (b) general medical wastes separated in most of the hospital. All waste coming out from emergency ward is considered as infectious waste. Sharp waste is considered as infectious or hazardous waste and kept in hard container. Infectious wastes are kept in red plastic bag and other wastes are in black plastic bag.

All infectious wastes suppose to be disinfected by chemical disinfectant before placing to the red bag. Municipal trucks carry all waste generated by the hospital. Only BMA found to have special vehicle to carry infectious waste. There was no well-established storeroom for infectious waste in any of private or government hospital visited except Bumrungrad private hospital.

A little attention was given for waste segregation on site, reuse and recycling which may reduce the amount of waste to be disposed or incinerate. There was no legal requirement in Thailand for reduction, recycling of medical waste stream. There was informal recycling through waste pickers and municipal workers were observed.

Awareness level of hospital staff is quite low. Ministry of Public Health is responsible for providing training on waste management for hospital staff. Infection control unit nurses and workers were aware about it, but staffs, doctors, or nurses of other section were not much aware, as they are not responsible to do so. All hospital visited found much aware about infectious waste only as AIDs is a concerning issue in Thailand. Nevertheless, they have well-established demonstration of waste management (as a model of proper waste segregation) that is just introduced not yet in use.

Different government agencies such as MOSTE, MOPH, DOE, PCD, local government are involved with medical waste management.

Nurse, hospital staff dealing with waste, laboratory technicians were identified as risk persons who are highly vulnerable to infectious diseases caused by sharp injury from Aids, hepatitis or tetanus infected persons. Few incident of accident and injury of nurses and waste pickers were reported.

Hospitals under MOPH with 30 beds have their own incinerator, though most of them were not operating. Almost all infectious waste generated in Bangkok City are collected and incinerated by private company owned by BMA. Only few pathological laboratories in government hospital autoclave their discarded microbial culture dishes and sample before disposal to the red bin. Most of the hospitals apply a simple incinerator technique, which was designed by the DOPH and blueprints supplied to the hospitals. Proposed future plan for medical waste treatment is shown in Figure 5.15.

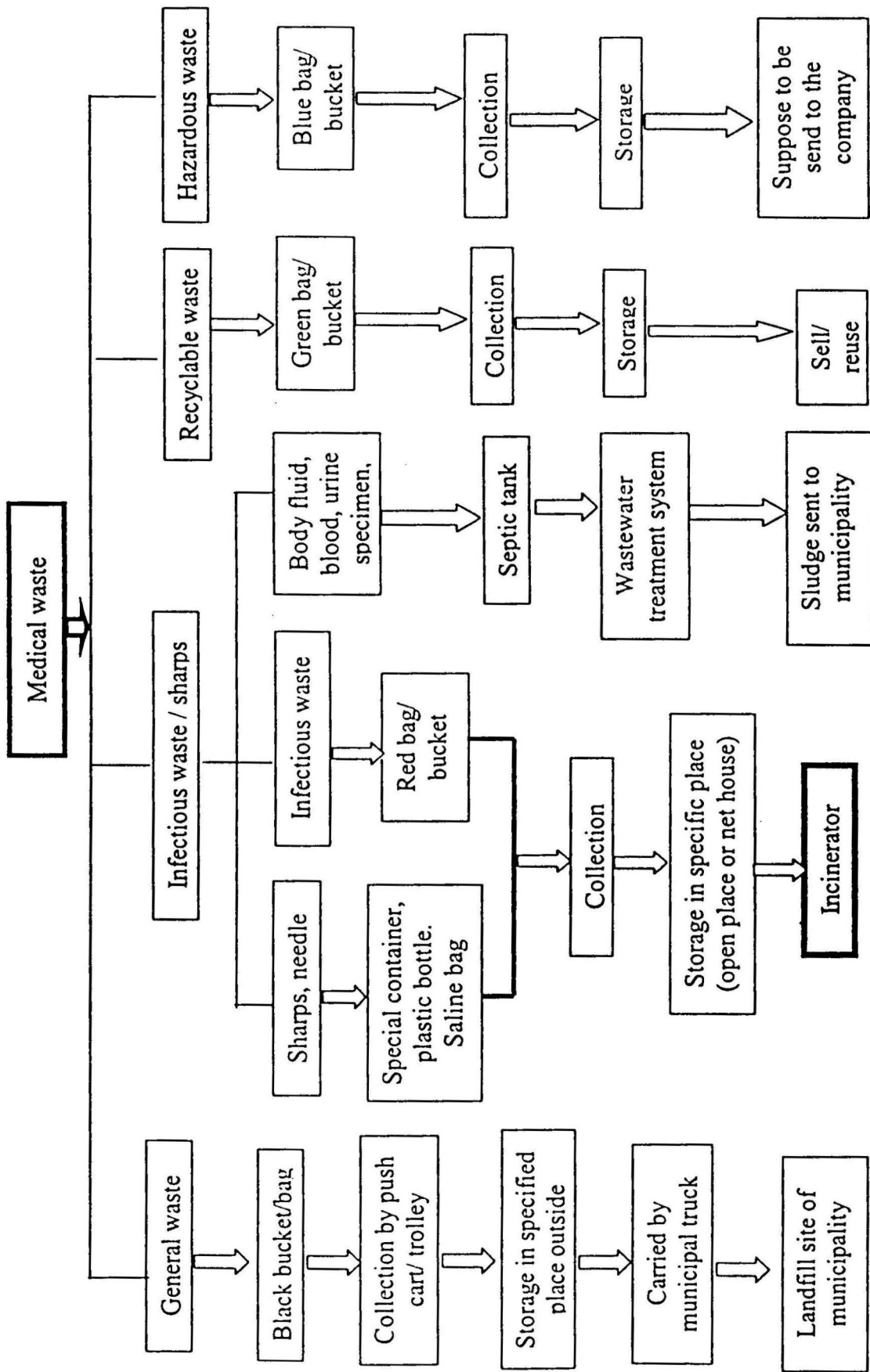


Figure 5.14 MW Disposal System in Most Government Hospital in Phitsanulok

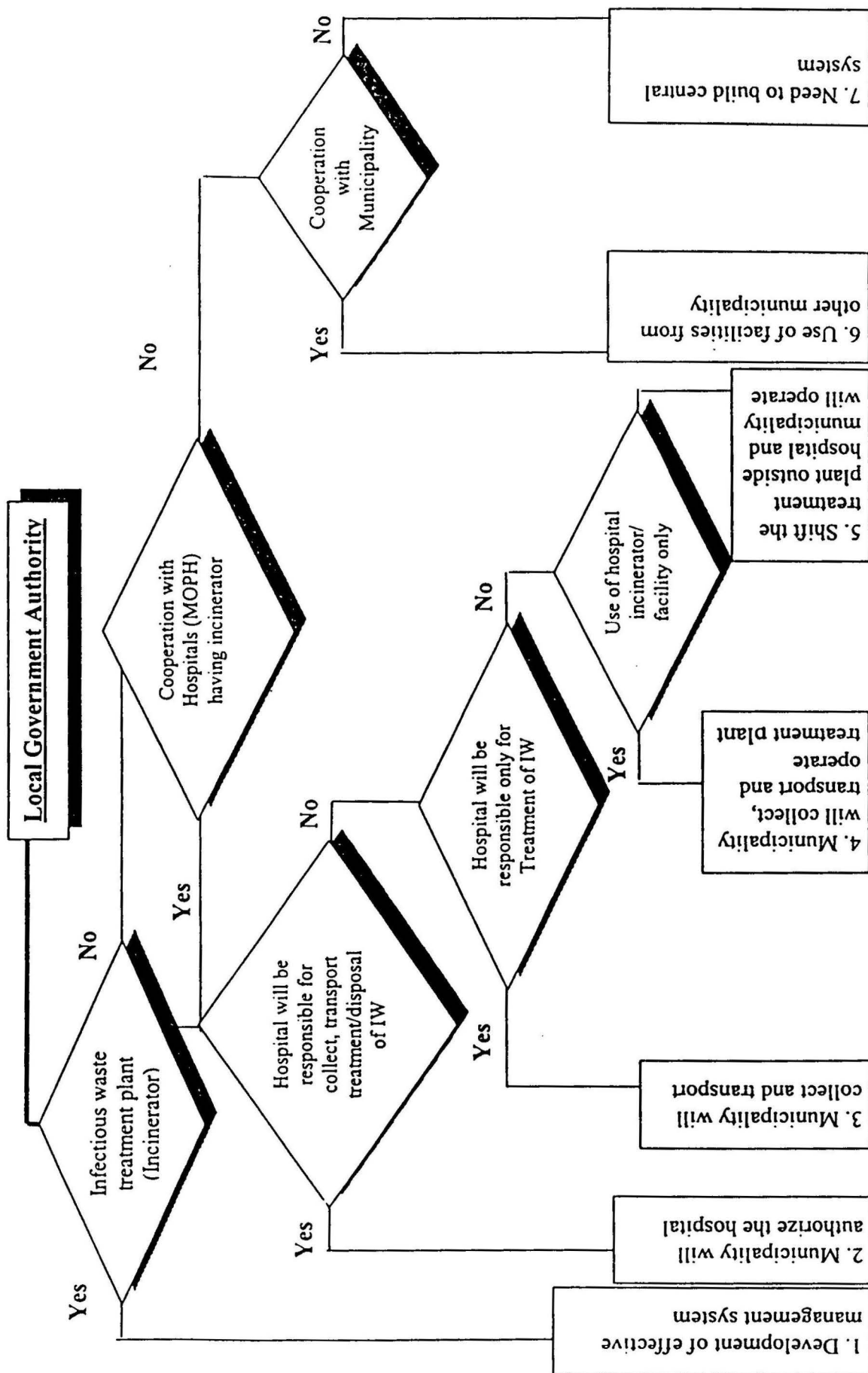


Figure 5.15 Future Plane: Proposed Central system for Infectious Waste treatment

CHAPTER 6

Medical Waste Management in Bangladesh and Thailand: A Comparison

6.1 Synopsis of Medical Waste Management in Bangladesh and Thailand

Medical waste management is a part of main solid waste management stream in most countries as it is found in Bangladesh and Thailand. "medical waste" or "infectious wastes" have not distinctively been defined in any Act or Laws in Bangladesh and Thailand, there are few definitions of 'hazardous waste' and/or 'environmental pollution' implies indirectly in defining medical waste. Both these countries are in the verge of developing the definition of medical waste/ medical waste and infectious waste. They have introduced ministerial requirements, manuals and/or guidelines on medical waste generation, segregation, collection, storage, transport, treatment, emission control, disposal, health and environmental aspects, and worker's safety. Still there is no legal enforcement authority to directly deal with medical waste situation without which, hospitals may be reluctant to follow the instructions mentioned in those manuals or guidelines.

There is no direct policies or regulations to deal with medical waste. There is no specification of waste i.e. what waste should be treated which way. There is no specification for incinerator installation or no standard for emission from IW incinerator. Some regulations for hazardous waste may fit into medical waste management. MOPH/MOPHFW, DOE, MOSTE, the City Corporation, metropolitan administration, and Local government are responsible for waste management. There are air, water and solid waste disposal standard for industrial emission in both countries, which may apply for hospital as well, if the regulation or laws come into force. Nevertheless, the waste analyzed from hospital and dumpsite in Bangladesh for this study did not met the standard of pathogen (Microbial count) for industrial emission either.

The amount of waste depends on what is considered as infectious waste. Most of the waste is found to produce in operating room and emergency ward. As compared to Thailand, there was not much waste found in emergency department in Bangladesh. This is because before the disease diagnosed all waste coming from emergency ward considered as infectious waste in Thailand. HIV being and grim problem here they consider all waste related to patient as IW using the universal precaution rule. They also do not separate HIV patient as it may create social problem for the patient.

In Thailand, waste recycling or reuse is not much popular as was in Bangladesh. Recycling of a few selected items like (saline bag, containers) are done centrally in some hospitals in Bangladesh, but unauthorized medical waste segregation, recycling and re-used were done in and outside hospital by informal sectors those are then sold. A large group of waste pickers and informal sectors are involved in collecting and selling recyclable waste. Proper segregation, re-cycling, re-use just in the demonstration process in Thailand. Waste cleaners or workers use standard safety measures (gloves, mask) during waste disposal. Container for waste is well designed unlike Bangladesh (only plastic bowl or bag thrown directly to the bin).

Some other limitations are resource unavailability, unskilled manpower, and unwillingness or attitude of people responsible and or engaged with this issue. Total health expenditure was 4.9% and 5.7% of country's GDP respectively for Bangladesh and Thailand that is quite low as compared to industrialized country. Population pressure is one of the obstacles for proper health and waste management service. As number of population per doctors are quite similar in both countries whereas population per hospital beds found very high in Bangladesh compared to Thailand. Contrarily, number of nurses per capita was higher in Thailand. Considering all the overall circumstances, Thailand is in better position than is Bangladesh.

Waste management structure in both countries work as 'Top-down' approached in government ladder. There are some NGOs just started working using 'Bottom-up' approaches at local level in Bangladesh. This might be useful to manage medical waste effectively valuing the local initiative and considering everyone's ideas and expertise.

Some pictures were taken during field visits are appended at the end of this dissertation to compare the different aspects of management practices in both studied countries. From Picture 1 to Picture 28 showed waste segregation, storage, transport, treatment, health and environment, and recycling and reuse practices in both countries.

6.2 Medical Waste Management Structure: Theory and Practice

Typical example of medical waste management structure in both countries is illustrated in this section. Figures 6.1, 6.2, elaborated the medical waste management structure prescribed in the guideline and/or by the authorities of Bangladesh and Thailand while Figures 6.3 and 6.4 illustrated the actual/existing situation and practice in both countries.

Figure 6.1 showed the proposed guideline of MWM by DG Health, Bangladesh. According to this jobs are distributed to the respective persons from the director level to the cleaner. Each person has a specific duty to make the system workable. Director, WMO and doctors are responsible for administrative management and Departmental head and nurses are directly involved with waste management since they supervise the activities of ward master, waste generators and cleaners. Nevertheless, this is not yet practiced in the hospital.

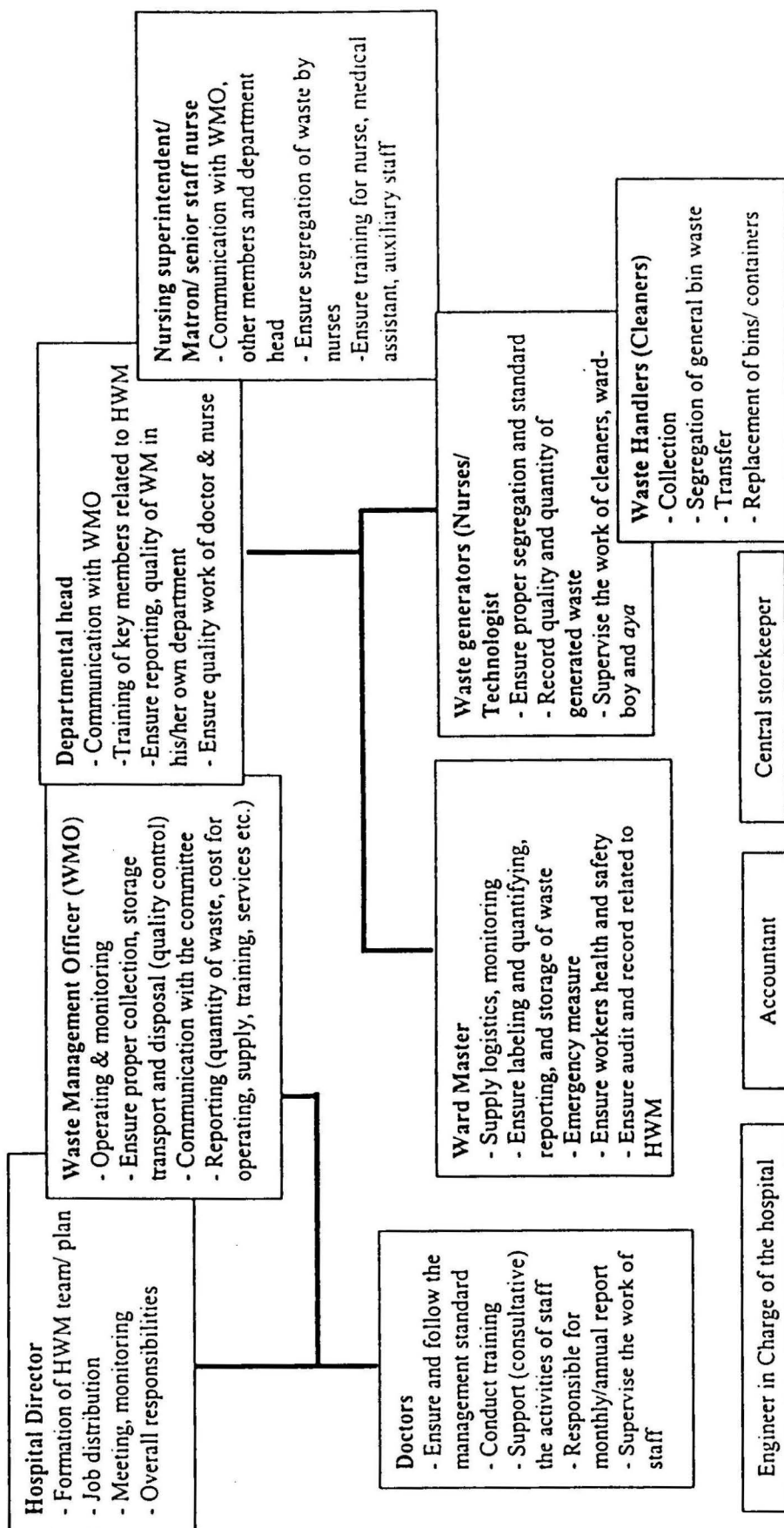


Figure 6.1 Proposed Medical Waste Management Structure in Bangladesh
(ref. Line director, 2001)

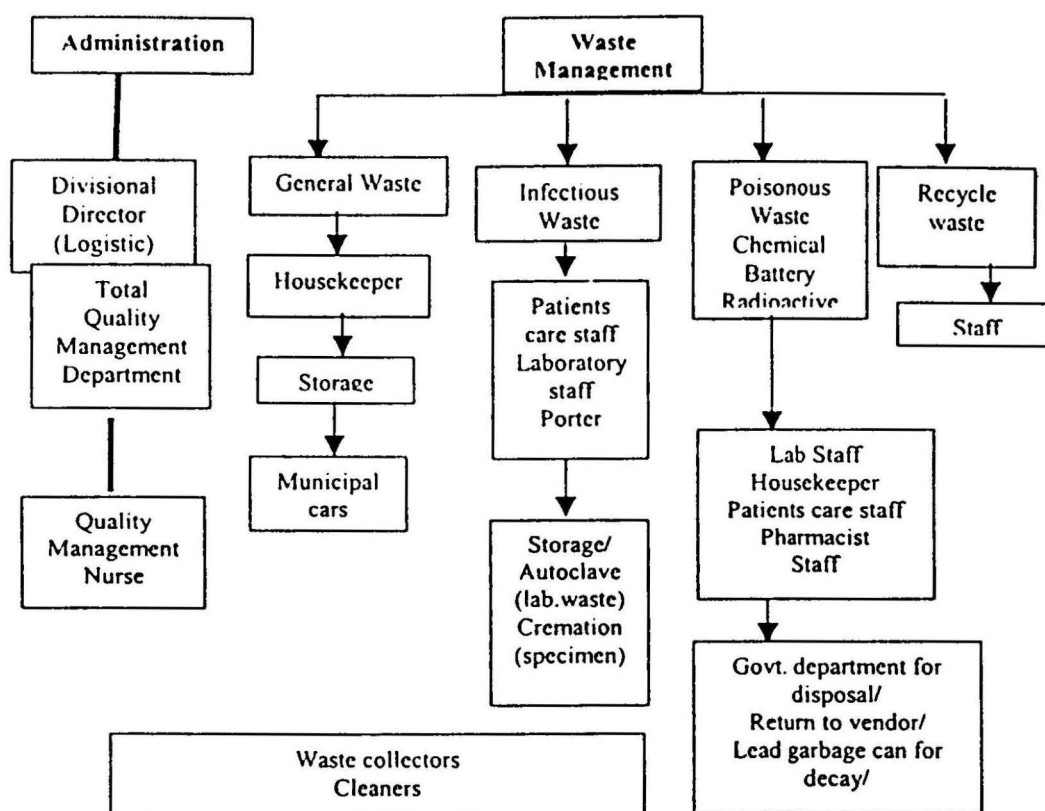


Figure 6.2 Medical Waste Management Structure in Thailand
(Combination of Bumrungrad and other hospital)

In Thailand, quality management nurses are responsible for waste management in administrative level. Figure 6.2 explained how system works in Thailand. Nurses are the one who ensure the proper waste management in hospital. These are outlined in the hospital manuals and/ or guidelines as well as ministerial guideline.

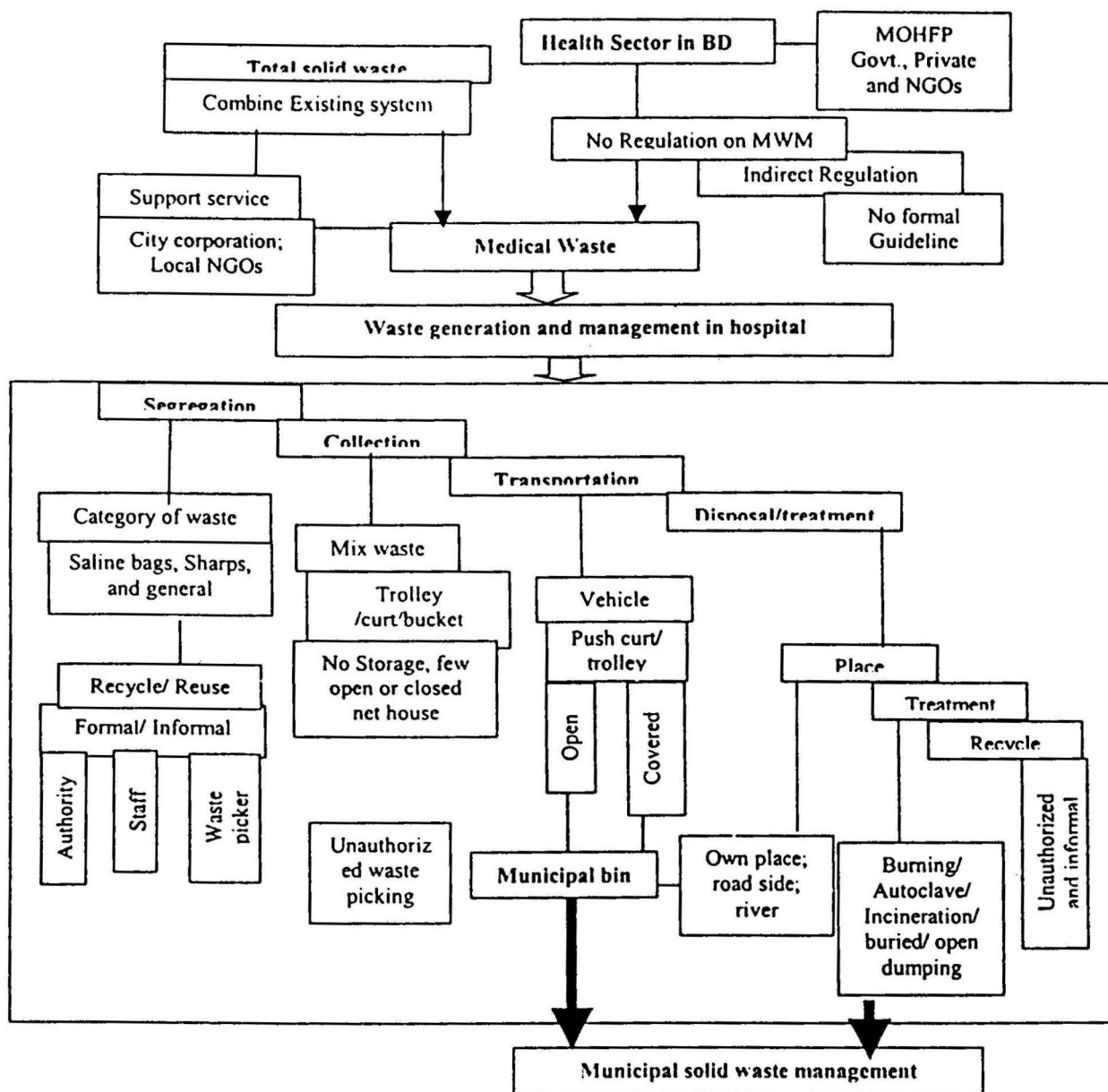


Figure 6.3 Existing Medical Waste Management in Bangladesh

Existing practice (Figure 6.3) is quite different from the abovementioned guideline. It is not clear who is responsible for whole WMW system in hospital except cleaners. After getting out waste from hospital it goes to the total solidwaste management system of municipality. As it is shown in above figure that there is no separate system for MWM.

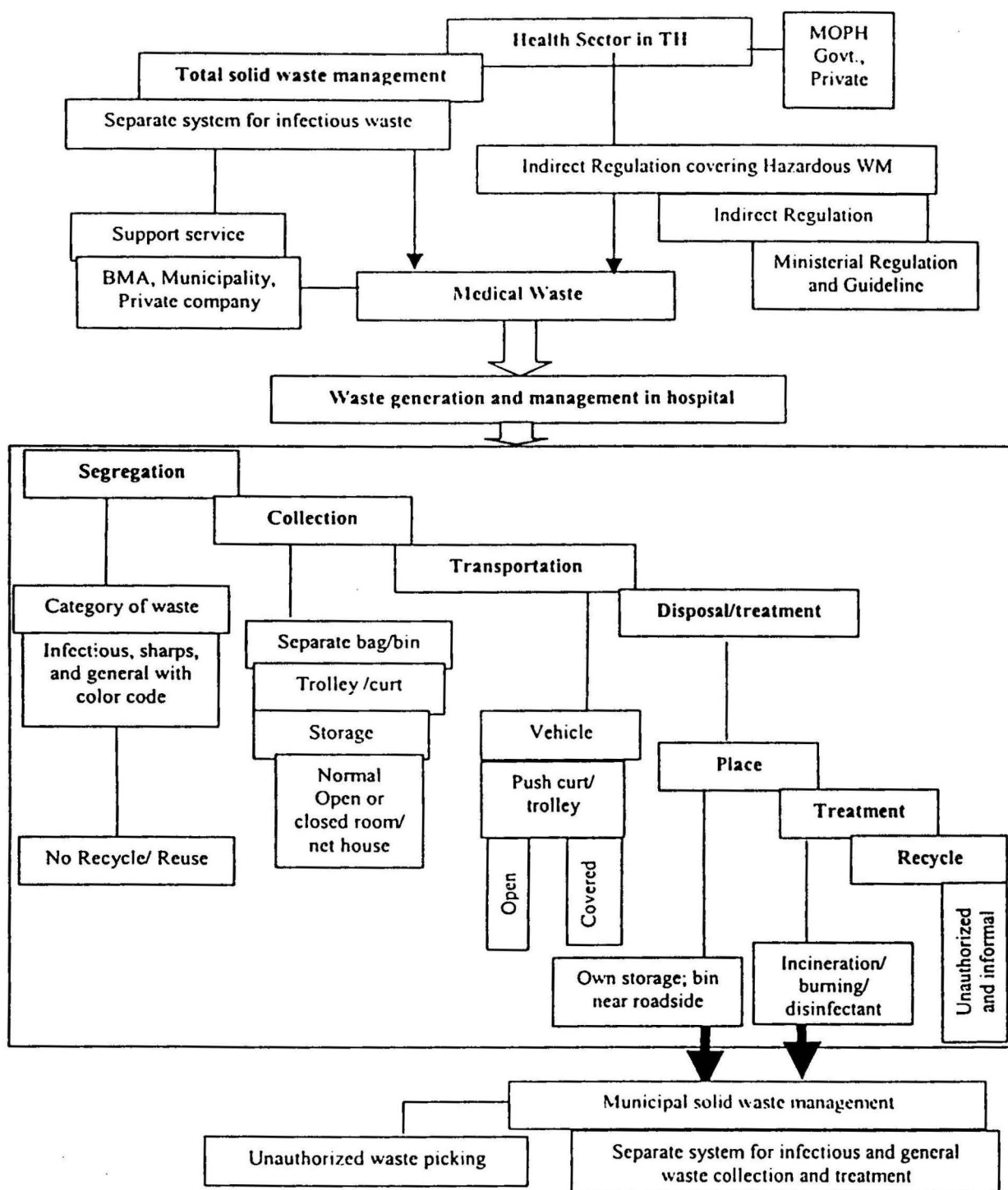


Figure 6.4 Existing Medical Waste Management in Thailand

There is a separate management system for infectious waste only in Thailand (Figure 6.4). Other wastes are going to the total solid waste management system of the municipality. Nevertheless, infection control nurses found to work for waste management in hospital.

6.3 Identified Obstacles Related to Proper MWM

Findings of problems related to MWM are summarized in this section. Table 6.1 explained the specific problems and limitations of proper MWM in both countries under three categories of 'legal aspects', 'awareness', and 'in-house management'.

Table 6.1 Identified Obstacles Related to HWM in Bangladesh and Thailand

Topic	Incase of Bangladesh	Incase of Thailand
Legal aspects of MWM	- There is no specific guideline or legislation pertaining directly to handling, transportation or disposal of medical waste. - No National Plan for sound medical waste disposal and management. - No authority, national or local, for looking into medical waste disposal and management in Bangladesh. - No standard format of incinerator or furnace or specific place to treat infectious waste.	- There is no intensive law to enforce in MWM. - There is problem of law enforcement; current laws and regulations are not updated to present situations. - There is no prescribed standard format for incinerators and emission. - No one follows the standard precaution for infectious waste storage. - There is no enforcement authority or monitoring authority to look after this matter.
Awareness/ training/ guidelines	- The medical waste management issue is not included in the medical school curriculum. - There is a lack of a systematic approach, training, or awareness campaigns at the national level that is specifically on waste management. - Since the authorities are unaware of the seriousness of the issue.	- Most of the training guidelines are not implemented in daily practice of MWM. - Most people are not concern about recycling and its affect on worker health. - No incentive for the workers or hospitals so that they will follow the guidelines or what they have learnt from the training.
In-house management practices	- There is no system for segregating the waste before disposal and no mechanism for handling hazardous waste. - There is no method for quantifying the amount of waste generated and no designated site for waste disposal. - In the majority of hospitals there is no incinerator or an alternative.	- There is no proper separation of waste causing huge amount of infectious waste. - Almost all medical wastes are sent to the incinerator increasing the cost of burning and lowering the capacity of burner. - No one seems to be interested in the reuse or recycling of waste. - No method or mechanism for handling unexpected hazardous waste situation.

6.3.1 Cause and Effect of Improper MWM

Based on WHO guideline, this section analyzes the cause and effect of improper MWM considering all the limitations in both countries. Summarized cause and effect of medical waste management are shown in Figure 6.5.

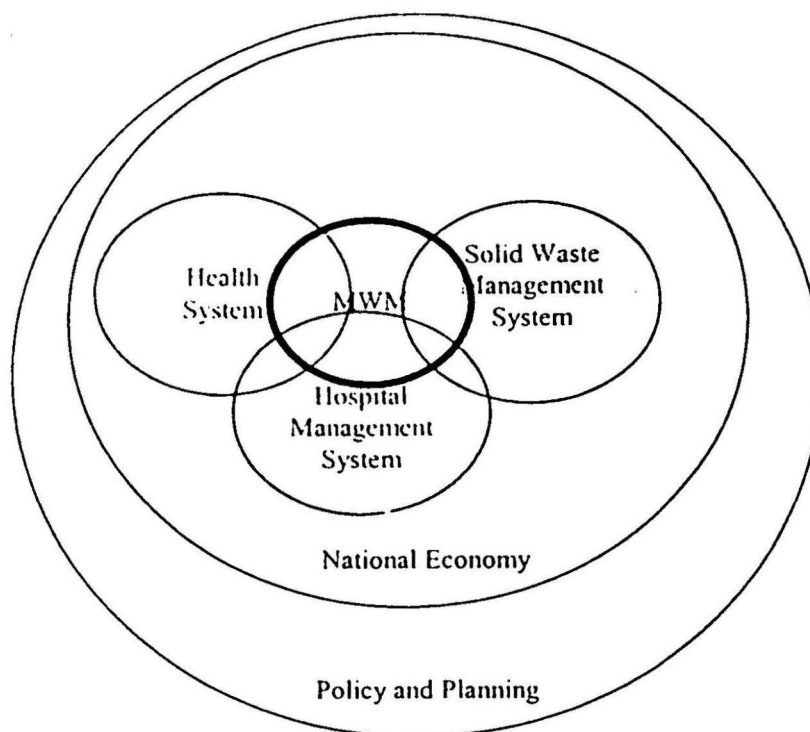


Figure 6.6 Components Influencing MWM in a Country

This figure (Figure 6.6) is somehow related with the previous figure 6.5. Nevertheless, it explained more about components influencing the system and their inter-relationship. MWM is related to total SWM system, hospital management system and health system. These components are directly influenced by national economy, as well as policy and planning of a country.

6.4 Medical Waste Management Scenario: Remarks and Proposed Solution

Medical waste management is a complex issue for considering. Different country has unique or specific state of affairs along with specific problems or limitations. A comparative analysis of existing situation (Table 6.2) offers an overview on the issues needing consideration for proper medical waste management. Analysis has been done under eight broad 'topics or parameters'. These are regulation, health resources, quantity and composition of MW, management, awareness, recycling and re-use and health aspects. Here the status in Europe is used as a standard base line to compare with. Possible reason and /or factors related to the situation is listed under 'remarks' column. It is also shown that how these situations could be improved in each country under 'solution or action column'. Though each country needs to consider different aspects and solutions for specific issues. Nevertheless, this analysis might provide some ideas to improve medical waste management situation in both countries.

Table 6.2 Summary of Medical Waste Management Scenario: A Comparative Analysis

Topics/ parameters		In case of Bangladesh	In case of Thailand	Europe	Remarks	Solutions/ Action
Regulation	In case of Bangladesh	- Inadequate national waste management policy and guidelines. - Ministerial regulation for hospital to get registration did not mention about waste treatment or management.	- National waste management policy indirectly covers medical waste management. - Implementation or enforcement is lacking. - Prescribed Ministerial regulation and guideline for hospital waste treatment and disposal.	- Well defined MWM policy and guidelines. - The prevention of waste as a policy priority. - Environmental damage as a priority, and that 'the polluter should pay'.	- Political commitment. - National economy. - Priority issues and basic needs. - Resources. - Institutional cooperation and technical capacity. - Enforcement.	Overall, short- and long- term, cost-effective strategy for SWM and ensure efficient management of the system.
	Health resources	- Population with safe drinking urban water available in the home or rural with reasonable access (%): 49.1, 96 3307 population per hospital bed 4096 population per physician (24 per 100,000) 9091 population per nurse - Health expenditure 7.54% of total expenditure - Health expenditure 4.9 as % of GDP - Life expectancy at birth (years): 59.5	- Population with safe drinking water available in the home with reasonable access (%): 93.2 501 population per hospital bed 4180 population per physician (24 per 100,000) 1149 population per nurse - Health expenditure 6.64% of total expenditure - Health expenditure 5.7 as % of GDP - Life expectancy at birth (years): 69.97 (M), 74.99 (F)	256-333 population per physician (303-350 per 100,000) 104-201 population per nurse - Health expenditure 9.8-10.5 as % of GDP	- Population pressure - Doctors scarcity in countryside - Nurses are overloaded with work - Population ratio - GDP, PPP - Resources - Equipment	- Local initiative - Simple technology - Job distribution - Motivation - Incentive
Quantity		7-20% of total municipal solid waste 0.5-1.1 kg/bed/day hospital waste 20% of total MW is infectious waste	- General hospital waste 0.22-6.45 kg/bed/day - Infectious waste 0.06-0.59kg/bed/day 6-7% of total MW is infectious waste	- Hospital waste 3-6 kg/bed/day 10% of total waste is hazardous	- Climatic condition - Disease pattern - Definition category	Proper segregation, packaging, labeling

Compositi on	Clinical waste and non clinical waste (general, IW, sharps, recyclable)	Infectious and general medical waste (general, IW, sharps, recyclable)	General, IW, sharps, hazardous	Type of service	Color code
Management	- Most infectious waste are coming out from surgical, laboratory - A part of total solid waste management scheme - Collection done by City Corporation with municipal waste - No storage facility for IW or GW - Segregation is absent except for syringes and needles with few exceptions - Informal segregation is done - Autoclave, open burning, burial, chemical disinfectant, incineration as treatment - Disposal in city corporation's bin, open dumping, municipal landfill site - Salvaged by hospital workers and waste pickers and resold/recycling - Safety measure: Apron, mask, gloves, not well practiced	- Established MWM system within SWM system with limitations - BMA owned private company or/and Municipality collects MW separately or together - Normal storage for both waste - Waste segregation was done centrally (not a common practice). - Not properly done - Chemical disinfectant, incineration, open burning - Common or separate places for IW and GW in the hospital premises, municipal landfill and incineration - Salvaged by municipal workers or waste pickers and resold - Apron, gloves, mask, covered shoes, mostly practiced	- Well established MWM system - Cold storage room - prevention approach into the promotion of the re-use and recycling of waste and the development of low-waste technologies - Optimization of final waste disposal - Sanitary landfill, incinerator, microwave - In the EU, landfill is still the preferred method of treatment followed by incineration	- Different system in Mega and small city - Awareness - Responsibility - Education - Cooperation (NGO, govt., private) - Quality of incinerator - Source segregation, selling recyclable, re-use, end of pipe solution - Incineration can only be accepted as a means of last resort	- Upgrading existing system - Prevention, re-use, recycling and other - Prioritizing of waste (pilot project) shared responsibility - Cooperation with informal or private sectors - Feasible system for small city - Appropriate technology - Improving the partnership among stakeholders involved in MWM - Bottom up approach - Central system
Awareness	- The level of awareness was low (~40% doctor and nurse). - No formal or informal training initiative from government level - Aware but not concern about health risk of medical waste - Individual institution, NGOs initiative to raise awareness	- Awareness is still not enough (~50% doctor and nurse) - MOPH provide training - Hospital officers have awareness in human health risk - Government initiative to raise awareness - More centralized		- Literacy rate - Resources - Personal behavior - Policy and regulation	- Capacity building; training, monitoring, evaluation - Building local public and political awareness in planning and management

Recycling & reuse	• Few selected items are re-cycled by hospital • Uncontrolled and informal recycling of waste exist • Waste pickers are normally hospital cleaners, workers, street urchins, resident near dump site • Waste are picked from dustbin, inside and outside hospital, dumpsite • No formal initiative for re-use of certain items	• Re-cycle item still in demonstration process • No formal probation of recycle or selling of waste • Waste pickers are usually municipal workers, garbage dweller • Waste are picked from municipal cars, dump sites • No formal initiative for re-use	• Hierarchy of prevention, reuse and recycling of waste as well as the safe disposal for the remaining residues	• Marketing • Health • Hygiene	• Promote recycling market • Health issue
Health	• Presence of selected infectious diseases among waste handler, hospital staff and nurses • These were skin diseases, hepatitis B/ C, typhoid, TB, malaria, diarrhea and dysentery. • Incidents of injuries occurred from broken glass, needles, and other metals present in the waste.	• Risk groups identified were nurses, waste handler, cleaner • Aids was identified as primary health risk from hospital waste among respondents • Risk group (nurse, staff) had accident caused mostly by sharps.		• Sanitation, safe drinking water availability; • Health personnel • Resources • Diseases pattern • Epidemics	• Management • Safety measure • Health checkup • Vaccine • Occupational safety • Total quality management • Standards

CHAPTER 7

Conclusion & Recommendation

7.1 Conclusion

Bangladesh and Thailand both the developing countries have some unique problem while there are some common problems exist in these two countries in the issue of medical waste management. However, overall findings of this research has come up with the following conclusion.

7.1.1 Management and Lesson Learned

Safe waste management systems are lacking in many health care establishments visited for this study. The study indicates that improving medical waste handling and disposal methods is a necessity for both countries. This is necessary at government hospitals, private laboratories, and clinics as well. The majorities of health care workers have only a basic understanding of health and do not perceive handling or disposal of medical waste as a hazard though due to AIDs prevalence in Thailand few hospital staffs consider some waste as a dangerous. Hospital authorities tend to overlook it as a proper system involves the expenditure of huge amounts of money. As long as there is no authority to watch it they do not have legal bindings to follow proper management practices of medical waste though most of them could explain what and how would be the proper medical waste disposal and management. This was common for both countries.

It is clear that, there is no control on medical waste after it getting out from the hospitals. Since there is almost non-existing solid waste management system in Bangladesh, medical waste does not get proper attention. Incinerators installed in some big hospitals were not allowed to operate it since DOE did not give permission. Hence all wastes are going to the general municipal waste bin without proper segregation or treatment. Other treatment options used also do not follow standard operating system and do not perform complete destruction of infectious waste and/or standard air emission.

Similarly in Thailand solid waste management system is not working properly. Although Thailand has better management practices, practically all hospitals are not complying with the legislation or not practicing the guidelines or regulation not fulfilling the ministerial requirement of medical waste management. System is quite well managed in the big cities, but at the district level or interior it is not working properly. Even for the small clinics or hospitals in the city situation is not much improved. Most of the incinerators used in Thailand are not guaranteeing a minimum of air pollution control. Not only that, some hospital just installed it as a ministerial requirement and they never used it or use other lower quality processors to burn infectious waste

The overall findings indicate that there is a lack of cooperation and lack of facilities in both countries with some extent. Different institutes or agencies involved with solid waste and medical waste management working separately on their own. Therefore, the system is not working properly. Moreover, medical waste management is not a priority issue in both countries. There are other issues getting priority considering the basic needs of the country's vast population as well as political commitments. Medical waste is just getting mere importance recently.

Identified obstacles related to proper MWM and possible causes of those problems have been explained in chapter six.

Considering the huge amount of municipal and industrial waste, which is generated, medical waste accounts for a small part of total solid waste. Infectious waste is merely 5% to 20% of that waste, and is therefore minute when compared to the total amount of solid waste. Yet, proper identification and segregation of hazardous medical waste will reduce the health risks involved by a great sum. A safe and sensible technology for the treatment of infectious waste must take into consideration all the limitations of management. It might not be harmful if it was well managed. The way it is managed makes it harmful especially in the hospital or wastes generation site i.e. mostly the practices of waste disposal. At different stage of disposal, groups of people are involved and they are exposed to it. So harmfulness could be minimized if it is properly handled. Risk is mostly depending on the in-house waste management practice. Therefore, proper identification and segregation of infectious and hazardous medical waste may reduce the quantity of waste as well as the risk of disposal. If the infectious waste is sent to landfill it would not be a problem as it is a small amount mixed with a huge amount will reduce the risk of infection.

With infectious medical waste, the problem is not just 'how to treat the waste', there are quite a few problems that need to be solved. Everything starts at the place where the waste is generated. A safe and sensible technology for the treatment of infectious and/or hazardous medical waste that takes all aspects of the problem into account must have solutions that apply from the very beginning. A safe and efficient way of treating dangerous waste makes little sense if people are infected during the collection and transportation of the waste.

Nevertheless, there were some good initiatives found in the case studies from Bangladesh and Thailand. Those are as follows:

1. Building awareness among local community to the higher authority, using bottom-up approach to medical waste management in city hospitals;
2. Involvement of local community and all stakeholders in planning and implementation of project is a successful example established by Prodiapan in Bangladesh;
3. Use of simple segregation, collection and disposal system as well as low cost technology to store, treat and dump medical waste centrally;
4. Safety measure used by community hospital workers in Thailand;
5. in-house training, evaluation, individual management guideline is some of good initiatives taken in Phitsanulok province and Bumrungrad hospital in Thailand;
6. Good housekeeping such as waste segregation prior to disposal, different type or colored container for different kinds of wastes are just introduced in some hospital at Phitsanulok.
7. Almost all hospital visited in Thailand have wastewater treatment plant except few small private hospital;
8. Use of disinfectant before disposal of infectious waste to the bin is a good practice;
9. Sharing of big facilities with small hospitals can reduce the cost of waste management and environmental degradation as well as utilization of maximum capacity as Rajabithi hospital share it's big incinerator with 4 other hospital near by to combust infectious waste. Similarly ICDDR,B at Dhaka share it's incinerator with some other small private clinics and NGOs; and

10. Common or central system of waste treatment and management may work effectively and it would be economically viable, like Krungthep Thanakom Company is the only one company taking care of all infectious medical waste in Bangkok metropolitan area. Decentralized waste treatment system practiced in Phitsanulok is not working properly as it was learned from the field investigation.

7.2 Recommendations

Improvements in healthcare waste management involve a number of activities, which can be undertaken as a series of small steps on the road to improvement. There is no 'one stop' technical solution. Considering the situation in developing countries and field observation there are recommendation for medical waste and infectious waste management as follows:

7.2.1 In-house Management

It is learnt that 'in-house' treatment/management of medical waste is the way forward and all potential hospital authority are always advised to review their in-house quality assurance procedure prior to install any technology. In-house management includes 'reduce', 'reuse', and 'recycling' following proper waste segregation (source separation), collection and storage. If it is strictly done there will be little amount of waste to be disposed and incinerate or treat using other method such as autoclaving, chemical disinfecting. When it could be managed properly in the place of generation then most of the waste management problem will be solved. Controlling these does not cost money rather can earn money by reusing or recycling valuable waste. Therefore, in-house management should consider the following aspects:

- clear definition of infectious waste;
- careful identification and safe separation of reuse and/or recyclable items;
- improve practices at all stages of the waste stream and do not focus on one component only, for example final treatment (disinfect before disposal, e.g. chemical treatment, steam/heat treatment);
- maximize safe and sanitary recycling / re-use (where appropriate) by improving in-house management;
- separate the different types of waste at source: in particular sort infectious waste, pathological waste, sharps and chemical waste from non-hazardous material;
- separation and sale of reusable but non-hazardous materials such as paper, plastic and glass can successfully take place under controlled conditions if the waste is separated at source; and
- be prepared to improve the systems incrementally rather than look to 'once and for all' solutions such as incineration of all waste from the outset; small steps can have significant impacts.

7.2.2 Reduce the Cost of Management

To date no low-cost, environmentally friendly and safe disposal options for health-care waste are available. Low-cost options are often polluting and are therefore indirectly potentially harmful to human health. Significant improvements can however be achieved by management options such as purchase policies, re-use, reduction, recycling, and

isolation and proper treatment of key segments of the waste. Nevertheless, following points could be considered to minimize the cost for medical waste management:

- in-house management (section 7.2.1);
- efficient separation, labeling of hazardous wastes; this reduces the total volume of hazardous waste and hence reduces the costs of the subsequent specialized disposal;
- establish a distinct management function for dealing with the waste generated;
- create a dedicated budget line for waste management;
- provide all staff with training on handling waste; and
- work out detailed procedures for storage, handling, transfer and disposals of waste according to its characteristics and potential risks.

Successful initiatives have been introduced at different places by individuals or NGOs (section 7.1.1) could be applied in other places of the country. As Rajbithi hospital and ICDDR,B are practicing, existing facilities in several hospitals at Dhaka may share their facilities with some other small hospital and/or clinics to make it cost-effective also to reduce the City Corporation's workload. In turn they can earn service charge. Others can get service and healthy environment as well. The MOPH of Thailand proposed future plan (central system for infectious waste treatment) has been included this option for existing facilities.

Some cost reduction options are discussed below for Bangladesh and Thailand (where appropriate). Such as:

- Common incinerator for all hospitals should be built outside the city to burn IW. This will reduce the air pollution problem and would be cost effective for small hospital or clinics. In that case, there is a need of special transportation arrangement. This could be normal waste collection car (in any case) but use separately at different time specifically for IW collection and transportation.
- Autoclave IW and dispose as normal waste. It might be cheaper, easy to operate, less operating and maintenance cost, no pollution, easy to manage on site, after autoclaving can be treated as general waste so no special transportation is needed.
- If IW is small in amount, it would be easy to autoclave, means need good separation
- Cooperation between small and big hospital and clinics to share the facilities, this will reduce the cost for big hospital as well as small hospital would have a chance to comply with legislation.
- Encourage private company for waste treatment and disposal; involvement of NGOs, institutional cooperation for collection, disposal, and treatment.

7.2.3 Regulations

With some extent both the countries should adopt and /or improve regulations and legal aspects of their country relating to medical waste and IW management. These are as follows:

- A national policy on medical waste management. This is a need for Bangladesh and need to revise and improve for Thailand.
- Set up criteria for new hospital and health facilities establishment (focusing on waste management) and mitigation measures for old ones.

- Formulation of appropriate laws and regulations governing the disposal of medical waste and the establishment of a mechanism for ensuring that proper disposal of medical waste takes place.
- Enforcement of existing law and regulation.
- Adequate and regular monitoring and evaluation from implementing authority.
- Specification of treatment technology, emission standard and alternatives.
- Incentive for the workers and institutes (award for best performer, allow workers to collect and sell recyclable items).

7.2.4 How it could be achieved

To make medical waste management a successful one and take action for above mentioned aspects in section 7.2.1, 7.2.2, and 7.2.3 following activities should be done:

1. A program for improving education, training and raising awareness about the adverse effect of improper disposal of medical waste for all stakeholders
2. Assistance from government and major NGOs for establishing proper medical waste disposal facilities
3. Initiation of programs at different hospital to ensure that proper handling and separation of medical waste take place before disposal. This should include training of all waste handlers
4. Inclusion of medical waste management in the curriculum of medical and nursing collages.

To reduce the health and environmental hazard management plan should also include the elimination of direct contact between people and hazardous waste by:

- providing personal protective equipment e.g. heavy duty gloves, safety glasses;
- designing systems to minimize contact e.g. good onsite storage, bagging of waste, use of boxes to store waste sharps, more effective transportation, no emptying of waste directly into municipal containers;
- implementing good hygiene practices when dealing with waste e.g. hand washing;
- immunizing those in contact with healthcare waste against certain diseases e.g. Hepatitis B and tetanus; and
- provide better access to healthcare for those in contact with waste e.g. in order to stop infections from deteriorating.

7.2.5 Linking of a Well Approached and Functional MWM System at Large

There are lots of other things need to be addressed for a well approached and functional medical waste management system. These factors are linked with the whole management system of a country. For example water supply and sanitation, food and safety, infrastructure, air-water and noise pollution, drainage and flooding, solid waste, health and education, national budget, population etc. Therefore, it would not be possible to give a simple solution for a well established and functional management system.

Nevertheless, factor those are influencing and need immediate attention or priority for a functional medical waste management system for Bangladesh and Thailand are outlined in the following Figure 7.1.

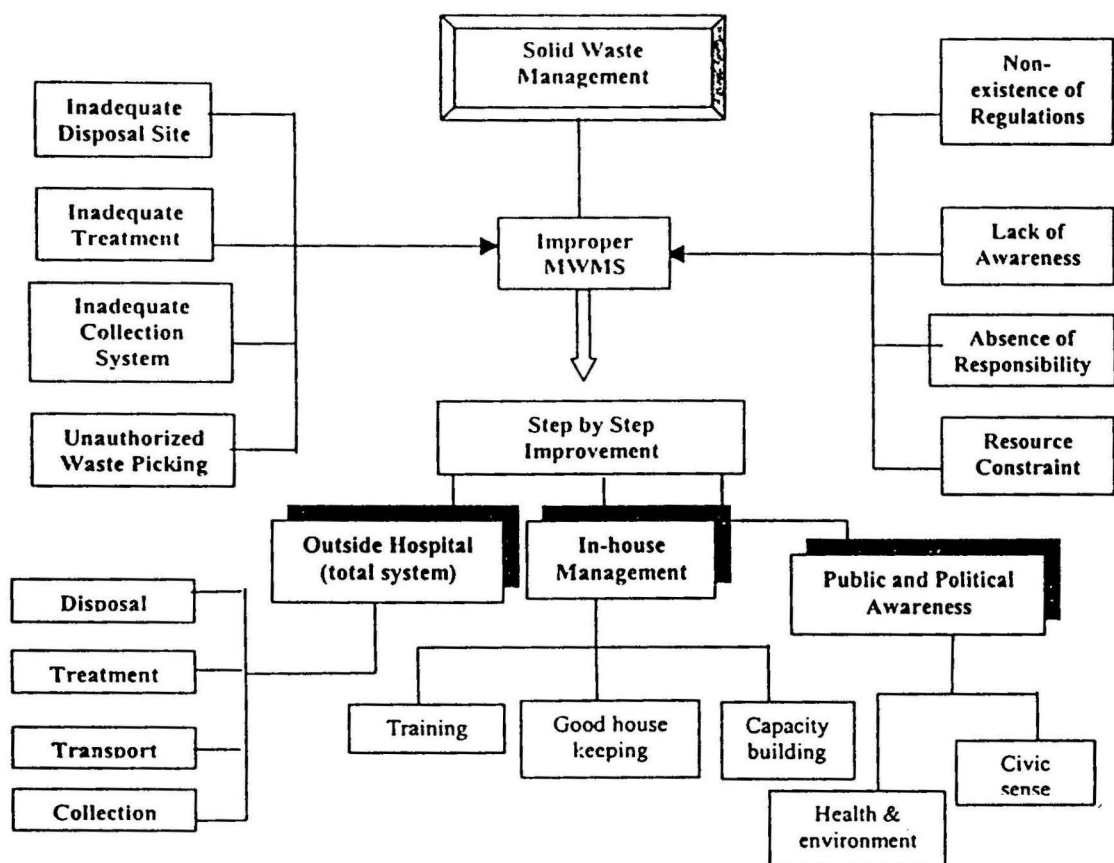


Figure 7.1 Factors Influencing Proper MWM and how to Overcome Those Obstacle

This figure indicated that the MWM is a part of total solid waste management. The reasons behind improper MWM system has been shown in upper portion of the figure, middle and lower portion explained how step by step improvement could be achieved by improving external and internal (in and outside hospital) condition of total management system. Lack or non-existence of regulations, economic condition, lack of responsibilities and lack of public and political awareness has been resulted improper and/or inadequate MWMS (e.g. collection, disposal, treatment and waste picking). Therefore, 'step by step' activities proposed in this figure is needed to make a functional MWMS. It includes total system, in-house management and public and political awareness building.

Following Figure 7.1, there are some more Figures (7.2, 7.3., 7.4., and 7.5) explained each point of 'step by step activities' with detail breakdown to make total medical waste management system functional.

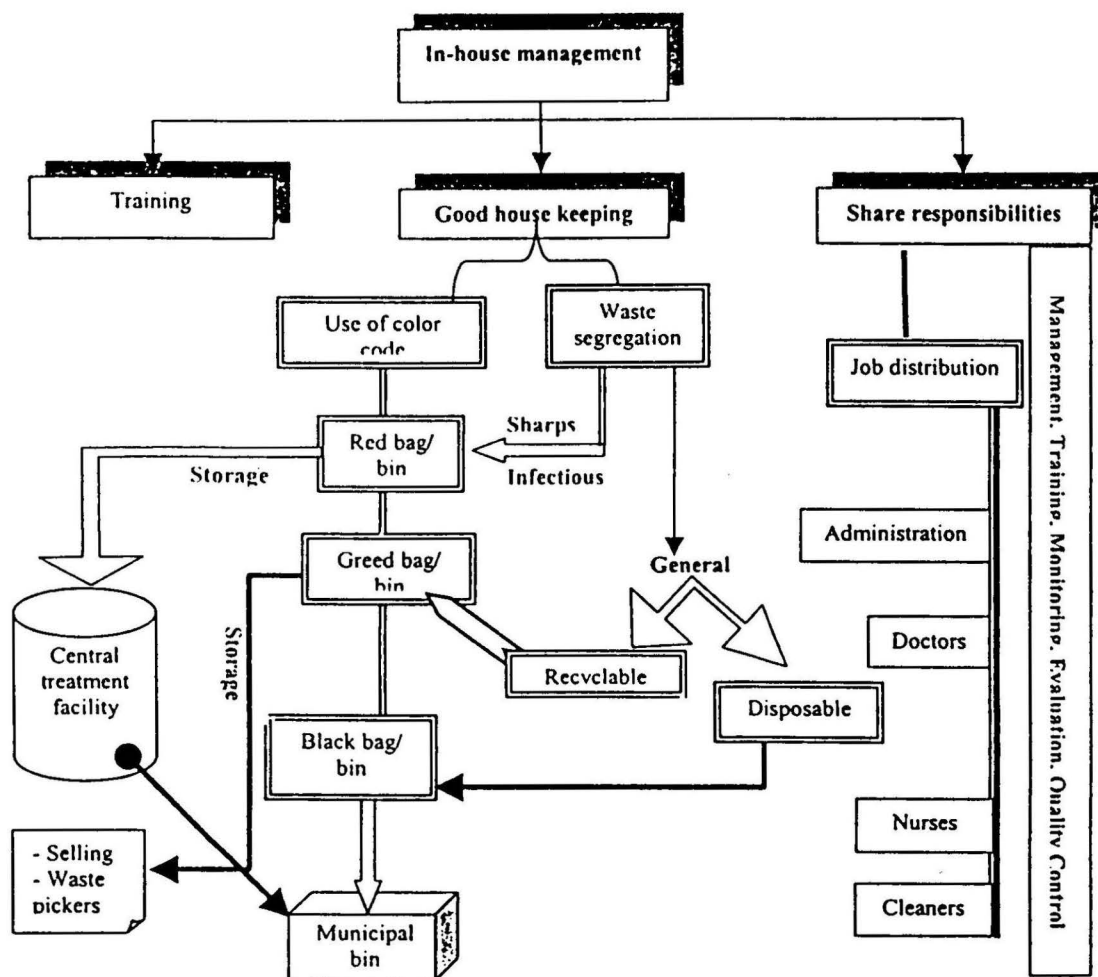


Figure 7.2 In-house Management: Good Housekeeping and Responsibility

Figure 7.2 showed components under in-house management e.g. good house keeping; share responsibilities; and training. Good housekeeping should include use of color codes after proper segregation of waste. Segregation should be done at least in three categories (e.g. infectious, disposable, and recyclable). These are then need to send in appropriate colored bin or bag for final treatment and/ or disposal accordingly. There is a need of share responsibilities among all in hospitals in relation to management, training, evaluation, and quality control as well as to ensure good house keeping.

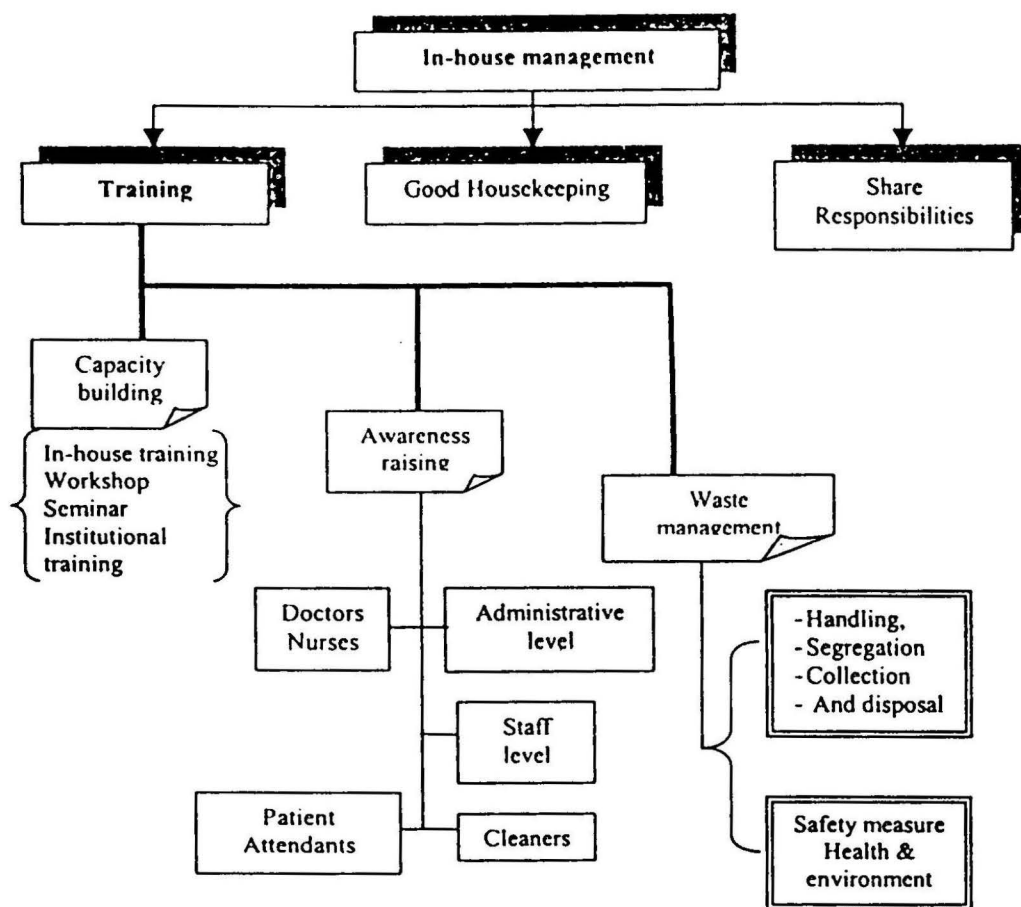


Figure 7.3 In-house Management: Training and Capacity Building

Figure 7.3 explained what are the things should be included in training program of in-house management, such as capacity building, public awareness, and waste management issue. There is a general awareness building needed for all staffs in hospital. Staffs involved in waste generation and management need special training on capacity building (acquire and apply in their daily activities) and waste management. Waste management training should include how to deal with waste (e.g. identification, handling, collection, treatment, and disposal) as well as the safety measures for workers and the environment.

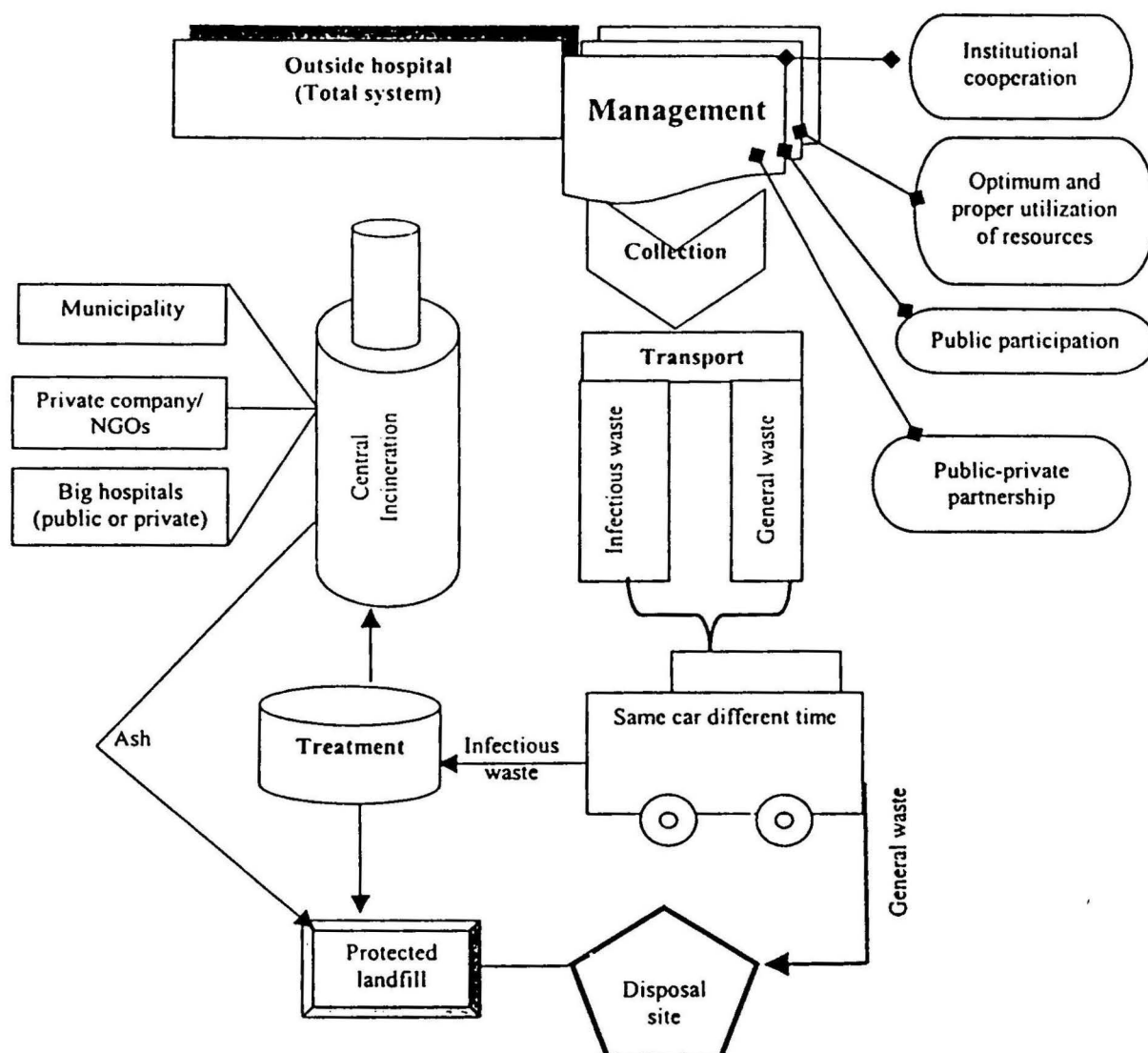


Figure 7.4 External Management: Collection, Disposal and Treatment

Figure 7.4 outlined total management system outside hospital (e.g. collection, transport, treatment, and disposal) and what is needed for proper management. To improve total medical waste management that is linked with the whole waste management system of a country should ensure the institutional cooperation, optimum use of resources, public participation and public-private partnership. All agencies or institutes (i.e. city corporation, municipality, DOE, MOPH, other ministries, NGOs) involved with this issue should work together to bring up guidelines, policies, implementing those and use and upgrade existing systems and available resources and infrastructure.

A management plan should includes all stack holders in planning process. Such as local authority, local community, public and private institutes, NGOs and all other relevant institutes should work together to find an appropriate option feasible for that area. Specific work should be distributed to the relevant institutes or organization.

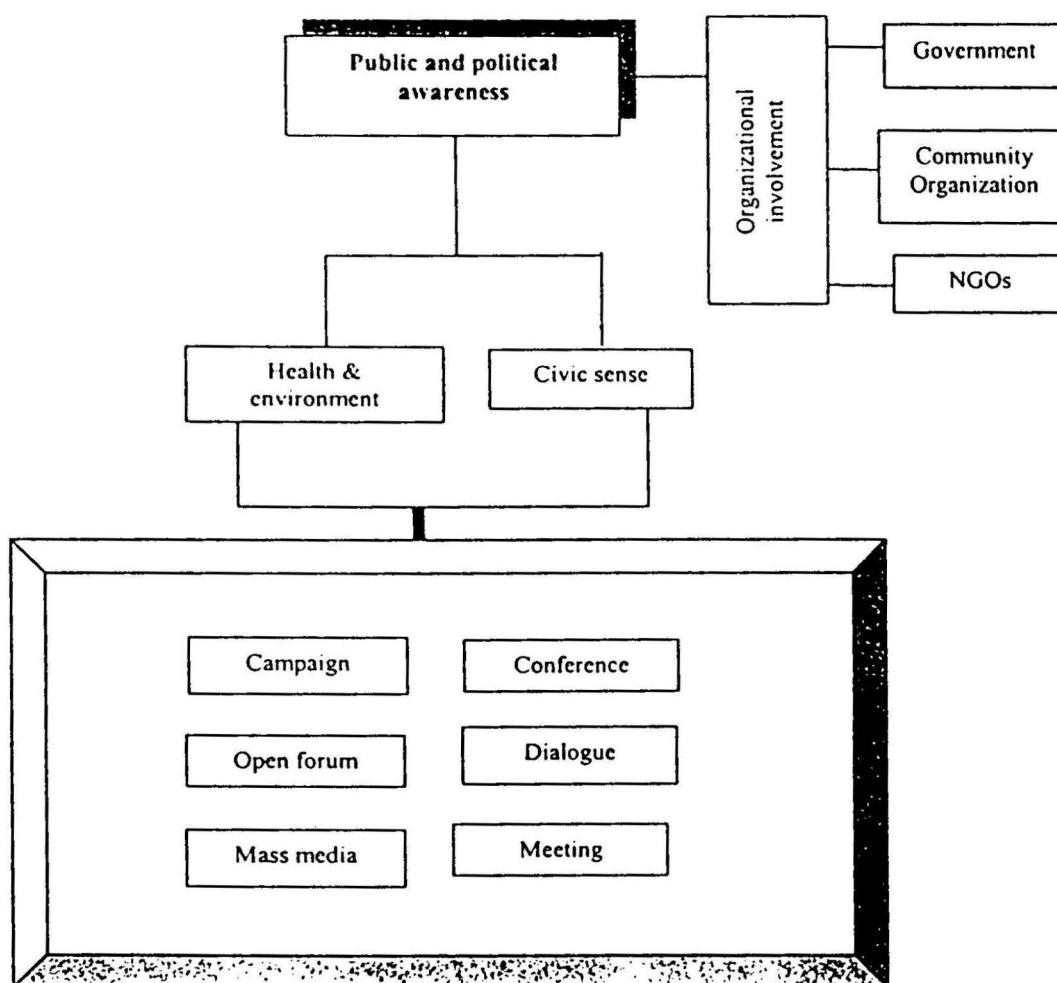


Figure 7.5 External Management: Public and Political Awareness

Figure 7.5 explained activities for public and political awareness and who should be involved to make it successful. This awareness should focus on health and environmental aspects and attitude and civic sense of people and commitments to the country and environment. Government is to take initiative and involve other agencies as well as share/distribute responsibilities among them. Community organization and NGOs can organize training and awareness program at local level. Government and national/private institutes, NGOs can organize nation wide program like campaign, dialogue, open forum meeting etc.

All aspects of this section keeping in mind, an action plan for proper medical waste management in Bangladesh and Thailand has been worked out and placed in the following section of this chapter.

7.3 Action Plan or Strategy Planning for MWM in Bangladesh and Thailand

Based on present study conducted in Bangladesh and Thailand SWOT analysis has been done. It is found that none of government and private and/or NGOs can work independently to achieve the sustainable management of medical waste. There is a need for people participation, partnership among different government organization (e.g. public health, department of environment, land use, urban planning etc.) and private sectors. Following the SWOT analysis (Appendix 17) based on this study it found that there are several good and bad aspects exist in both countries. There are some limitations of those could be overcome and /or bring up alternatives following the case studies of Bangladesh and Thailand as well as the example of industrialized countries. To formulate a **management scheme** these all aspects needed to be considered (described in previous section 7.2).

It is quite clear that the most significant portion of the strategy is the waste minimization action plan. Considering **step by step** improvement plan the medical waste management action plan is formulated in next section.

7.3.1 Medical Waste Management Action Plan

Purpose

The purpose of medical waste management plan is to provide guidance on the segregation of medical waste from other waste streams and establish proper handling and disposal procedures for hospitals and health facilities in Bangladesh and Thailand.

Policy

The policy to segregate medical waste at the point of generation and handle the waste properly using appropriate personal protective equipment and good work practices.

Action plan is divided in to two broad categories:

1. In-house management
2. External management strategy at national level

7.3.1.1 In-house management (internal)

I Definitions

Medical Waste - All of the following:

- Bio-hazardous waste and/or sharps waste.
- Waste which is generated or produced, as a result of the diagnosis, treatment, or immunization of human beings. Medical waste may be **infectious**.

Bio-hazardous and Infectious Waste means laboratory waste including, but not limited to:

- Medical and pathological human or animal specimen cultures.
- Cultures and stocks of infectious agents.
- Waste from the production of bacteria, viruses or the use of spores, discarded live and attenuated vaccines, culture dishes and contaminated devices used for above.
- Discarded waste from specimens sent to the laboratory.

- Human specimens or tissues removed at surgery or autopsy, which are suspected by the attending physician or dentist of being contaminated with infectious agents.
- Waste materials contaminated with excretion, exude, or secretions from humans who are isolated by the infection control staff, attending physician, or the local health officer to protect others from communicable diseases known to be infected with diseases communicable to humans.

Sharps Waste - Any device having acute rigid corners or edges, or projections capable of cutting or piercing, including:

- Hypodermic needles, syringes, blades and needles.
- Broken glass items, pipettes and vials which are contaminated with other medical waste.

Biohazard Bag means a disposable red bag which is impervious to moisture and has sufficient strength to preclude ripping, tearing, or bursting under normal conditions of usage and handling of the waste filled bag.

II Segregation of medical waste inside hospital

A. Red bag or bio-hazard/Infectious waste

- Contaminated plastics products.
- Decomposable product (cotton, bandage, body fluid, organs etc.).
- Chemical and radioactive products.

B. Non-contaminated waste:

Non-infectious or non-contaminated waste could be separated and kept in different container following the categories mentioned below:

General medical waste

- All kind of decomposable wastes (food waste, cotton, gauge, bandage etc.) kept in one bag or container and send to the normal municipal bin.

Recyclable waste (items could be sold by authority or waste pickers)

- Disposable plastics (syringes, plastics, bags, wrappings, tube etc.).
- Paper waste (box, wrappings, container).
- Glass items (broken or intact used bottles, vials, medicine bottle).

Re-usable medical waste (items could be used by hospital itself or re-sold)

- Glass bottles, vials, container which could be used for specimen collection, other purposes (as solvent container, drug container etc.).
- Glass and plastics (such as saline bag, blood bag, water or other solution/chemical container) could be used to contain disposable needle, sharps, body fluids, and contaminated liquids.
- Paper box, hardboard.

III Containment and Storage Of Medical Waste

A. To containerize or store medical waste, employees shall do the following:

- Medical waste shall be contained separately from other waste at the point of origin.
- To segregate and contain each of these above-mentioned type of waste plastic bag, or container, in some cases paper box or hardboard could be used (for re-usable or recyclables).
- Biohazardous/ Infectious waste shall be contained in a red biohazard bag conspicuously labeled with the words "Biohazardous Waste" or with the international biohazard symbol and the word "Biohazard". *If it is not possible then use red bag only.*
- Sharps containers must be rigid, puncture and leak resistant when sealed, cannot be reopened without great difficulty, and properly labeled (empty plastic bottle or container could be used). Sharps containers may be placed in the red biohazard bags.
- All bagged medical waste shall not be opened or removed from the bags.

B. To containerize biohazard or Infectious waste in a biohazard bag, employees shall do the following:

- The bags shall be tied to prevent leakage or expulsion of contents during all future storage, handling, or transport.
- Biohazardous red bags must be placed for storage, handling, or transport in a rigid or disposable container. The containers must be:
 1. Leak resistant and fitted with tight covers.
 2. Sanitary and in good repair.
 3. Can be any color.
 4. Must be labeled with the words "Biohazardous Waste" or with the international biohazard symbol and the word "Biohazard" on the lid and on the sides so as to be visible from any lateral direction.
 5. Washed and decontaminated each time they are emptied. Approved methods of decontamination include, but are not limited to:
 - i. Exposure to hot water at 120 °C for a minimum of 15 seconds.
 - ii. Rinsing or immersing in one of the following for a minimum of 3 minutes:
 - Hypochlorite solution [500 parts per million (ppm) available chlorine].
 - Phenolic solution [500 ppm active agent].
 - Iodoform solution [100 ppm available iodine].
 - Quaternary ammonium solution [400 ppm active agent].

C. To containerize sharps, employees shall do the following:

- Place all sharps into a sharps container (plastic container, bottle).
- Tape closed or tightly lid full sharps containers ready for disposal to prevent spills.

- Label sharps containers with the words "Sharps Waste" with the international biohazard symbol and the word "Biohazard".

D. Storage and Security:

- Storage enclosure must be clean and orderly, secured to deny access to unauthorized persons, posted with the warning sign in English stating "CAUTION – Biohazardous waste storage area – unauthorized persons keep out" and in Own language (in Bangla or in Thai).

IV Storage Time

- A. Biohazardous waste should not keep more than one day and send as soon possible for treatment.
- B. Biohazardous waste may be stored for 7 days above 0 degrees centigrade or up to 90 days below 0 degrees centigrade. *This might be possible for Thailand, not for Bangladesh. Therefore, in Bangladesh waste should be transported every day or alternate day as it was done by Prodipan.*
- C. Full sharps containers ready for disposal may be stored for up to 7 days (longer storage times may be requested from the local enforcement agency).

V Handling and Treatment

- A. A person handling medical waste must wear the appropriate type of personal protective equipment, e.g., gloves, safety glasses, mask, lab coats/apron.
- B. Trash/laundry pipeline, compactors, grinders shall not be used to transfer or process untreated medical waste.
- C. A person generating medical waste shall ensure that the waste is hauled by a registered/entitled hazardous waste hauler to a permitted medical waste treatment facility.
- D. Central treatment facility such as incinerator, microwave would be cost effective and environmentally sound.
- E. Recognizable human anatomical remains shall be incinerated or buried

VI On-Site Waste Treatment with appropriate options

- A. Any kind of infectious waste should be mixed with chemical disinfectant before put in to the red bag.
- B. Laboratory culture, specimen should be autoclaved before discard
- C. Medical waste that has been treated (autoclave, sterilize) becomes solid waste, which is not hazardous.
- D. Facilities (equipment, technology, treatment, budget)

VII Administration and Record Keeping

- A. There should be responsible personnel and staff to deal with medical waste. Board for waste management and individual personnel with specific responsibility.
- Record keeping
 - Supervising
 - Monitoring
- B. Departments with on-site waste treatment must have:
- Information Document on-site.
 - An emergency action plan for spills on-site.
 - Treatment facility operating records for three (3) years.
- C. Departments using a hazardous waste hauler for off-site waste treatment must have:
- Information Document on-site.
 - Records of quantity and type of waste transported, date transported, and the name of the registered hazardous waste hauler.
 - Tracking document records must be maintained for three (3) years.
- D. Contents of Information Document must state how waste is:
- Contained
 - Stored
 - Treated
 - Disposed

7.3.1.2 Management strategy at national level (external)

I Policy and regulation by the government

- Formulation of national policy, appropriate laws and regulations on medical waste management by the government.
- Enforcement of existing law and regulation.
- Regular monitoring and evaluation.
- Tax imposed to the hospitals and service provider; incentives for good practices.

II Participation of all parties and principle of shared responsibility

- Use of integrated approaches (top-down and bottom up approach) in waste management for both countries.
- Involvement of all stakeholders in local waste management planning (e.g. public authorities, private and public companies, environmental organizations, NGOs and individuals).
- Value the local level initiatives for waste management and utilize their experiences.

- Involvement of NGO, private agencies or other organization in waste management activities such as:
 - For collection of medical waste from different hospitals
 - Installation of treatment plant and treatment of waste
 - Managing disposal site specific for medical waste (separate place should be provided by municipality in municipal dumpsite)
 - Providing training and awareness on medical waste management issue
- All participants should be agreed upon service charge or any other cost related to medical waste management and disposal (as it was done by PRODIPAN)

III Training/ awareness raising program

- Training and awareness program should be started from the community level involving all stakeholders (City Corporation, local government, and hospital authority).
- Individual hospital or institute could be trained separately as it is done by some NGOs in Bangladesh (e.g. BRAC, BCAS).

IV Central system of waste transport, treatment, and disposal

There should be common or central system run by government /private company or NGO for collection, treatment and disposal of medical waste. The system should ensure the following aspects:

- Temperature controlled special vehicle used in Bangkok might not be affordable for other parts of Thailand and as well as Bangladesh. Therefore, small and closed truck or van could be used for transporting medical waste from hospital to the dumping or treatment site.
- Vehicle used for medical waste transportation should not be used for other purposes.
- Routine clean up and maintenance needed for the vehicle before and after carrying medical waste.
- Incinerator, sanitary landfill or any other treatment facilities should be provided centrally that will be cost effective and ensure the proper management by small hospital or institution.

V Appropriate options /Technology:

- Waste reduction (good house keeping); waste characterization should be practiced inside hospital.
- Sanitary re-use/recycle of certain waste.
- Training/awareness.
- Central Incinerator
 - Central incinerators run by private company or NGO (like Krungthep Thanakom company or PRODIPAN).

- Simple technology could be used for Bangladesh to install an incinerator prescribed by WHO or SKAT (e.g. PRODIPON).
- It should be far from residential area or city.
- Existing incinerators at different big hospital should use their facility with other small hospitals near by and share the cost (e.g. Rajbithi, ICDDR,B).
- Isolated sanitary landfill provided by Municipality operated by any other parties (NGO, private company)
 - It should be far from the city, as well as in the municipality landfill site (e.g. Khulna City landfill site).
 - Might be maintain by private company or NGO (e.g. PRODIPAN).
 - Simple technology could be used in Bangladesh as it was done by PRODIPAN just to store medical waste before burning and to decompose some waste.

All aspects of external management would be possible if all stakeholders ensure cooperation and coordination among each other. NGO could take the initiative for in-house management as it was done by PRODIPAN and involved all other stakeholders. Government and or local administration should take the initiative for external management system as it is done by BMA and Phitsanulok municipality. Developing countries in Asia may encouraged NGOs to take part in all sectors of the health services and waste management system. Strengthening the solid waste management system will ultimately make the medical waste management system workable.

REFERENCES

- Adsavakulchai, S. (2000), Study on waste from hospital and clinics in Phitsanulok. Final Report. Supported by The Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). Solid Waste Management Project of Phitsanulok. Phitsanulok municipal office. Thailand.
- Agarwal, R. (1998), "Medical Waste Disposal. Issues, Practices and Policy. An Indian and International Perspective". Seminar on Health and the Environment. Center for Science and Environment. New Delhi. India.
- Akter, N. (2000), "Medical waste Management: A review" in Ahmed, F. M. (Ed.), Bangladesh Environment 2000 (An outcome of International Conference on Bangladesh Environment-ICBEN-2000), BAPA, Bangladesh Poribesh Andolon. ISBN 984-31-1082-X. Dhaka, Bangladesh.
- Akter N., Acott, R. E. Sattar, MG. and Chowdhury, S.A. (1998), "Environmental Investigation of Medical Waste Disposal at BRAC Health Centers", BRAC, Research and Evaluation Division, 75 Mohakhali, Dhaka 1212, Bangladesh.
- Akter, N., Hussain, Z. Tränkler, J. and Parkpian, P. (2002), "Hospital Waste management and it's probable health effect: a lesson learned from Bangladesh", Indian Journal of Environmental Health, National Environmental Engineering Institute. Nehru Marg, Nagpur 440020. India. Vol. 44, No 2.
- Akter, N., Kazi, N. M. and Chowdhury, A. M. R. (1999a), "Environmental Investigation of Medical Waste Management System in Bangladesh With Special Reference to Dhaka City", BRAC, Research and Evaluation Division, 75 Mohakhali, Dhaka 1212, Bangladesh.
- Akter, N., Kazi, N. M. and Chowdhury, A. M. R. (1999b), "Medical Waste Disposal in Dhaka City: An Environmental Evaluation", Publisher International Centre for Diarrhoeal Disease Research, Bangladesh. Mohakhali, Dhaka 1212 (GPO Box 128, Dhaka 1000), Bangladesh. Special Publication No. 87. February 1999.
- Appleton, J. and Ali, M. (2000), "Healthcare or Health Risks?" Risks from Healthcare Waste to the Poor. Copyright © 2000 WELL. (web: <http://www.lboro.ac.uk/well/resources/well-studies/full-reports-htm/task0326-full%20report.htm>).
- Asaduzzaman, M. and Hye, S.A. (1997), "When both market and state fail: The crisis of solid waste management in urban Bangladesh." In crisis in Governance. A review of Bangladesh's Development 1997. Centre for policy dialogue. University Press Limited. Dhaka, Bangladesh.
- Asian Development Bank. (1998), "Dhaka City Management reform pilot project". Draft final report. Prepared by Bangladesh Center for Advanced Studies (BCAS) and BRAC. Dhaka Bangladesh.
- BAN and HCWH. (1999), "Medical Waste in Developing Countries". *An analysis with a case study of India, and A critique of the Basel -TWG guidelines*. Basel Action Network (BAN) secretariat, Asia Pacific Environmental Exchange, 1827 39th Ave. E., Seattle, WA. 98112 USA.
- Bangladesh Environmental Lawyers Association. (1996), The Environmental Preservation Act 1995. Unofficial English Version. Bangladesh, Dhaka.

- Bangladesh Gazette. (2000), Bangladesh environment Preservation Act, 11 no. law of 2000. Peoples Republic of Bangladesh.
- Bangladesh Gazette. (1997), Registered No: DA-1. Ministry of Environment and Forest. Access issue. Peoples Republic of Bangladesh.
- Bangladesh Center for Advanced Studies (BCAS). (1997), Hospital environment management project. Bangladesh Center for Advanced Studies. GPO box 3971, Dhaka, Bangladesh.
- Bangkok Metropolitan Administration (BMA). (1998), Annual Report of Bangkok Metropolitan Administration. Bangkok, Thailand.
- Cheremisinoff, P.N. and Shah, M.K. (1990), "Hospital Waste Management". Pollution Engineering. 22, 4:60-66.
- Coker, A. O., Sangodoyin A. Y. and Ogunlowo. O. O. (1998), "Managing hospital waste in Nigeria". 24th WEDC Conference. Sanitation for all. Islamabad, Pakistan.
- Colgate J. D. (2001), "Standards for the alternative technological treatment of healthcare waste". International directory of solid waste management. The ISWA year book. James & James Ltd. London, UK.
- Conway, Richard A. (1982), "Introduction to Environmental Risk Analysis" in Conway, Richard A. (Ed.). Environmental Risk Analysis for Chemicals. P.E. Van Nostrand Reinhold Company. N.Y. USA. pp558.
- Dana, T. (1999a), "Hospitals Waste Disposal in Dhaka". An Exploration in Search of Policy, Guidelines and Rules. Bangladesh Legal Aid and Services Trust (BLAST), 141/1 Segunbagicha, Dhaka 1000, Bangladesh.
- Dana, T. (1999b), "Alternatives: Health and Hospitals: An Exploration in Search of Policy, Guidelines and Rules". The Daily Star, Volume 3 Number 66, Fri. October 29, 1999. Dhaka, Bangladesh.
- Drauschke, S. (1999), "Clinical Waste Policy in Germany". KEG Sonderabfall-Entsorgungsgesellschaft mbH, Am Schlangengraben 20, 13597 BERLIN, GERMANY.
- Eigeheer E., and Zanon, U. (1991), "O que fazer os residuos hospitalares. Proposta para classificacao, embalagem, coleta e destinacao final". Arquivos Brasileiros de Medicina, Vol. 65, No. 3.
- Environmental Protection Agency (EPA). (1986), EPA guidelines for Infectious waste Management. U.S. EPA. Office of Solid Waste, Washington D.C.
- EPA. (1990), Operation and Maintenance of Hospital Medical Waste Incinerators. Handbook. Technology transfer, January 1990. EPA/625/6-89/024.
- EPA. (1991), Medical and Institutional Waste Incineration: Regulations, Management, Technology, Emissions, and Operations. Seminar Publication. Technology Transfer. Office of Research and Development. Washington, DC 20460. December 1991. EPA/625/4-91/030.
- EPA. (1997), Overview of the 1997 U.S. EPA Standards and Guidelines for Medical Waste Incinerators. 18 November 1997. prepared by Jackie Savitz of the Environmental Working Group (<http://www.commonweal.org/HCWH.html#anchor1361056>).

- EPA. (2000), Medical Waste Module. Draft student manual. Submitted by Science Application International Corporation, 221 Third Street, Newport, RI 02840. Submitted to US EPA, 401 M Street SW. Washington, DC 20460.
- EPA-Victoria (1993), Manual for the Management and Disposal of Biomedical waste in Victoria 2nd edition, publication no. 268. EPA Victoria, Australia.
- EPA-Victoria (1994), Environmental Heidelberg Repatriation Hospital Performance and Improvements. Publication no. 435, Victoria, Australia.
- Farooque, M. and Hasan, R. (1996), Unofficial English Version of the Bangladesh Environment Conservation Act, 1995 in "Laws regulating environment in Bangladesh". Bangladesh Environmental lawyers Association. Dhaka, Bangladesh.
- Faustman, E.M. and Omenn, G.S. (1990s), Risk Assessment in Klaassen, C. D. (Ed), "Casarett and Doull's Toxicology – the basic science and poisons". International edition. Unit 1.
- Fereres, J. (1991), "Hospital Waste: Human Health". European Conference on Hospital waste Management 13-15 May, 1991, Copenhagen, Denmark.
- Glasson, J., Therivel, R., and Chadwick, A. (1994), Introduction to environmental impact assessment. UCL Press Limited. London, England.
- Gleis, M. (1997), "Healthcare Waste Management in Germany and in the European Union" in Federal Environmental Agency, Federal Republic of Germany. A Selection of Recent Publications (Vol. 5). Editor: Federal Environmental Agency Umweltbundesamt. P.O. Box 330022. D-14191 Berlin. Germany.
- Griffith, J., Aldrick, T., and Drane, W. (1993), Risk assessment in Cooke, C. (Ed), "Environmental Epidemiology and Risk Assessment". VAN NOSTRAND REINHOLD. New York, USA. pp 1- 274.
- Hadi, M. A. (1999), "Monitoring of hospital waste management in Dhaka City: A study using GIS approach". M Sc. thesis. Department of Geography and Environment, University of Dhaka, Bangladesh.
- Hall, S. K. (1989), Infectious Waste Management: A multifaceted problem. Journal of Pollution Engineering. 21, (8): 74-78.
- Hanks, T. G. (1967), "Solid Waste / Disease relationships- a literature survey". U.S. Department of health, education, and welfare. Public Health Service Publication. CINCINNATI. USA. pp 179.
- Hempen, S. (2002), Training Materials on Waste Management. A Report prepared for the European Environmental Bureau. Source: http://www.roheline.ee/eng/eu/eu_waste.doc. downloaded in March 2002.
- HMSO. (1995), "Making Waste Work": a strategy for sustainable waste management in England and Wales", HMSO, 1995. Command Paper 3040. HMSO web site at www.hmso.gov.uk.
- International Institute for Sustainable Development. (1996), Global Green Standards. ISO 14000 and sustainable Development. IISD, Winnipeg, Canada, pp 91.
- IRPTC. (1985), Treatment and Disposal Methods for waste chemicals. United Nations Environment Program, Geneva, Switzerland, 20pp.

- Islam, M. N., Mahmud, S., Karim, F. and Ahmed, A. (1993), Monitoring and evaluation report of women's health and development program. Number 15: Evaluation of TB laboratory operations in women's health and development program of BRAC. Research and Evaluation Division, BRAC, Dhaka, Bangladesh.
- International Training Network (ITN). (1997), Orientation Manual. International Training Network. Bangladesh University of Engineering and Technology (BUET). Dhaka, Bangladesh.
- Jantsch, F. and Heino, V. (1999), "Management of solid waste and liquid waste at small healthcare facilities in developing countries". Division 44. Environmental Management, Water, Energy, Transport. GATE information service. Published by Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH. Postfach 5280, 65726 Eschborn, Germany.
- Kaiser, B., Eagan, P., and Shaner H. (2001), "Solution to Health Care Waste: Life-Cycle Thinking and "Green" Purchasing". Environmental Health Perspectives. Volume 109. Number 3. March.
- Kazi, N. M. (2000), Healthcare Waste Management in Khulna City: An integrated Approach for Sustainability. A paper presented in an International workshop on "Planning for sustainable and integrated solid waste management", Manila, Philippines September 18-21 2000. Organized by the collaborative working group of municipal solid waste management in low- and middle- income countries contact via SKAT. Vadianstr. 42, 9000 St Gallen, Switzerland.
- Kazi, N.M. (1998), "Waste Management in Dhaka". Dhaka City Management Reform Workshop. Organized by BRAC and Bangladesh Center for Advanced Studies. Dhaka. Bangladesh.
- Kazi, N.M. (1997), "Waste Management in Dhaka". Bangladesh Environmental Newsletter, vol.8, No.4. Bangladesh Center for Advanced Studies (BCAS), Dhaka, Bangladesh.
- Krungthep Thanakom Company. (2001). Guideline for Hospital waste management in Bangkok. Bangkok Metropolitan Administration. Bangkok, Thailand.
- Laber, J., Haberl, R., and Shrestha, R. (1999), Two-stage constructed wetland for treating hospital wastewater in Nepal. Wat. Sci. Tech. Vol. 40, No. 3, pp. 317-324. ©1999 IAWQ. Published by Elsevier Science Ltd. Printed in Great Britain.
- Liberti, L., Tursi, A., Costantino, N., Ferera, L., and Nuzzo, G. (1994), Optimization of Infectious Hospital Waste Management in Italy: Part-I Waste Production and Characterization Study. Waste Management and Research. 14:373-385.
- Line Director. (2001), "Manual for Hospital Waste Management" in Rahman A.K.M.Saiedur (Ed.), Line Director (hospital services) Directorate General of Health Services, Ministry of Health and Family Welfare. DGHS, Mohakhali, Dhaka, Bangladesh.
- Line Director. (2000), "Situation assessment and analysis of hospital waste management (a pilot study)" in Rahman A.K.M.Saiedur (Ed.), Line Director (hospital services). Directorate General of Health Services, Mohakhali, Dhaka, Bangladesh.
- Litchfield, J. and Pheland, D. (1992), Clinical Monitoring and Control. Waste Management, 12:19-20.

- Matrix Associates Co., Ltd. (2001). "Study of present situation and trends for solid waste management in Thailand" to support the Thai-German research project. Matrix Associates Co., Ltd. July 2001. Bangkok, Thailand.
- Meaney, J.G. and Cheremisinoff, P.N. (1989), Medical Waste Strategy. Pollution Engineering 21, 11:92-106.
- Medical waste disposal. (1994), Medical waste Committee (WT-3). Technical Council Ait and Waste Management association. J of Air Waste Manage Assoc. 44:1176-1179.
- Ministry of Environment and Forest of Bangladesh. (1995), National Environment Management Action Plan (NEMAP), Dhaka, Bangladesh.
- Ministry of Public Health. (2000), Thailand health Profile 1997-1998. Ministry of Public Health. Thailand. ISBN 974-291-890-2.
- Ministry of Water Resources. (1995), Manual for Environmental Impact Assessment. Bangladesh Flood Action Plan. Irrigation Support Project For Asia and the Near East, Technical Support Center.
- Murtagh and Associates. (1997), Material safety data sheets. 160 Bay Court Winchester, VA, U.S.A.
- NaQuin D. (2000). Medwaste Regulations Go Global. Available: www.wasteage.com/edit/month/9905/199905g.html (cited 27 July).
- Nessa, K., Quaiyum, M.A. and Barkat-e-Khuda. (2001), Waste Management in Healthcare Facilities: A Review. ICDDR,B Working Paper No. 144. ICDDR,B: Center for Health and Population Research. Mohakhali, Dhaka 1212, Bangladesh.
- Nurunnabi, A. S. M. (1997), Waste management practices in city. The Daily Star, March 29th, 1997, Dhaka, Bangladesh.
- Paranan, E. (1997), "Upgrading of hospital waste management: A case study in Bangkok", Thailand. MS thesis (EV-97-16). SERD, Asian Institute of Technology. Thailand.
- Park, K. (1994), Preventive and social medicine. M/s Banarsidas Bhanot Publishers, Jabalpur, India.
- Pollution Control Department (PCD). (2000), Integrated Municipal waste management, Handbook for local administrative organization executives, 48 pages. Bangkok. Thailand.
- Rahman, M. M. and Ashraf. A. M. (2000), "Waste management and environmental pollution in Bangladesh". Paper presented at the International Conference on Bangladesh Environment, ICBEN, at BUET, Dhaka Bangladesh. 14-15 January 2000.
- Rashid, S. (1996), "Medical waste disposal in Dhaka city: A survey". North-South University. Bangladesh, Dhaka.
- Reinhardt, P.A. and Gordon, J.G. (1991), Infectious and Medical Waste Management. Lewis Publishers, Michigan, USA.
- Rouf, A H M A. (1996), A study on Hospital Waste generated in private clinics situated in Dhaka City. An M.Phil thesis of NIPSOM, Dhaka. Bangladesh.
- Rutala WA, Odette RL, and Samsa GP. (1989), Management of infectious waste by US.. hospitals. JAMA 262 (12):1635-1640.

- Sangodoyin, A. Y. (1993), Consideration on a Contamination of ground waste by waste disposal system in Nigeria. Environmental Technology, 14, (10): 957-964.
- Sangodoyin, A. Y. and Agbawhe. O. M. (1992), "Environmental Study on Surface and Ground water Pollutants from Abbatoir Effluents". Bioresource Technology, 41 (3): 193-200.
- Sathasivan, A. (1999), Microbial Quantitative Risk Assessment in Sydney Bathing Beaches. A report prepared on 11 November 1999. UEEM, SERD, Asian Institute of Technology. Thailand.
- Sathasivan, A., and Mahendarn, K. (1999), A teaching material for a workshop on "ISO 14000 and its Environmental Management System". Asian Institute of Technology. SERD. Bangkok. Thailand.
- Schmidt, W. and Schmidt, T. (1994), Environmentally and Hygienically Sound Disposal of Hospital Waste in Brazil: Separate Collection saver Costs. *Gate 1*, 31-35.
- Sekitar J. A. (1987), A handbook of environmental impact assessment guidelines. Department of Environment. Sementarian Sains, Teknologi Dan Alam Sekitar, Kuala Lumpur.
- Shaner, H. (1997), Professional Development Series; Becoming a Mercury Free Facility: A Priority to be Achieved by the Year 2000. American Society for Healthcare Environmental Services of the American Hospital Association.
- Shapiro K., Mark, S., Robert, G., and Linda, F. (2000), "Healthy Hospitals: Environmental Improvements Through Environmental Accounting". Submitted to: US Environmental Protection Agency. Office of Prevention, Pesticides and Toxic Substances (July 2000). 11 Arlington Street, Boston, MA 02116-3411. Tel: 617-266-5400. Fax: 617-266-8303. www.tellus.org. (source: http://www.h2e-online.org/enviro_accounting.asp).
- Shrestha, R.R., Haberl, R. and Laber, J. (2001), Constructed wetland technology transfer to Nepal. Water Science and Technology. Vol 43 No 11 pp 345-350 ©IWA Publishing.
- Special Waste Regulations. (1996), Waste and Recycling: Special Waste (England). Department for Environment, Food and Rural Affairs. (Downloaded from <http://www.defra.gov.uk/environment/waste/special/index.htm> on 2002)
- Sumon, A. (2000), A seminar paper on hospital waste management in Khulna City. Urban and Rural Planning, Khulna University. Bangladesh.
- Thakur, N. S. (1998). Alternative Strategies of securing livelihoods in the hills of Nepal: A case study of Bhattadanda VDC, Lalitpur district. Master's thesis. Asian Institute of Technology. SERD. Bangkok. Thailand.
- The Daily Star. (2000), Staff Correspondent reported on the Seminar on "Urbanisation in Bangladesh: Emerging Challenges" organized by Bangladesh Institute of Planners, Department of Urban and Regional Planning and Poribesh Rokhha Shopoth (Porosh). October 1, 2000. Dhaka, Bangladesh.
- Townend, W. K. (2001), Healthcare waste management. International Solid Waste Association (ISWA). Healthcare waste working group. Conference paper.
- Tränkler, J. and Akter, N. (2001), Market Place Monitoring Project "Health Care Waste" in China, Thailand, Malaysia, and Vietnam. Report to the Asia-Invest Program.

- U.S. Congress, Office of Technology Assessment, (1990), Finding the Rx for Managing Medical Wastes. U.S. Government Printing Office, Washington D.C.
- Wangsaatmaja, S. (1997), Environmental Action Plan for a Hospital. An MS thesis (EV-97-49). SERD. Asian Institute of Technology. Bangkok, Thailand.
- World Health Organization (WHO). (2002), http://www3.who.int/whosis/whr_statistics/locate.cfm?path=statistics,whr_statistics,whr_locate&language=english;http://w3.whosea.org/cip/annex1.htm (downloaded in March 2002).
- WHO. (1994), Managing Medical waste in Developing countries: report of a consultation on Medical wastes Management in Developing countries: Geneva.
- WHO. (1996), Suggested Guiding Principles and Practices for the Sound Management of Hazardous Hospital Wastes, Chiang Mai, Thailand.
- WHO. (1998), Teacher's guide: management of wastes from health-care activities, Prüss, A and W.K. Townend (Ed). WHO/EOS/98.6. DISTR: GENERAL. ORIGINAL: ENGLISH. World Health Organization. Geneva.
- WHO. (1999a), Guidelines for safe disposal of unwanted pharmaceuticals in and after emergencies. Essential Drugs and Other Medicines Department, World Health Organization, Avenue Appia 20, CH-1211 Geneva 27, Switzerland.
- WHO. (1999b), Safe Management of Wastes from Health-Care Activities. edited by A Prüss, E Giroult and P Rushbrook. 1999. XIV + 230 pages + 4 colour plates (available in English; French and Spanish in preparation). ISBN 92 4 154525 9. CH-1211 Geneva 27 Switzerland.
- WHO. (2000a), WASTES FROM HEALTH-CARE ACTIVITIES. WHO information, Fact Sheet N° 253, October 2000. <http://www.who.int/inf-fs/en/fact253.html> (downloaded in March, 2002).
- WHO. (2000b), Policy analysis Management of Health-care wastes. (intended to provide a quick overview of the topic at policy-maker level, in particular at national level). Downloaded in April 2002.
- WHO. (2000c), World Health Report 2000:Health Systems —Improving Performance. Geneva. Switzerland.
- WHO. (2000), WASTES FROM HEALTH-CARE ACTIVITIES. WHO information, Fact Sheet N° 253, October 2000. Available in <http://www.who.int/inf-fs/en/fact253.html>, (downloaded in March 2002).
- World Bank. (1991), Environmental assessment sourcebook. Volume II: Sectoral Guidelines. World Bank Technical Paper No 140, Environmental Department, The World Bank. Washington, DC.
- World Bank. (2000), Healthcare waste management guidance note. Urban Development Division, Infrastructure Group, Environment Department and Health, Nutrition and Population Team. The world Bank.

Pictures on Medical Waste Management Practices in Bangladesh and Thailand

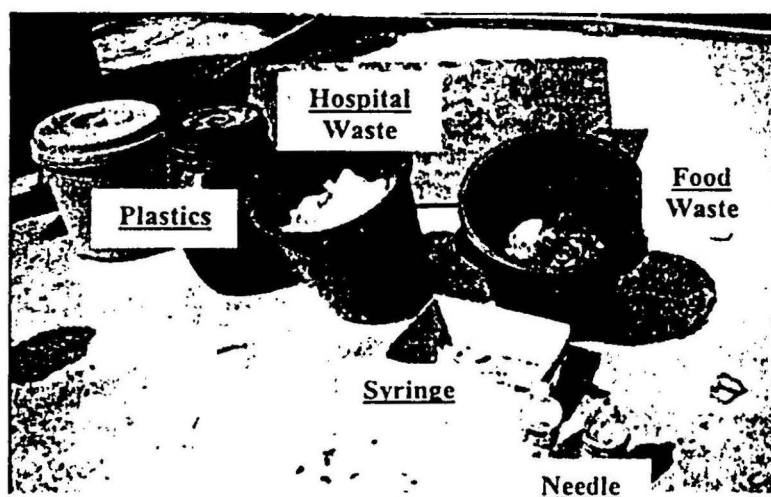
Waste Segregation in Hospital Bangladesh



Picture 1 Waste Segregation Displayed in ICMH, Matuail, Dhaka



Picture 2 Infectious Waste in ICDDR,B and Recyclable Waste in ICMH, Dhaka



Picture 3 Waste Segregation by Pradipon in Hospital at Khulna City

Thailand



Picture 4 Infectious and General Waste Segregation in Rajabithi Government Hospital, Bangkok



Picture 5 Recyclable and Infectious Waste Segregation in Buddhachinarat Government Hospital, Phitsanulok



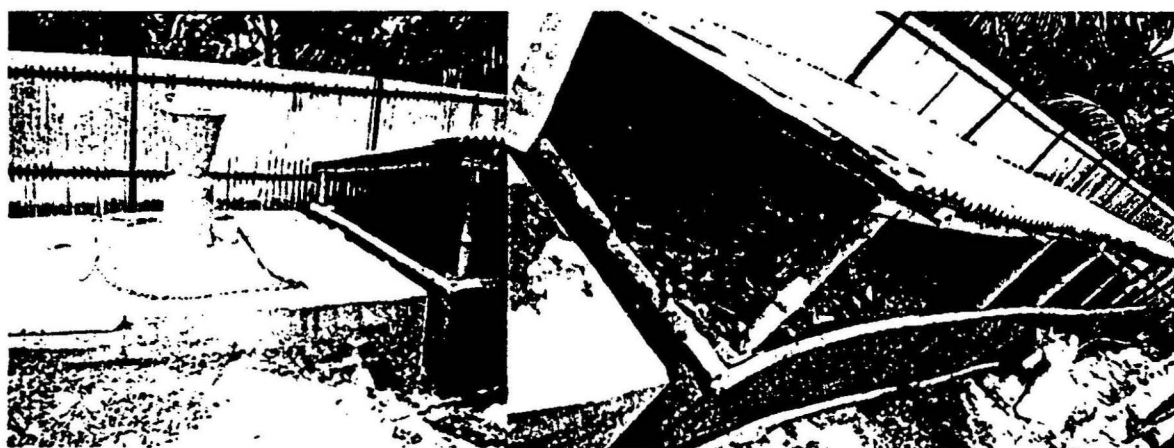
Picture 6 Waste Segregation in Common Room of a Community Hospital, Phitsanulok

Storage of Medical Waste

Bangladesh



Picture 7 Infectious Waste Stored inside Incinerator for Few Days before Burning at ICMH, Matual, Dhaka



Picture 8 Sharps and Syringes Storage (left side) and Clinical Waste Storage (right side) by Pradipon, Khulna



Picture 9 Medical Waste Dumping near Roadside Bin at DMCH, Dhaka

Thailand



Picture 10 Temperature Controlled Storeroom for Infectious Waste
at Rajabithi and Bumrungrad Hospital, Bangkok



Picture 11 Open Storeroom for Infectious and General Waste at two
Hospitals, Phitsanulok

Medical Waste Transport and Treatment
Bangladesh



Picture 12 Clinical Waste Transportation Car of Pradipon, Khulna



Picture 13 Abandon Incinerator at DMCH (left) and Operating Incinerator of ICMH, Dhaka



Picture 14 Incinerator Operated by Pradipon, Khulna and ICDDR,B Incinerator, Dhaka

Thailand



Picture 15 Infectious Waste transportation car of Krungthep Thanakom Company, Bangkok



Picture 16 Incinerator of Krungthep Thanakom, Bangkok and a Community Hospital at Phitsanulok



Picture 17 Unutilized Incinerators behind the Left Oven Type Incinerator and a Drum Type Burner in a Private Hospital, Phitsanulok

Health and Environment In and Outside Hospital
Bangladesh



Picture 18 Drug Addicted Waste Picker at DMCH Waste Bin, Dhaka



Picture 19 Waste Picker Collecting Saline Set from SSMCH Waste Bin, Dhaka



Picture 20 Waste Dumping at Matuail Dumpsite Encroached to a Fishpond, Dhaka

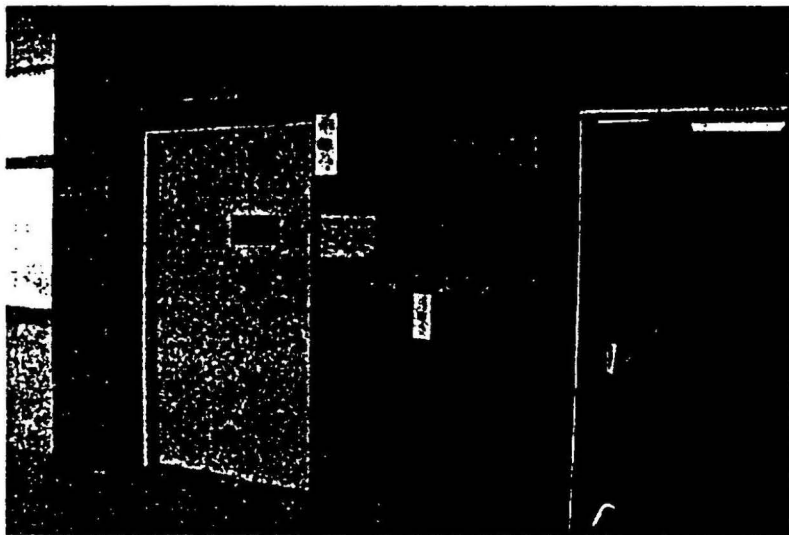
Thailand



Picture 21 Incinerator's Ash Dumped in Open Place at Onnut Dumpsite

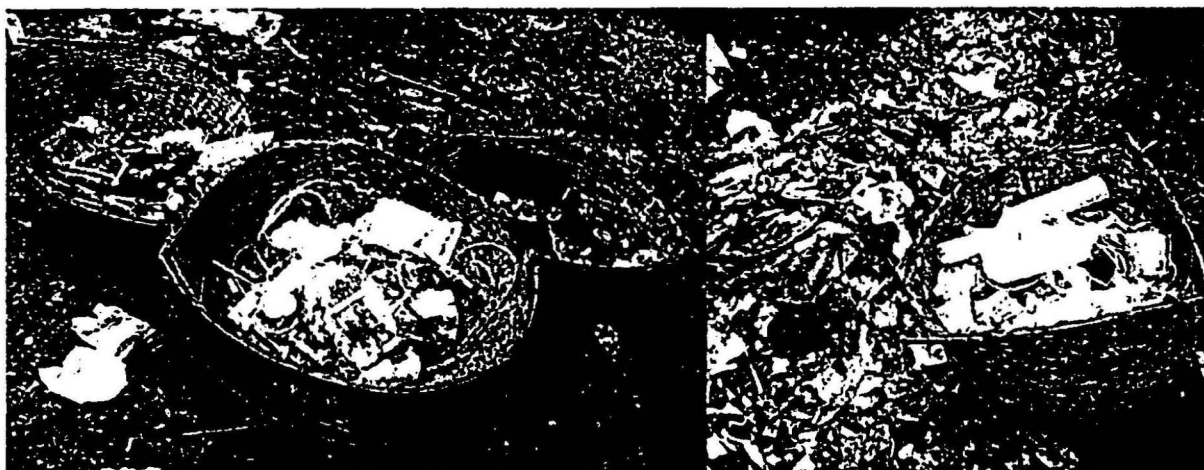


Picture 22 Incinerator Stack with Uncontrolled Smoke in a Community Hospital, Phitsanulok

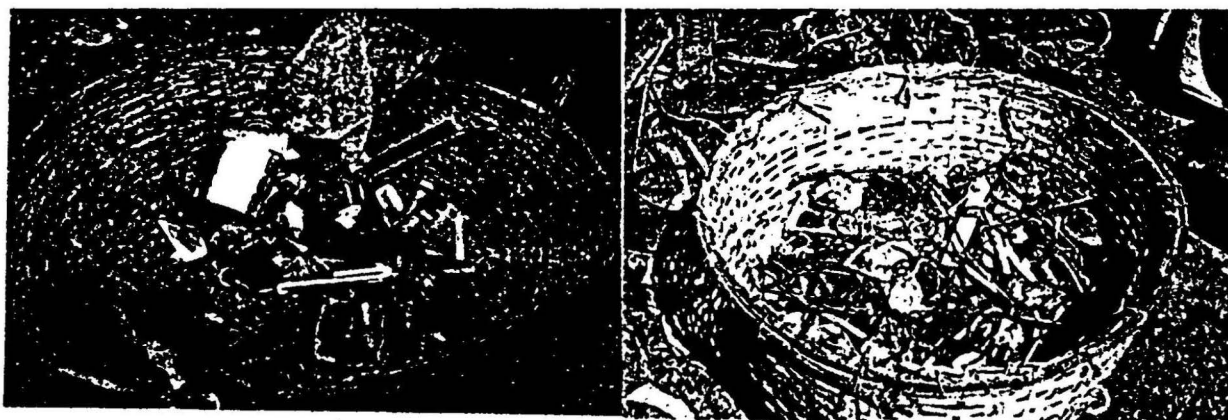


Picture 23 Separate Elevator to Carry MW in Buddhachinarat Government Hospital. Phitsanulok

Waste Collection Recycling
Bangladesh



**Picture 24 Informal Waste Collection to Sell from Medical Waste Bin from
DMCH and SSMCH, Dhaka**



**Picture 25 Waste Collected to Sell from Matuail Dumpsite (syringes with needles could
be seen at left side basket), Dhaka**

Thailand



**Picture 26 Recyclable Waste in Buddhachinarat Government Hospital,
Phitsanulok (display only)**

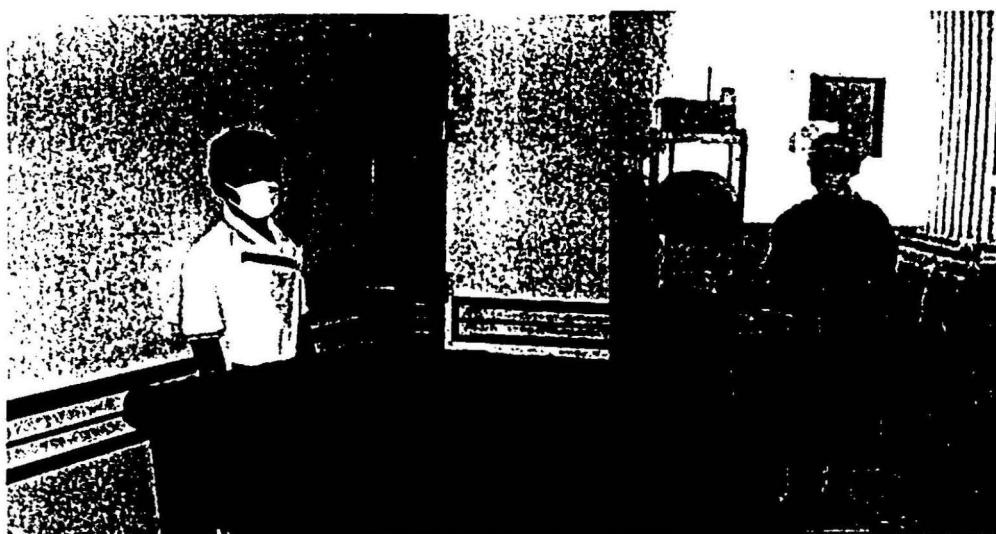
Waste Handler in Hospital

Bangladesh



Picture 27 Medical Waste Cleaner at DMCH, Dhaka

Thailand



Picture 28 Medical Waste Handler at Bumrungrad and Rajabithi
Government Hospital, Bangkok

Appendix 1 Name of the Hospitals, Clinics and Diagnostic Centers Visited in Bangladesh with bed Number

Name of selected hospital from Dhaka	No of beds	Name of selected hospital from Khulna	No of beds
Institute of Post Graduate Medicine Research (IPGMR)	750	Khulna Medical College and Hospital	250 beds
Dhaka Medical College Hospital (DMCH)	1050	Surgical Hospital, Khulna	100 beds
Sir Salimullah Medical Collage Hospital (SSMCH)	600	Garib Newaz Clinic, Khulna	60 beds
Infectious Disease Hospital (IDH)	100	Islami Bank Hospital, Khulna	50 beds
National Medical Institute and Hospital	250	Pangu Hospital, Khulna	20 bed
Ibnesina Diagnostic Center	No bed	Mahanagar Diagnostic Center	No bed
Modern Clinic	No bed	Bashundhara diagnostic Center	No bed
Medinova Diagnostic Center	No bed		
Holly Family	500		
Popular Diagnostic Center	No bed		
Delta Medical Center and Clinic	No bed		
Institute of Child and Mother Health (ICMH)	70		
International Center for Diarrhoeal Disease Research, Bangladesh (ICDDR,B)	250-300		
Combined Military Hospital (CMH)	200		

Note: From no 1-7 hospitals and centers from Dhaka were selected for questionnaire survey, including these 7 hospitals and centers all others were selected for interview and field investigation as well.

Appendix 2a Government Hospitals and Health Service in Phitsanulok Province

District	Number of central hospital	Number of beds	Other hospital*
Muang	1 (Buddhachinnarat)	1000	2/165
Nakorn Thai	1	60	-
Chatrakarn	1	30	-
Bang Rakum	1	30	-
Bang Krathum	1	30	-
Phrom Phiram	1	30	-
Wat Bot	1	30	-
Wang Thong	1	30	1/10
Neon Maprang	1	30	-
Total	9	1270	3/175

**Military hospital*

Source: provincial Public Health in Phitsanulok 1999 and field interview 2000

Appendix 2b Private Hospitals in Phitsanulok Municipality

Name of hospital	Number of beds
Narasuan	150
Phitsanuvej	250
Rumephat	95
Ratanavetj	100
Intervethchakarn	70
Radiotherapy	49
Eye hospital	12

Appendix 2c Private Health Service in Phitsanulok Province

District	Medical clinics	Dental clinics	Obstetrics	Veterinary	Others*	Total
Muang	50	24	27	5	9	115
Nakorn Thai	-	-	7	-	-	7
Chatrakarn	-	-	4	-	-	4
Bang Rakum	3	1	9	-	-	13
Bang Krathum	2	-	7	-	-	9
Phrom Phiram	1	-	14	-	-	15
Wat Bot	1	-	7	-	-	8
Wang Thong	2	1	12	-	-	15
Neon Maprang	-	-	3	-	-	3
Total	59	26	90	5	9	189

*Traditional medicine laboratory

Source: provincial Public Health in Phitsanulok 1999 and field interview 2000

Appendix 3 Checklist for Secondary Information

1. Waste inventory in different facility
2. Information on medical waste management legislation/ Act/ regulation
3. Existing waste management practices in study place (different hospitals)
4. Available technology of medical waste treatment in all over the world
5. How manage in different country e.g.:-

USA	Thailand	Bangladesh	Europe

6. Type, amount of chemicals used in diagnosis, laboratory, therapy in medicine (how much they buy for how long, company or distributor, purpose of uses.)
7. What do they use / no of patients (reg. Book from hospital) / services (kind of treatment)
8. Manual (ask doctor what chemical used fir which treatment, how dispose, any hazard

Appendix 4 Environmental Checklist for Field Observation

IMPACT/ISSUE	YES	NO
PUBLIC HEALTH IMPACTS - open dumping - contact with animals - contact with humans		
PUBLIC NUISANCE IMPACTS - encroachment on roadways - diminishes landscape aesthetics - unpleasant odours - irritating dust		
LAND USE ISSUES - soil contamination - wind blown waste - clandestine dumping		
WATER ISSUES - surface water contact - ground water contact		
AIR ISSUES - burning of waste		
SOCIAL & CULTURAL ISSUES - public nuisance aesthetic - informal recycling sector		

Appendix 5 Questionnaire for Interviewing Hospital Director or Divisional Heads

General information

Environmental Questionnaire for "Appropriate Management Options of Medical Waste for Developing Countries (the case of Bangladesh and Thailand)"

Name of the interviewer: _____ Date _____

BACKGROUND

Name of the Clinic/Hospital: _____

Location/ address: _____

Source of Information (name and position): _____

Number of years involved in medical services: _____

General information:

How many doctors and nurses work at the clinic (number of other staff also)?

Doctors () nurses () wardboy () cleaners ()

How many patients visit each day (residential or/ and outdoor)?

Number/day Residential (), outdoor ()

Number of beds in the hospital. Number ()

How much waste is generated/disposed everyday from this hospital? (Quantity in kg or ton)
_____ (and Infectious waste?) _____

Guidelines about how to handle hospital waste.

Director/Divisional head

Environmental Questionnaire for "Appropriate Management Options of Medical Waste for Developing Countries (the case of Bangladesh and Thailand)"

Name of the interviewer: _____ Date _____

BACKGROUND

Name & address of the Clinic/Hospital: _____

Source of Information (name and position): _____

Number of years involved in medical services: _____

MEDICAL WASTE DISPOSAL AND KNOWLEDGE

1. How many kinds of waste are generated from the hospital? _____
2. Do you do any waste segregation before disposal of waste? How and how many kinds?
3. Do you use separate bag or bin for different kind of waste? : _____
4. If yes please name the colour of bag or bin for different kind of waste: _____
5. How is medical waste disposed of (give ✓ and write items name)?
 - A) sold _____ B) burned _____
 - C) buried _____ D) dumped _____ E) other _____
 - A) If medical waste is sold who purchases it? : _____
 - B) If medical waste is burned:
 - i) who burns it _____
 - ii) where is it burned _____
 - C) If medical waste is buried:
 - i) who buries it _____
 - ii) where is it buried _____
 - D) If medical waste is dumped:
 - i) who dumps it _____
 - ii) where is it dumped _____
6. Where are medical wastes disposed of? : _____
7. Is there any waste treatment system available in your hospital? (such as: Incineration/ burning, autoclave, disinfectant etc.): if yes, please give name.
8. Is there any guidelines about how to handle infectious waste? : Yes No
9. Has anyone voiced concerns to you about disposal of medical wastes (please describe)?:
10. Are there any toxic, hazardous or harmful elements present in hospital waste (give example)? :
11. In your experience, how do the medical waste affect the human health And environment (give example)? : _____
12. What kind of materials are recycled from hospital waste (please tell name)? _____
13. Any idea about harmful impact of recycling? _____

MANAGEMENT

1. Bottle necks: in your opinion and experience what are the problems and/or limitations in hospital waste management? : _____
2. Please give your suggestions for improvement: _____
3. Willingness to pay for improved service (if improved services provided by government or private agencies will you pay for that?)
4. If there is any health risk and problems of medical staff involve with waste, how do you manage? (nurse, ward-boys, cleaners)

Appendix 6 Environmental Questionnaire for all Levels Respondents.

Doctor

Environmental Questionnaire for "Appropriate Management Options of Medical Waste for Developing Countries (the case of Bangladesh and Thailand)"

Name of the interviewer: _____ Date _____

BACKGROUND

1. Name of the Clinic/Hospital:
2. Location/ address:
3. Source of Information (name and position):
4. Number of years involved in medical services:

MEDICAL CARE

1. What type of medical care is given?

MEDICAL WASTE DISPOSAL AND KNOWLEDGE

1. How much waste is generated/disposed everyday from this hospital? (quantity in kg or ton)
2. How many kinds of waste are generated from the hospital?
3. How does medical waste dispose from this hospital?
4. Do you do any waste segregation before disposal of waste? How and how many kinds?
5. Do you use separate bag or bin for different kind of waste? : _____
6. If yes please name the colour of bag or bin for different kind of waste:
7. How is medical waste disposed of (give ✓ and write items name)?
A) sold _____ B) burned _____
C) buried _____ D) dumped _____ E) other _____

A) If medical waste is sold who purchases it? : _____
B) If medical waste is burned:
i) who burns it _____
ii) where is it burned _____
C) If medical waste is buried:
i) who buries it _____
ii) where is it buried _____

D) If medical waste is dumped:

- i) who dumps it _____
- ii) where is it dumped _____

8. Where are medical wastes disposed of? : _____
9. Is there any waste treatment system available in your hospital? (such as: Incineration/ burning, autoclave, disinfectant etc.): if yes, please give name.
10. Is there any guidelines about how to handle infectious waste? : Yes No
11. Has anyone voiced concerns to you about disposal of medical wastes (please describe)?
12. Are there any toxic, hazardous or harmful elements present in hospital waste (give example)? :
13. What kind of waste is dangerous for health and how? :
14. In your experience, how do the medical waste affect the human health (give example)? :
And environment (give example)?
15. What kind of materials are recycled from hospital waste (please tell name)?
16. Any idea about harmful impact of recycling?
17. Are you aware of any laws that restrict or prohibit medical waste disposal? detail

MANAGEMENT

1. Bottle necks: in your opinion and experience what are the problems and/or limitations in hospital waste management? :
2. Please give your suggestions for improvement:
3. Willingness to pay for improved service (if improved services provided by government or private agencies will you pay for that?)
4. If there is any health risk and problems of medical staff involve with waste, how do you manage? (nurse, ward boys, cleaners)

Nurses

Name of the interviewer: _____ Date _____

BACKGROUND

1. Name of the Clinic/Hospital:
2. Location/ address:
3. Source of Information (name and position):
4. Number of years involved in medical services:

MEDICAL WASTE DISPOSAL AND KNOWLEDGE

1. How much waste is generated/disposed everyday from this hospital? (quantity in kg or ton)
2. How many kinds of waste are generated from the hospital?
3. How does medical waste dispose from this hospital?
4. Do you do any waste segregation before disposal of waste? How and how many kinds?
5. Do you use separate bag or bin for different kind of waste? : _____
6. If yes please name the colour of bag or bin for different kind of waste:
7. How is medical waste disposed of (give ✓ and write items name)?

- A) sold _____ B) burned _____
 C) buried _____ D) dumped _____ E) other _____
8. Where are medical wastes disposed of? : _____
9. Is there any waste treatment system available in your hospital? (such as: Incineration/ burning, autoclave, disinfectant etc.): if yes, please give name.
10. Is there any guidelines about how to handle infectious waste? : Yes No
11. Has anyone voiced concerns to you about disposal of medical wastes (please describe)? :
12. Are there any toxic, hazardous or harmful elements present in hospital waste (give example)? :
13. What kind of waste is dangerous for health and how? :
14. In your experience, how do the medical waste affect the human health (give example)? :
 And environment (give example)?
15. What kind of materials are recycled from hospital waste (please tell name)?
16. Any idea about harmful impact of recycling?
17. Are you aware of any laws that restrict or prohibit medical waste disposal? detail

INFORMATION ON DISEASES (for health impact),

1. Do you have any illness with in this 15 days? Yes No
2. If yes, what kind of illness? Please name the disease

3. Have you gone to see a doctor? Yes: No:
4. If yes please show your prescription: Have seen: Not seen:
5. Do you have any disease suffering for long time? Yes: No:
6. If yes what is that? Please name the disease if you know

7. How many years are you suffering from this disease? : _____
8. How did you get this disease as your opinion?

9. Did you go to see any doctor? : Yes: No (why?):
10. If more than one disease please name other diseases as well.

cleaner, and workers

Name of the interviewer: _____ Date _____

BACKGROUND

1. Name of the Clinic/Hospital:
2. Location/ address:
3. Source of Information (name and position):
4. Number of years involved in medical services:

INFORMATION ON DISEASES (for health impact),

1. Do you have any illness with in this 15 days? Yes No

2. If yes, what kind of illness? Please name the disease

3. Have you gone to see a doctor? Yes: No:

4. If yes please show your prescription: Have seen: Not seen:

5. Do you have any disease suffering for long time? Yes: No:

6. If yes what is that? Please name the disease if you know

7. How many years are you suffering from this disease? : _____

8. How did you get this disease as your opinion?

9. Did you go to see any doctor? : Yes: No (why?):

10. If more than one disease please name other diseases as well.

11. Use of garbage (plastic, papers, foods, others.)

Purpose of use: (fuel, firewood, containers, wrapping etc.), recycling (sell?), reuse

Source of garbage: _____

12. Has anyone ever been injured due to exposure of medical wastes (inside/ outside of hospital premise)? : _____

13. What kind of injury? (please write in detail): _____

waste pickers, local residence

Name of the interviewer: _____ Date _____

BACKGROUND

1. Name of the Clinic/Hospital:

2. Location/ address:

3. Source of Information (name and position):

4. Number of years involved in this job or activity: _____

CONTACT WITH MEDICAL WASTE

5. How long are you living in this place?: _____ years

6. Before dumping or dumping started after you started living here?

before _____ after _____

7. How old is this dumping site? : _____ years

8. When did the dumping stopped? : _____

9. Do you have any illness with in this 15 days? Yes No

10. If yes, what kind of illness? Please name the disease:

11. Have you gone to see a doctor? Yes _ No _

12. If yes please show your prescription: seen _ not seen: _

13. Do you have any disease suffering for long time? Yes _ No _

14. If yes what is that? Please name the disease if you know:

15. How many years are you suffering from this disease? : _____ years

16. How did you get this disease as your opinion?:

17. Did you go to see any doctor? Yes ____ No ____

18. Prescription? Yes ____ No ____

19. If more than one disease please name other diseases as well.

20. In your family is there any other person who has normal or chronic diseases?

21. Please tell detail (who , how old, how long suffering, doctors etc.)

Use of garbage (plastic, papers, foods, others.)

Purpose of use: (fuel, firewood, containers, wrapping etc.), recycling (sell?), reuse

Source of garbage: _____

22. Has anyone ever been injured due to exposure of medical wastes (inside/ outside of hospital premise)?: _____

23. What kind of injury? (please write in detail): _____

24. Talk with local residence and waste pickers or people who deals with waste (what do they do with waste, how, where, when, any problem)

25. Do local residents have access/contact with medical wastes? (Write in detail)

Interview: _____

Observation: _____

26. Do animals come into contact with medical wastes? (Interview, observation)

Interview: _____

Observation: _____

INFORMATION OF RECYCLING (through observation and interviewing cleaners, waste pickers, etc.)

1. items: _____

2. working groups: _____

3. market, business and employment: _____

4. health risk of the group concern: _____

Laboratory technicians/ doctors/ responsible person in the lab

Name of the interviewer: _____ Date _____

BACKGROUND

1. Name of the Clinic/Hospital:

2. Location/ address:

3. Source of Information (name and position):

4. Number of years involved in medical services:

LABORATORY SPECIFICATION (Laboratory technicians/ doctors/ responsible person in the lab)

1. What types of test are done here? (List of different test)
2. Exposure to infectious diseases what kind of pathogens are identified (write disease name what they can diagnose in the lab)?:
3. How many doctors, lab technicians and nurses work at the clinic (number of other staff including aya)?

Doctors _____ lab technicians _____ nurses _____ bearer _____ (aya)
 _____ cleaners _____

4. Items are used are they:
 - disposable (name)
 - re-used (name)

CHEMICALS USE IN THE LABORATORY (Laboratory technicians/ doctors/ responsible person in the lab)

- 1 How do they handle chemicals (safety measure observation)?
- 2 Where do they dispose of? : _____
- 3 Do they have any safety measure to handle chemicals? If yes what are those?
- 4 Safety measure to handle instruments (X-ray, UV, Radio therapy etc.)
- 5 Safety measure to handle or collect specimen or sample from the patient

Chemicals: (try to find more chemicals name by asking e.g. what for x-ray, ultrasono, therapy etc.)

No.	Types of chemicals (name)	Purpose of uses	Quantity used / month/day/week	Frequency of uses (how often)

MEDICAL WASTE DISPOSAL AND KNOWLEDGE

1. How many kinds of waste are generated from the hospital?
 2. Do you do any waste segregation before disposal of waste? How and how many kinds?
 3. Do you use separate bag or bin for different kind of waste? : _____
 4. If yes please name the colour of bag or bin for different kind of waste:
- How is medical waste disposed of (give ✓ and write items name)?
- A) sold _____ B) burned _____
- C) buried _____ D) dumped _____ E) other _____
5. Where are medical wastes disposed of? : _____
 6. Is there any waste treatment system available in your hospital? (such as: Incineration/ burning, autoclave, disinfectant etc.): if yes, please give name.
 7. Is there any guidelines about how to handle infectious waste? : Yes No
 8. Has anyone voiced concerns to you about disposal of medical wastes (please describe)?
 9. Are there any toxic, hazardous or harmful elements present in hospital waste (give example)? : _____
 10. What kind of waste is dangerous for health and how? : _____

In your experience, how do the medical waste affect the human health (give example)? : _____

And environment (give example)?

11. What kind of materials are recycled from hospital waste (please tell name)?
12. Any idea about harmful impact of recycling?
13. Are you aware of any laws that restrict or prohibit medical waste disposal? detail

Appendix 7 Details of Waste Sampling for Pathogen Analysis

Collection date: 24 and 27 July, 2000; Time : 11:30 am - 4:15 pm			
SL	Sample no	Sampling hospital/ dumpsite	Sampling site
1	1S	IBNE SINA diagnostic center and clinic	Soil sample near dustbin
2	1W		Wastewater (leachet) from dustbin
3	2S	Institute of Post Graduate Medicine Research	Soil from the drain where all wastes are dumped
4	2W		Water from the same drain
5	3S	Dhaka Medical College Hospital	solid waste from hospital dustbin outside hospital premises
6	3W		Wastewater (leachet) from dustbin
7	4S	Kamalapur dumping site	soil/ solid waste from front side of dumping site
8	4W		water (leachet) from front side
9	5S	Kamalapur dumping site	from back side or near the lake side
10	5W		lake adjacent to dumping site
11	6S	Matuail dumping site	solid waste (old) near the vangari shop
12	6W		fish lake at the east side
13	7S	Matuail dumping site	solid waste (new) near the road way of dumping
14	7W		leachet and drain water near shop
Collection date: 21 and 22 March, 2001; Time: 10 am - 5 pm			
1	Dump-1	Matuail dumping site	Solid waste (new) near the road way of dumping
2	Dump-2	Matuail dumping site	Solid waste (old) near the road way of dumping
3	Dump-3	Matuail dumping site	Fresh solid waste immediate after dumping
4	DMCH (med)	Dhaka Medical College Hospital	Waste collected from medicine ward
5	DMCH (Surg)	Dhaka Medical College Hospital	Waste collected from surgical ward
6	DMCH (Uro)	Dhaka Medical College Hospital	Waste collected from urology ward
7	IPGMR	Institute of Post Graduate Medicine Research	Solid waste from hospital dustbin outside inside premises

Note: w= wastewater, s= solid waste

Appendix 8 Quantity of Infectious Waste Collected in fiscal year 1997-1998 (in BMA, Thailand)

Month	Total (kg)/ moth	Average (kg/day)
Oct-96	247700	7990.323
Nov-96	254500	8483.333
Dec-96	233090	7519.032
Jan-97	252470	8144.194
Feb-97	225110	8039.643
Mar-97	256590	8277.097
Apr-97	241440	8048
May-97	269930	8707.419
Jun-97	265340	8844.667
Jul-97	279640	9020.645
Aug-97	286810	9251.935
Sep-97	278870	9295.667
Oct-97	283880	9157.419
Nov-97	256120	8537.333
Dec-97	267590	8631.935
Jan-98	260700	8409.677
Feb-98	248470	8567.931
Mar-98	244910	7900.323
Apr-98	226320	7544
May-98	240070	7744.194
Jun-98	246850	8228.333
Jul-98	243670	7860.323
Total	5610070.4	184203.4
Average	255003.2	8372.9

(source: BMA Annual report 1998)

Appendix 9 Amount of Hospital Solid Waste (HSW) and Infectious Waste (IW) and % of IW in Total Medical Waste at BMA area in May 1999 to February 2000

Month/ Year	HSW (Kg)	IW (Kg)	Total (Kg)	% of IW
May '99	4074730	296220	4370950	6.78
June '99	4154060	276040	4430100	6.23
July '99	3952950	284310	4237260	6.71
Aug. '99	3948710	281990	4230700	6.67
Sep. '99	4022390	282310	4304700	6.56
Oct. '99	4447290	311430	4758720	6.54
Nov. '99	4831930	282910	5114840	5.53
Dec. '99	4052220	282835	4335055	6.52
Jan.'00	4269840	285367	4555207	6.26
Feb. '00	3985975	261394	4247369	6.15

(suorce BMA office and Khrugthep Thanakom Company)

Appendix 10 Pathological Analysis of Waste

The analysis was done in July 2000 and again in March 2001 from the same hospital sites and City corporations' solid waste dumping site. Samples were collected from 2 big government hospital and one private clinic. Identification of coliform or faecal coliform indicates the presence of other pathogens that may have been disposed off from the hospitals without disinfection. These pathogens may spread infectious diseases to workers dealing with garbage, waste pickers and local residents around the area. Presence of *V. cholerae* (non-O139 strain) also reiterates that there is unsafe disposal of waste. Salmonella spp. / Shigella spp were not found in the first sampling. Akter *et al.*, (1999) found this pathogen along with Mycobacteria and Amoeba from Medical waste that was collected from disposal bins and from wastewater collected from the hospital's drainage and laboratory basins. The absence of Salmonella spp. / Shigella spp from the first samples collected for this study may be attributed to the fact that the wastes were old and these two pathogen can not survive in an environment where a host is not present. Microbial pathogen concentration in the second sampling in March 2001 was higher than earlier sample (DMCH, IPGMR in the table), since the sample was collected fresh immediate after disposing to the bin in second sampling. The presence of *Vibrio spp* and *Salmonella spp* in second sampling of the DMCH surgical department waste indicates the un-safe disposal of waste without any treatment of infectious waste. However, laboratory analysis of medical waste showed improper disposal practices and severe contamination of these infectious wastes to the environment. Results are in the Appendix table Tables 10.1 and 10.2.

Appendix Table: 10.1 Pathological Analysis of Waste Sample Collected from Dustbin near Hospital and Dumpsites and Obtained Results (July 2000)

Sample No.	Total coliform/ 100ml or gm	Faecal coliform/ 100ml or gm	Faecal Streptococci /100ml or gm	Vibrio spp	Salmonella spp. / Shigella spp.
1S (IBNE SINA)	3.2×10^6	1.7×10^6	3.2×10^4	<i>V. cholerae</i> non O1, non O139 present	Absent
1W	1.6×10^8	1.3×10^8	3.6×10^6	Absent	Absent
2S IPGMR	8.4×10^7	6.0×10^7	4.4×10^4	<i>V. cholerae</i> non O1, non O139 present	Absent
2W	7.2×10^7	4.8×10^7	1.2×10^5	<i>V. cholerae</i> non O1, non O139 present	Absent
3S DMCH	1.2×10^5	1.1×10^5	--	<i>V. cholerae</i> non O1, non O139 present	Absent
3W	2.2×10^8	6.0×10^7	--	<i>V. cholerae</i> non O1, non O139 present	Absent
4S	1.1×10^6	8.0×10^4	2.1×10^4	Absent	Absent
4W	4.4×10^6	3.6×10^6	4.2×10^6	Absent	Absent
5S	6.0×10^4	4.0×10^4	--	Absent	Absent
5W	9.6×10^6	5.2×10^6	--	<i>V. cholerae</i> non O1, non O139 present	Absent
6S	8.0×10^4	6.0×10^4	--	Absent	Absent
6W	1.1×10^3	9.7×10^2	--	<i>V. cholerae</i> non O1, non O139 present	Absent
7S	9.2×10^6	7.6×10^6	3.7×10^4	<i>V. cholerae</i> non O1, non O139 present	Absent
7W	2.0×10^5	1.2×10^5	1.3×10^6	<i>V. cholerae</i> (rough)	Absent

Note: w= leachate from dustbin, s= solid waste (sample 4 to 7 from dumping site)

Appendix Table: 10.2 Pathological Analysis of Waste Sample Collected from Hospitals and Dumpsite and Obtained Results (March 2001)

Sample No	Total coliform /gm	Faecal coliform /gm	Feecal streptococci /gm	Vibrio spp / Aeromonas spp.	Salmonella spp. / Shigella spp.
Dump-1	8.0x10 ³	4.0x10 ³	2.0 x10 ⁴	Absent	Absent
Dump-2	4.2x10 ²	2.7x10 ²	8.0x10 ³	Absent	Absent
Dump-3	4.5x10 ⁷	3.9 x10 ⁷	6.0x10 ⁶	Absent	Absent
DMCH (med)	3.8x10 ⁷	3.2x10 ⁷	1.6 x10 ⁶	Absent	Absent
DMCH (Surg)	6.8x10 ⁸	2.4x10 ⁸	8.4x10 ⁷	V. cholerae non O1, non O139 present	Salmonella spp. present
DMCH (Uro)	3.6x10 ⁶	2.4x10 ⁶	3.6x10 ⁴	Absent	
IPGMR	3.9x10 ⁹	2.9x10 ⁹	2.0x10 ⁶	Absent	Absent

Appendix 11 Lists of Diseases Found during Interview (% of positive cases only)

15 days disease history of respondents			
Name of the diseases	Nurse (N=124)	Cleaners (N=167)	Waste pickers (N=85)
1. Diarrhoea/ dysentery	2.42	4.79	7.06
2. Hepatitis B/ C	6.45	19.76	4.71
3. Normal sickness	41.13	41.32	67.06
4. Skin disease/ allergy	49.19	32.93	10.59
5. Non infectious	0.81	1.20	9.41
6. Hand, leg cut			1.18
Long time diseases among the respondents			
Name of the diseases	Nurse (N=132)	Cleaners (N=121)	Waste pickers (N=88)
1. Diarrhoea/ dysentery	0.76	12.40	7.95
2. Hepatitis B/ C	12.12	33.88	20.45
3. Normal sickness	6.82	26.45	18.18
4. Skin disease/ allergy	15.91		7.95
5. Pox	3.79	0.83	
6. TB			2.27
7. Malaria			1.14
8. Typhoid			12.50
9. Leg injury			1.14
10. Non infectious	60.61	26.45	28.41

Appendix 12 Ministerial Regulatory Scheme (Guidelines) of Infectious Waste Management and Control

Affected by these regulations are (controlling target)

- Health facilities comprising all human and animal health facilities under both of government and private sector
- Hazardous pathogen laboratories under both of government and private sector
- Local Government Agency or the persons who are assigned to operate for Local Government Agency
- Persons who are authorized to operate a business on collecting, transferring and disposing of the waste

The Local Government Agency is main unit for controlling the collecting, transferring and disposing the waste in its district. It is their obligation to (controlling principle)

- Provide storage places for the transfer of waste and also set disposal methods followed the hygiene approach.
- Provide at least one officer who got B.Sc. or B.Eng. or higher for the management and supervision of waste collecting, transfer and disposal.
- Control the persons who are assigned to operate for the Local Government Agency and the persons who are allowed to do business on waste management in the said local area and have to comply with the infectious waste management regulation.
- Control health facilities and hazardous pathogen laboratories to observe the ministerial regulation

Health facilities and hazardous pathogen laboratories have to collect the infectious waste according to the ministerial regulation and have to furnish trained personnel.

The ministerial requirements about the collection of health care waste are determined as follow:

- According to the characteristics of the infectious waste an appropriate container has to be selected. A stable box or bin is to be used for sharps and bags are supposed to be sufficient for non-sharps. The containers have to be of red color and marked as "Infectious waste" and "Don't open".
- The waste has to be collected at the place generated immediately and not commingled with other waste. The containers should not be filled up more than 2/3 of a bag or 3/4 of a box. In case that the waste cannot be transferred immediately, it can be stored at the place not longer than one day.
- A building or a room for waste storage should be separated and spacious to retain at least a 2-days amount of waste. The room should be well ventilated, with walls, which are easy to clean and a locked door. This room should be clearly marked as "Infectious storage place"
- If the waste has to be stored for more than 7 days, it has to be kept in a temperature controllable room at 10-degree Celsius or less.

For the transfer of containers should be an officer accountable who has been trained. The officer must wear protective clothing. The transfer route and time schedule should be fixed.

A detailed explanation and guidelines on how to deal with the transfer of infectious waste are given

There is no need to provide waste storage for the health facilities, which have no beds and for animal health facilities, which keep the sick animal not longer than MOPH regulation.

The ministerial requirements about the transfer of health care waste are determined as follow

- The operational unit (Local Government Agency/ Assigned Agency/ Business unit) has to have transport vehicles, waste storing place, parking area for the vehicles and has to train the driver and officer on car.
- The workers should wear protective clothing.
- The vehicles must have a closed body and its inner walls should make of durable and easy to clean material. If a car is used to transfer waste kept longer than 7 days at place, that car has to be able to control the temperature. With a car, a protection and communication tool has to be provided. Moreover, on the car must be written a red phrase that this car is "used for transferring infectious waste only"

The ministerial requirements about the disposal of health care waste are determined as follow

- The operational unit must provide a waste storage place for keeping waste before final disposal. The waste should be disposed of within 30 days starting from the day collected at source.
- Waste disposal workers must be trained and have to wear protective clothing during work
- If incineration is used for disposing the waste of, a 2-chamber incinerator is required. The temperature of waste primary chamber should not be lower than 760 degree Celsius and the exhaust gas should be processed in the secondary chamber at temperatures not lower than 1,000 °C. The emitted fluegas has to monitored and fulfil the related emission standards.
- If another disposal method than incineration is applied, it should follow the biological standard. It should have the efficiency to extinguish bacteria, fungi, viruses and parasites in the waste.
- Health care waste treated by these methods can be subsequently handled like common solid waste.

Appendix 13 Emission Standards of Thailand for Air and Liquid Discharge

Building effluent standards

Parameter	Unit	Permitted Value
pH	-	5 - 9
BOD	mg/L	20
Solids		
Suspended	mg/L	30
Settleable	mL/L	0.5
Total dissolved	mg/L	500
Sulfide	mg/L	1.0
Total Kjeldahl Nitrogen (TKN)	mg/L	35
Fat, Oil and Grease	mg/L	20

Notification of MoSTE 1994

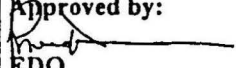
Emissions into the air are limited by the Industrial emissions standards as presented in the following table.

Industrial emission standards

Substances	Source	Unit	Standard values
Particulate	Boiler or furnace	mg/Nm ³	
	Heavy oil		300
	coal		400
	other fuel		400
	Other sources		400
Antimon	Any source	mg/Nm ³	20
Arsenic	Any source	mg/Nm ³	20
Copper	Furnace	mg/Nm ³	30
Lead	Any source	mg/Nm ³	30
Chlorine	Any source	mg/Nm ³	30
Hydrogen chloride	Any source	mg/Nm ³	200
Mercury	Any source	mg/Nm ³ ppm	3
Carbon monoxide	Any source	mg/Nm ³ ppm	1000 or 870
Sulfuric acid	Any source	mg/Nm ³ ppm	100 or 25
Hydrogen Sulphide	Any source	mg/Nm ³ ppm	140 or 100
Sulfur dioxide	Combustion	ppm	1250
Nitrogen oxides	Boiler	mg/Nm ³ ppm	
	coal as fuel		940
	other fuels		470
Xylene	Any source	mg/Nm ³ ppm	870
Cresol	Any source	mg/Nm ³ ppm	22

Notification of the Ministry of Industry 1993/1995 at reference condition 25 degree Celsius at 1 atm

Appendix 14 Bumrungrad Hospital Administration Policy (Title: Waste Management) cont.

 BUMRUNGRAD HOSPITAL		Page 1 of 3
HOSPITAL ADMISTRATION POLICY		Document No: HAP 1.53
Date of Original Issue: 1 January 1996	Date of Last Amendment: 1 September 2000	Dept. Name Total Quality Management/ QA/RM Department
Title: WASTE MANAGEMENT		Originator:  Division Director
		Approved by:  EDO

Purpose

1. To provide standard guidelines for waste management.
2. For safety and infection control for all patients and staff.
3. *Less effect to the environment which relevant to environment law.*

Scope

All staff.

Definitions

1. Definitions of waste as following :

1.1 Infectious garbage means all waste product from treatment areas such as:

- 1.1.1 Blood or body fluid
- 1.1.2 Biopsy and an organ of the body from operation.
- 1.1.3 Medical waste all contact or suspect blood and body fluid : cotton, gauze, IV set.
- 1.1.4 Sharp waste such as needles, blades and ampules.
- 1.1.5 Vaccine vial made from lifely infectious.
- 1.1.6 Germ and media waste from laboratory.
- 1.1.7 Waste from infectious patient's room.
- 1.1.8 Patient's specimen from laboratory.

1.2 Recycle waste means product which can be modified and reuse such as:

- 1.2.1 Products made of glasses : IV bottle, medical glasses, vials.
- 1.2.2 Products made of metal : drinking can.
- 1.2.3 Products made of papers and plastic : office paper, boxes, newspaper and plastic bottle.

Note : paper that can be use in the department should be paper that is not specified definite characteristic : HN, address, patient's document.

1.3 Poisonous waste means waste is harmful to the body according to the physiography / chemical biography characteristic such as things that can be flammable, explosive and erosive such as battery, fluorescen neon spray, vial or disinfectant bottle (expired), chemical product from laboratory, radioactive waste product, chemotherapy substance and preparation set.

1.4 General waste means waste which does not contact blood and body fluid, kitchen garbage.

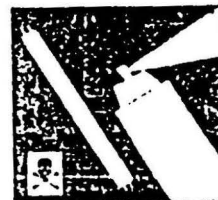
Appendix 14 Bumrungrad Hospital Administration Policy (Title: Waste Management) cont.

 BUMRUNGRAD HOSPITAL		Uncontrol Page 2 of 3
HOSPITAL ADMINISTRATION POLICY		Document No: HAP 1.53
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Title: WASTE MANAGEMENT		

2. Symbol shows poisonous waste and recycle waste on container.



Recycle Waste



Poisonous Waste

Reference

1. *Hazardous Substance (HAP 7.03)*
2. *Standard operating policy safety for nuclear medicine department (IMG 1.03)*

Description

1. *Waste container / bag used in hospital.*
 - 1.1 *White plastic bag for general non infectious waste.*
 - 1.2 *Red plastic bag for infectious garbage.*
 - 1.3 *Green plastic bag for recycle waste.*
 - 1.4 *Gray plastic bag for poisonous waste.*
 - 1.5 *Needle container for needles and blades*
 - 1.6 *Plastic container with lids for medication ampules.*
 - 1.7 *Lead container with radioactive caution for radio pharmaceutical substance.*
2. *Other waste management, refer to description in Appendix 1.*
3. *Collection and transportation of waste products.*

Housekeepers must:

 - 3.1 *Wear apron, mask, and rubber gloves when working*
 - 3.2 *Check the container to ensure no leakage. Fasten the bag and put in double red bag for infectious garbage.*
 - 3.3 *Be careful during lifting and moving the bag.*
 - 3.4 *Label and separate "Infectious and poisonous garbage" cart from general cart.*
 - 3.5 *At main container, separate garbage according to infectious, poisonous, recycle, general and food garbage etc.*
 - 3.6 *All the garbage will be moved out and disposed by BMA once daily.*

Appendix 14 Bumrungrad Hospital Administration Policy (Title: Waste Management) cont.

 BUMRUNGRAD HOSPITAL		Page <u>3</u> of <u>3</u>
HOSPITAL ADMINISTRATION POLICY		Document No: IIAP 1.53
Date of Original Issue: 1 January 1996	Date of Last Amendment: 1 September 2000	
Title: WASTE MANAGEMENT		

- 3.7 In case of the leakage of body fluid, one must wear thick gloves using tongs to clean the area and soak the floor with chlorox 1:20 for 10 minutes. Then, wipe out the solution and clean the floor. To put up "Slippery Floor" signage.
- 3.8 *If chemical reagent (poisonous waste) leaking or dripping, follow Hazardous Substance (HAP 7.03) and for radioactive follow Standard operating policy safety for nuclear medicine department (IMG 1.03)*
4. Cleaning the garbage cart and transportation.
Housekeepers must :
 - 4.1 Clean garbage cans in patient rooms, exam rooms, and others with Bactyl 1:100 daily. For infectious garbage cans, clean with 0.5% Chlorox.
 - 4.2 Clean the garbage cart daily with 0.5% Chlorox.
 - 4.3 After delivery to BMA, clean main container thoroughly with 0.5% Chlorox daily.
5. After finishing daily routine job.
Housekeepers must :
 - 5.1 After collecting garbage from each floor, take off the gloves before touching the cart.
 - 5.2 After finishing the daily job, take off rubber gloves, apron, mask and boots. Soak items in 0.5% Chlorox for 30 mins. Then rinse thoroughly with water.
 - 5.3 Wash hands thoroughly after work.
6. Incident Reports :
All staff must report to immediate supervisor as soon as an unusual occurrence is detected. If any housekeeper refuses to follow hospital guidelines, the housekeeper supervisor should be notified immediately.

Quality Record
Nil

Appendices
Appendix 1 Waste management in the hospital

Appendix 14 Bumrungrad Hospital Administration Policy (Title: Waste Management) cont.

Waste Management

Type	Container	Staff	Description
1 General waste products 1.1 Non-contaminated garbage 1.2 Kitchen garbage	White plastic bag	Housekeeper Housekeeper	- Collect garbage twice daily using white plastic bag - Fasten the bag before putting in the main container
2. Infectious garbage 2.1 Contaminated with body fluid such as blood, stool, urine, secretion 2.2 Specimen and body 2.2.1 From operation room such as fat, leg, intestine. 2.2.2 Surgical Pathology body fluid, spinal fluid, amniotic fluid. 2.2.3 Specimen	Red plastic bag Red plastic bag Red plastic bag	Direct patient care staff Direct patient care staff and porters Laboratory staff Laboratory staff and Porter.	- Collect contaminated material into plastic bags before putting into the main container for infectious garbage. Body fluid should be flushed in the toilet - For small specimen, put in the red plastic bag and dispose in the container for infectious garbage - Dispose weekly. Fasten the container sealed with parafilm. Then put in a red plastic bag and sterilize in autoclave before taking out from the department - Dispose weekly. Separate pieces of specimen from formalin. Then fasten in the red plastic bag - Call porter to pick up the specimen to the morgue - Keep specimen in the refrigerator to wait for cremation

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Appendix 14 Bumrungrad Hospital Administration Policy (Title: Waste Management) cont.

Type	Container	Staff	Description
2.3 Laboratory waste product			<i>Uncontrolled</i>
- Body fluid	Red plastic bag	Laboratory staff	Dispose body fluid into red bag and sterilize in autoclave before taking out from the departments
- Sharpen waste product	Plastic container	Laboratory staff	Put all the sharp waste products into plastic container for sharp objects. Sterilize in autoclave before taking out from the department
- Fluid waste product		Laboratory staff	Put the fluid into 10% Sodium Hypochlorite or Virkon at least 1 hour before draining to the pipe for treatment
- Disposable materials	Red plastic bag	Laboratory staff	Put materials into a red plastic bag. Sterilize in the autoclave before taking out from the department
- Reusable material i.e. Microbial tube	Red plastic bag	Laboratory staff	Sterilize in autoclave. Drain the waste product into the red plastic bag before taking out from the department
2.4 Needle, Blade	Gallon / Plastic container	Direct patient care staff	- Detach needles appropriately and dispose into the container - Fasten the container when it is full and put in the container for infectious in the department
2.5 Vaccine Vial	Gallon / Plastic Container		Put in the can for infectious garbage in the department
2.6 Gauze, Syringe, IV set	Red plastic bag	Direct patient care staff	Put in the red plastic bag
2.7 Plates and foods from infectious patient	Red plastic bag	Direct patient care staff and canteen staff	Fasten in the red plastic bag.

Appendix 14 Bumrungrad Hospital Administration Policy (Title: Waste Management) cont.

Type	Container	Staff	Description
3. Poisonous waste product			Uncontrolled
3.1 Chemical product from laboratory i.e. Xylene, Formalin, Acetone	Plastic or stainless steel container with lid	Laboratory staff and housekeeper	Dilute with water until concentration about 50% before fastening the container with a lid. Container must be labeled "Dangerous Chemical Substance" including collection date and termination date. When container is full, housekeeper should collect the container and send to the government department monthly for disposal
3.2 Chemotherapy substance and preparation set, vaccine	Gray plastic bag	Direct patient care staff and pharmacist	Put in the container for toxic materials in the department
3.3 Vial, Disinfectant bottle (espied)	Gray plastic bag	Staff	Put in the gray bag for toxic waste garbage.
3.4 Battery, fluorescen neon spray	Gray plastic bag	Staff	- Detach needles appropriately and dispose into the container - Fasten the container when it is full and put in the container for infectious materials in the department
3.5 Radioactive waste product			
3.5.1 Radio pharmaceutical substance	Lead container	Nuclear medicine staff	Radioactive substance is prepared and packed in the lead box by the vendor. After use, put the syringe into the lead box and return to the vendor
3.5.2 Radioactive contaminated materials i.e. blanket, bed sheet, disposable food container	Gray plastic container and lead garbage can	Nuclear medicine staff	Collect materials into the gray bag, label the bag "Radioactive substance" with name, date, time, and staff name. Then put the bag into the lead garbage can until the radioactive substance is decayed. The radiation activity must be equal to the background before disposal or routine cleaning process

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Appendix 14 Bumrungrad Hospital Administration Policy (Title: Waste Management) cont.

Type	Container	Staff	Description
4. Recycle waste			
4.1 Made by glass such as bottle fluid, vial.	Recycle garbage with label of "Glass"	Staff	Put in the recycle garbage each type of recycle waste.
4.2 Made by steel, plastic paper such as can, plastic bag.	Recycle garbage with label of "steel, plastic, paper"	Staff	

Appendix 15 Prodipan a Case Study from Bangladesh

General introduction

Prodipan, a community based local non-government organization working in Khulna City of Bangladesh. Khulna is the third largest city of Bangladesh and is located in the southwest part of the country. It has a population of 1.2 million in 45.65 square kilometer City Corporation area. Khulna the port city of south Bangal is glorious the seaport Mongla and the Mangrove forest Sundarbans. The city has the similar environmental and health problems related to medical waste management as other cities of Bangladesh and these problems call for a safe collection and disposal system. Medical waste management is one of the components of a "municipal solid waste management project in Khulna" City being undertaken by Prodipan. Prodipan has initiated this project to formulate and demonstrate a model that can be scale up in Khulna and replicated in other cities and towns of Bangladesh.

Health service facilities

There are 248 health facilities in Khulna City, out of these about 73 healthcare establishments generate most medical waste regularly. Different categories of existing health facilities at Khulna City are shown in Appendix table 15.1.

Appendix Table 15.1 Existing Health Facilities in Khulna City

Type of facilities	Number	Percentage
Clinics	34	13.7
Hospital	15	6
Maternity center	3	1.2
Family planning center	21	8.6
Pathological or diagnostic center	12	4.8
EPI center	124	50
OPD	39	15.7
Total	248	100

(Source: Sumon, 2000)

Waste generation and characteristics

Appendix Table 15.2 Clinical Waste Generated from Different Health Facilities of Khulna City

Name of the facility	No of bed	Total waste (kg/day)	Waste kg/bed/day
Small facilities			
Khulna nursing home	4	1.00	0.25
Nibedita sheba sadan	15	2.07	0.14
Nazma clinic	5	4.07	0.81
Khulna clinic	12	1.95	0.16
Ali clinic	6	2.50	0.42
Arogya niketon	12	2.10	0.18
City nursing home	17	5.45	0.32
Al amin hospital	15	0.48	0.03

Name of the facility	No of bed	Total waste (kg/day)	Waste kg/bed/day
Green maternity hospital	10	14.00	1.40
Matrimongol clinic & Shasthya kendra	10	1.18	0.12
Niramoy clinic	4	0.37	0.09
Total	110	35.16	3.92
Average	0.36		
Medium facilities			
Sheba clinic	20	15.00	0.75
Uposhom private hospital	20	3.00	0.15
Cure home general hospital	20	2.10	0.11
Nargis memorial	26	4.18	0.16
Nahar clinic	30	3.50	0.12
Pangu hospital	20	10.00	0.50
Garib-e-newaz clinic	38	12.00	0.32
	174	49.78	2.45
Average	0.35		
Large facilities			
Khulna Surgical & medical hospital	100	29.00	0.29
Khulna Medical college hospital	250	45.00	0.18
Khulna general hospital	150	45.00	0.30
	500	119.00	1.12
Average	0.37		

Primary data source: Sumon, 2000

In this data all waste coming out from health facilities except kitchen waste was considered as clinical waste.

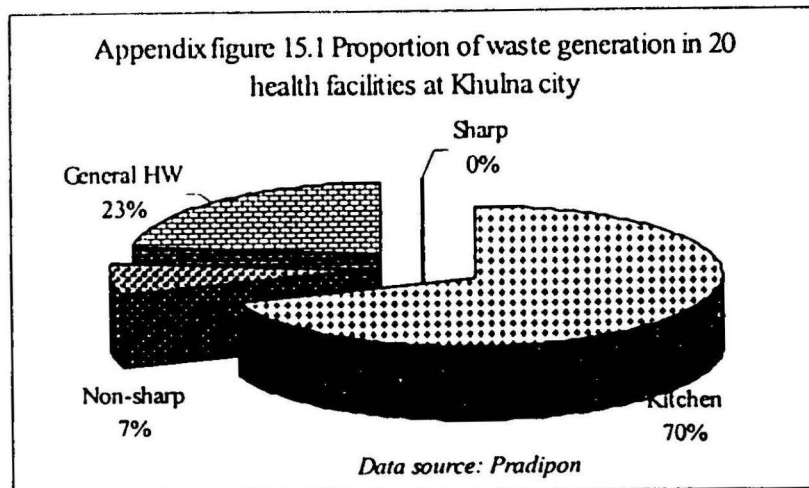
Appendix Table 15.3 Average number of syringes and needles disposed from different facilities every day

Type of facilities	No of disposed needles/ day	No of disposed syringes/day	Disposed in dustbin (%)	Sold (%)
Large hospitals	450	400	100	-
Medium facilities	50	50	97	3
Small facilities	25	25	90	10

Source: Sumon, 2000

Appendix figure 15.1 (next page) showed different kind of waste generated in health facilities. In this data general medical waste were considered as all waste coming out from the health facilities except sharps and non-sharps (saline bag, syringes), and kitchen waste.

Prodipan has been active in solid waste management in Khulna City since 1997. As a part of its program, the organization has undertaken a pilot project that involves the collection and disposal of medical waste from 20 healthcare establishments in the city. Khulna City Corporation (KCC), the Hospital and Clinics Owner's Association (HCOA) of Khulna City, the Bangladesh Medical Association (BMA), and representatives of local people were the principal stakeholders of the program. It was noted that, this is the first time in the country that there has been a medical waste management project of this type Kazi, 2000).



The pilot project started operating in February 2000, and the City Mayor formally inaugurated the pilot project on 13 June 2000. The project has been operating successfully and in a sustainable manner since its inception. Integration different stakeholders at different stages of project cycle, and consideration of the various potential impacts have been identified as the key factors in the success of the project. The case study demonstrates how an integrated approach can lead to a sustainable waste management project in cities of low-income countries.

Project description

Twenty hospitals and clinics within the city were covered by this pilot project. An in-house waste management system has been introduced in each healthcare establishment to separate various types of wastes as the point of generation. Proper training in waste segregation, collection, storage and handling was given to those who are actively involved in the waste management process. A specially designed transport vehicle is used to carry various types of hazardous wastes to the final disposal site. A specially designed land-filling cell was constructed at the KCC landfill site for disposing of non-sharp hazardous waste, and lined pit covered with concrete slab was constructed for sharps waste.

The actors involved in medical waste management were identified. These actors are mainly cleaners, ward attendants, nurses, and hospital managers. A one-day training workshop was organized and various group of actors from hospitals and clinics under this pilot project participated in the workshop. Various aspects of medical waste management particularly aspects relating to the existing situations in the hospitals and clinics, were discussed. Discussion topics included segregation, storage, handling, transportation and final disposal of wastes.

Technology: literature and various reports related to different issue of medical waste management in this region were reviewed. The help desk of SKAT was also contacted for technical advice that was incorporated into the design of landfill cell. A dedicated vehicle was designed following specifications presented by the London Waste Regulatory Authority (LWRA) for transporting the hazardous waste from hospital to the final disposal site. Following the international color coding system, yellow bags were introduced to store and carry non-sharp hazardous waste, and specially designed rigid containers were used to collect and carry sharps. Non-sharp hazardous waste was disposed of in a landfill cell, and sharps were tipped into the lined pit covered concrete slab.

Health and environment: environmental and occupational health implications were considered from the planning stage of the project in order to make it safe and environmentally sound. Protective measures such as gloves, masks, boots etc. were provided to those who were actively and directly involved in the handling of hazardous wastes. The disposal site is far away from the city and it was already used for solid waste disposal, so the environmental impacts were not considered very significant in comparison to the potential impacts from the development of a new disposal site. The landfill site is located in an elevated area and so free from seasonal flooding, and therefore there

was less possibility of surface waste pollution. The groundwater level is also very low in the area and so there was less possibility of groundwater contamination. Moreover, a clay layer was installed at the bottom of the cell to prevent leaching into the groundwater. Thus the waste disposal system was considered environmentally sound because of these technical factors.

General acceptability: there was considerable concern as to whether the owner of the hospitals and clinics would accept the waste management system because it imposed a service charge. The existing practice to tipping waste into the KCC's bins and nearby street or low-lying areas was an easy way for them. They did not require any additional manpower, finance or time to get rid of their waste. Moreover, there was no legal obligation or regulation that could enforce them to adopt the new system of medical waste management.

In order to obtain a general acceptance of the system, a local-level workshop was first organized to discuss the various issues and opportunities of medical waste management in the city. All the stakeholders involved with medical waste management in the city were invited to participate in the workshop. Cleaners, nurses, laboratory technicians, doctors, hospital administrators and managers from different hospitals and clinics, and representatives from professional associations such as BMA and HCOA, and the KCC etc., all participated in the workshop. Integration of stakeholders in planning and decision making was very effectively done by involving them in different forum, deciding service charger for medical waste collection etc.

Financial stability: The pilot project has become almost financially sustainable, because of the introduction of the service charges. This income has covered the expenditure except for a little short which has been compensated from donor's grant. In future the service charge will be determined on the basis of the actual amount of waste generated and the services will be extended to more healthcare establishments in order to make the program self-supporting and financially sustainable. The owners of the hospitals and clinics in the pilot scheme accepted the service charge imposed on them because it was jointly decided by various stakeholders such as BMA, KCC, HCOA etc. If Prodipan alone had introduced the service charge, it would probably not have been accepted by the hospital management. The City Mayor played a very significant role in implementing the service charge system. Integration of various stakeholders made the system successful. Because of heavy pressure from various groups, owners and managers of hospitals and clinics agreed to pay the service charge. If there had been no combined pressure, they might not have paid the service charge.

Appendix 16 Phitsanulok a Case Study form Thailand

General Information

Phitsanulok province is located in the northern part of Thailand. The total area is about 10,896.05 square kilometers. There are nine districts under this province. Three districts were visited for this study namely Muang, Bang Krathum and Wang Thong district (Map). Total population of the province is 863,451 with the population density of 79 per square kilometer. Public health resource persons and population ratio is as follows:

Doctor = 1: 4,307; Dentist = 1:26,232; Pharmacist = 1:13,962; Nurses = 1:1,1039

Public health service facilities

There are nine government hospitals with 1270 beds under Ministry of Public Health in the province and seven private hospitals with 820 beds located only in the municipality. Buddhachinnarat government hospital is the central hospital in south part of northern Thailand. Other than this 3 military hospitals with 175 bed also in this province. A total of 189 clinics are in this province of which 115 are located in the Muang district only (shown in Appendix 2). It is noted that there is no bed in these private clinics.

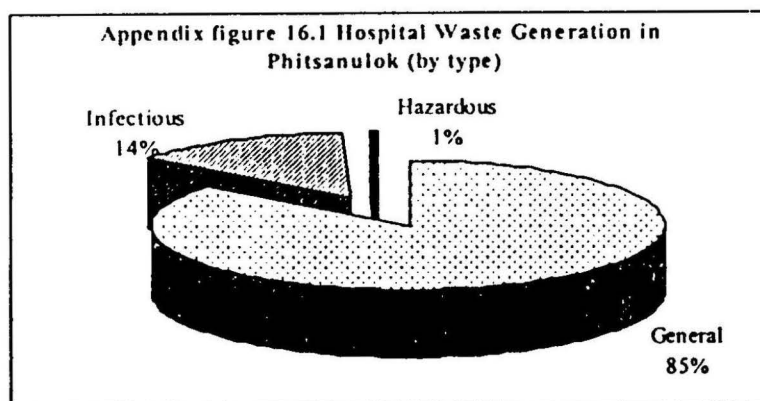
Medical waste characteristics

Medical waste characteristics and categories with quantity is shown in appendix table 16.1 below.

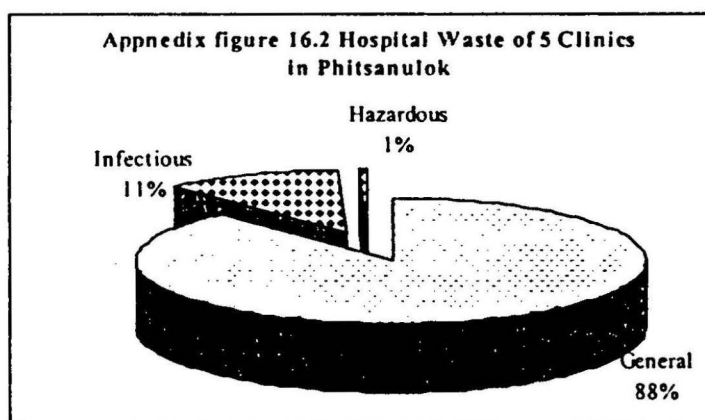
Appendix table 16.1 Medical Waste Generation in Phitsanulok

Name of hospital	Number of beds	Daily waste generation (kg/bed)		
		General	Infectious & sharps	Hazardous
<u>Government hospital</u>				
Buddhachinnarat	1000	0.868	0.180	0.001
Bang Krathum	30	1.632	0.196	0.010
Bang Rakum	30	4.085	0.870	0.030
Wat Bot	30	2.245	0.250	0.007
Wang Thong	30	3.340	0.652	0.007
<u>Private hospital</u>				
Narasuan	150	0.922	0.069	0.004
Phitsanuvej	250	0.519	0.078	0.002
Rumephat	95	0.555	0.075	0.002
Ratanavetj	100	0.440	0.055	0.009
Intervethchakarn	70	0.347	0.021	0.013
Radiotherapy	49	0.096	0.005	0.032
Eye hospital	12	0.486	0.013	0.011
Average		1.751	0.284	0.013

Community hospitals showed more medical waste. This is might be due to patients' load per day and disposal timing and some other factors. Waste generation by type in all hospital and few selected clinics are shown in two figures (appendix figure 16.1 and 16.2) below, there infectious waste included used sharps as well.

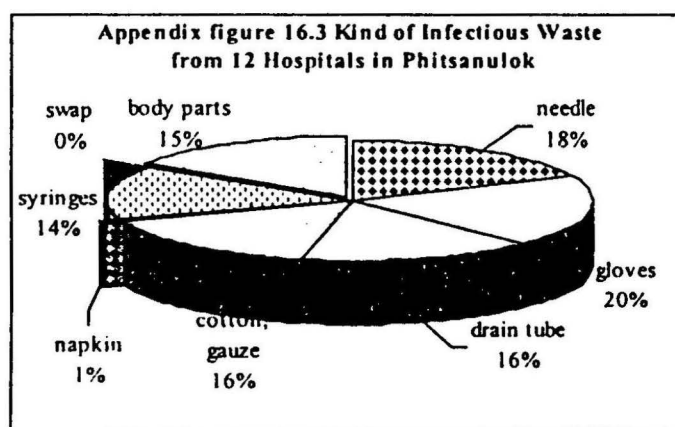


Source: field data from Phitsanulok Municipality (Adsavakulchai, 2000)



Source: field data from Phitsanulok Municipality (Adsavakulchai, 2000)

Based on field visit and data it was found that 85%-88% of medical waste generated in Phitsanulok could be considered as general waste. While 11%-14% was infectious, sharps and saline set and 1% was hazardous waste (chemicals, fluorescent lamp, battery, aerosol container, and radioactive products). It was found from field observation that major portion (about 50%) of infectious waste are generated from emergency ward section since all waste from the ward is considered as infectious waste in Thailand and kept in red bag. Kind of infectious wastes are shown in figure below (appendix figure 16.3).



Observation and discussion

Some observations were made during field investigation of hospitals, clinics and health centers in Phitsanulok. This section described details about it.

Pitsanuvej hospital: private hospital consists more than 200 beds, run by a family. This is quite an expensive and well-equipped hospital. This hospital authority (Managing Director) does not concern about the expenditure for waste burning and profit of reuse or recycle. Therefore they don't do much separation of waste and incinerate almost all waste since the capacity of incinerator is higher than the actual amount of infectious waste. Except infectious waste and sharps almost all waste kept together in black bag for municipal truck to transfer. Municipal workers open the black bags for collecting recyclable items as respondent mentioned. Incinerator brought from Australia, temp 800-1000 °C. As they burn all items even glasses, this is deteriorating the quality of incinerator.

Ruampaet Hospital: Private, quite a big hospital. This hospital separate saline set other plastic items for selling. X-ray water (fixer) is sold as well. Syringe, needle kept in used saline bag and IW kept in red bag those is then stored in a place outside hospital in a net house. The private Incinerator Company (which is in fact one man employed drum burner outside the city) carries these wastes and normal waste is carried by municipal car. Food waste is sent to the piggery farm. Both of these two private hospital visited have their own waste waster treatment plant.

Ratanevej Hospital: private hospital with 60-70 beds. The category of waste in this hospital is 2 kinds of waste general +hazardous (e.g. battery) in black bag/bin and IW in red bag/bin. IW generation is 250-300 kg/month, incinerate twice a week, keep in closed room, no temp control. Fuel cost for incinerator is 600-700 B/month.

(All hospital sent their incinerator ash to the municipality)

Two clinics name Phun-lop Clinic and Noree & Sanit Clinic were visited in the city. There is no bed in the clinics, only outdoor treatment. They kept all waste together except needle kept in a plastic container, and vial (small glass bottle) is collected. General waste is carried by municipal truck and needle sent to government hospital for burning, vial sent to government hospital to reuse for specimen collection. Though government hospital deny that they do not except any waste from the clinics, then it seems uncertain that what happen to those waste. They separate re-usable item those are then taken by garbage collector for selling.

AIDS section of Public health service office was visited during the field investigation. It was found that they kept used needles in a box with disinfectant solution to dispose, all other waste kept in a red bag that used to send with infectious waste from other section for incineration.

Buddhachinarat Hospital: biggest government hospital in Phitsanulok hospital has 1000 beds, 700 nurses and 700 doctors. It's a medical school as well. Infectious Control unit, female ward, children ward, chemotherapy unit, pathological laboratory, waste disposal site, incinerator, and wastewater treatment plant were visited. Nurses and doctors involved with the activities were interviewed.

Wastes are collected by their own truck around hospital then IW and body part or organ is burned in own incinerator, ordinary waste sent to municipal car. No treatment system for chemotherapy waste, sent to Bangkok, wastewater treated and use for watering plant and sludge sent to the municipality to use for composting. X-ray fixer solution is sold but developer is sent to the WWTP.

Hospital generates 100kgIW/day, weighing before burning only. All kind of waste from patients before identifying the disease considered as IW. Normally waste under bed considered as general waste.

Good separation of waste just introduced. (Recyclable, disposable, reusable, selling, etc.). Red bag for IW, blue for hazardous, green for recycle/plastic, wooden box for glassware/cloth reuse, plastic sharp box for needle (burn it), black for general waste. It seemed that these different categories are kept in display place only for training and demonstration. Otherwise only red and black bags and sharp box were found to be in regular practice. Paper waste are recycled, glass syringes are reused after sterilization.

Training for staff and nurses about how to handle waste by Infection Control (IC) department nurse. IC nurses as supervisor train other nurses who are related with waste. IC takes care of waste management in the hospital. All waste from intensive care unit and emergency room are treated as IW. This is the only hospital found to use separate lift for waste transport.

Wangthong Community Hospital: a district hospital outside city with 30 beds. Hospital separates four categories of waste as IW, general waste and hazardous waste, and recyclable waste. Sharps kept in a plastic box then put in a red bag to incinerate. Hazardous waste (e.g. battery, Hg lamps) is sent to the municipality landfill site. They are constructing a tank for dumping hazardous waste. X-ray fixer is sold. WWTP is built for liquid, chemical disinfectant, cleansing solution, and wastewater. Plastic, glass, metal, paper, saline bag are recycled. This hospital generates 40-60 kg IW/day, 2 hrs to burn 30-40kg. Two incinerators, one in use, 30,000B/month maintenance cost. Temp 700-900 & 800-1000 °C. Very black smoke coming out from the chimney was found during the burning of waste. Nevertheless, worker uses special dress, gloves, mask, and boot as safety measure.

Training once a year for chief trainer (chief of sanitary section) at MOPH, guideline from MOPH. He provide training for workers who deals with waste and IC nurse. Evaluation is done every 3 months using a questionnaire. IC nurses provides training for all other nurses. Hospital has its own guideline for waste management.

Bangkratum Community Hospital: similar hospital in another district. 30 beds but not all occupied 150 patients at OPD/day. All waste found to keep together including IW, disposable needle, and paper. Food waste used as fish feed. This hospital has two types of incinerator, one good and one brick made like oven (in use). Good one does not use because of high maintenance cost, since no fund for that. Waste generation is 50-kg waste/day, 5 -6.5kg IW/day. General waste is used for burning of IW in brick incinerator including metal container. It was found that the waste was not well burnt. This hospital is far from municipal office, therefore no collection is done by municipality. They use their own dumpsite (pit) for general waste and needle. During visit 2-3 years old dump or landfill site was found, after fill it up makes another one. Chemical goes to WWTP. Needle used for medicine mixing is reused.

(No pathological test is done in community hospital)

One military hospital found to have a lower quality burner made of brick, since there is no budget for medical waste management. After visit and discussing with hospital staff it seemed that waste management issue is not well considered in military hospital.

Concluding remarks

From field investigation, interview and discussion with the health workers, hospital staff, authority, heads, municipal office staff and personnel, it was found that, every hospitals and community hospitals (30 beds) at Phitsanulok have incinerator according to MOPH regulation. Though those incinerators did not maintain standard and cannot burn well. Most of the times it is just a burner with chimney. No incineration takes place during weekend in some hospital. Some hospital has separate incinerator for general waste also. Municipality takes care of clinic's waste. Small clinics and hospitals separate only sharps and needles. Some hospital reused bottles/ glasses. Most clinics use at least disinfectant or chemical before disposal of infectious waste to the municipal car.

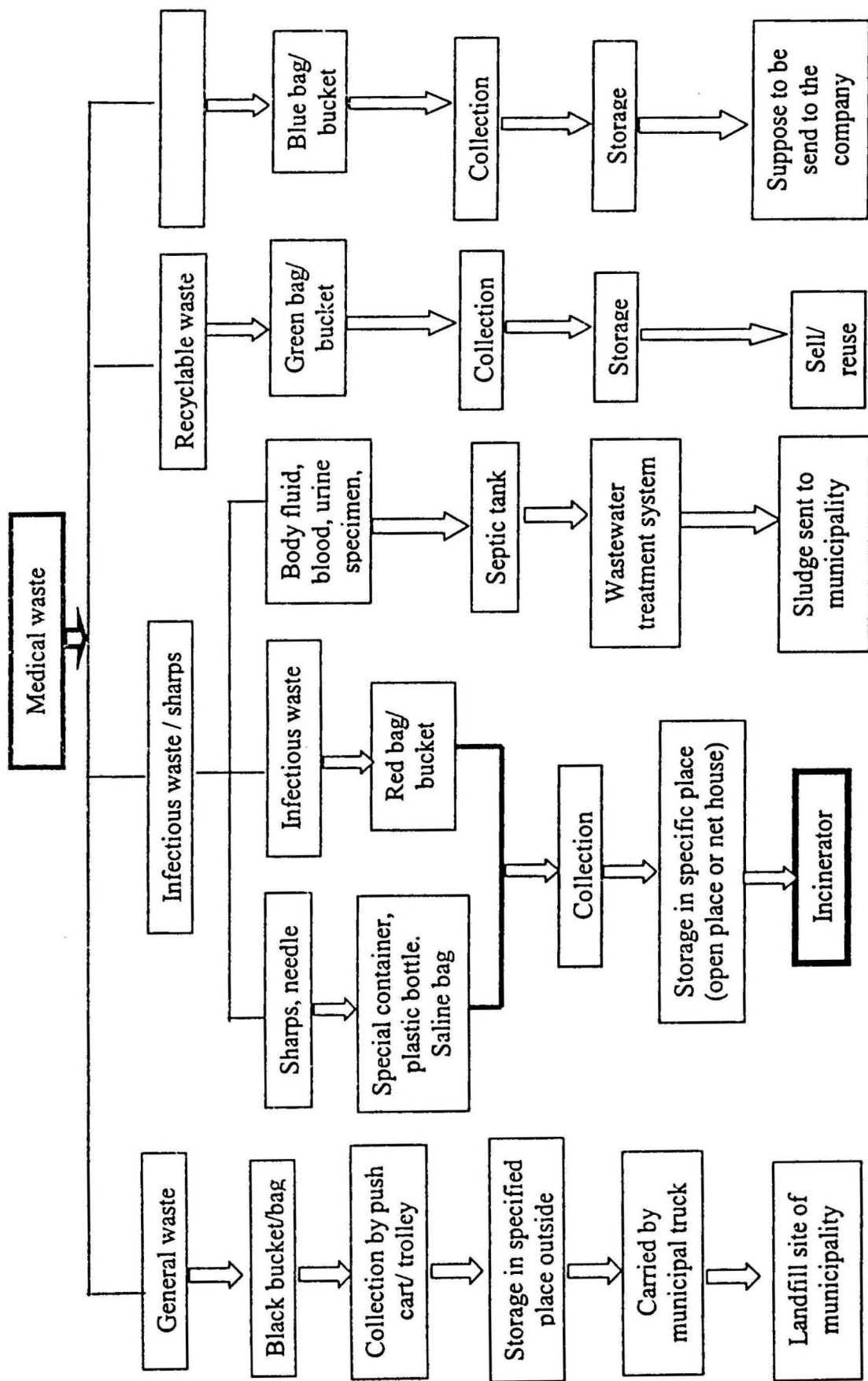
Buddhachinarat government hospital is a good example of proper waste management in Thailand, among the hospital visited in Thailand. Medical waste management practices is newly introduced in this hospital. Compare to Bangkok Phitsanulok has better situation in medical waste management. This is might be due to some waste management projects are running over there and Phitsanulok is used as a model for proper waste management.

It was understood from the discussion that even they have required facilities prescribed by MOPH, but most of hospital or clinics does not use those. In some hospital no one is sure when they use the incinerator for infectious waste burning even they have it, may be this is just to fulfill the regulation. Most clinics use disinfectant or chemical before disposal of infectious waste to the municipal car. But this may not effective for all kind of pathogens. According to municipal landfill

project personnel, lots of sharps and needles were found in landfill site, which should not be there is all hospital follow the regulation. From some respondents it was found that there is a limitation of fund to run incinerator. Therefore, they prefer to send their waste to the municipal bin.

Lesson Learned from Phitsanulok and Bangkok

1. There are some good example of medical waste management found in Bangkok and Phitsanulok. These could be considered to make a sound medical waste management plan. Those are as follows:
2. All kind of waste from patients before identifying the disease considered as IW. All waste from intensive care unit and emergency room are treated as IW also.
3. Most clinics use at least disinfectant or chemical before disposal of infectious waste to the municipal car
4. Private company to take care of medical waste collection, disposal and treatment. A Company under BMA area operates common incinerator for all hospital, which may help to reduce expenses of incineration and maintenance.
5. Better quality incinerator found in one government hospital subsidized by DOE. This hospital sharing it's incinerator to burn waste from other 4 hospital as well, which minimizes the cost of incineration.
6. Air quality monitoring by the hospital or company own initiative to ensure environmental standard, though there is no regular monitoring system from the authority.
7. Standard cold storage room for infectious waste storage found in Bamrungard private hospital only. This hospital received ISO 9001 and preparing for ISO 14000 for better environmental quality which will ensure quality of environment as well as quality of service and health for all in turn hospital will be benefited by getting more patients coming for better treatment facilities.
8. All most all hospitals at Phitsanulok have incinerator according to MOPH regulation although it is not up to the standard.
9. Food waste from hospital used as fish feed or animal feed
10. All big hospital in Phitsanulok and Bangkok has their own waste waster treatment plant. Treated wastewater then use for watering plant in the garden.
11. Some re-usable item from small clinics sent to the government hospital, such as vials, glass bottles to use for specimen collection
12. Some clinics and hospital segregate re-usable items such as; paper, glassware and plastics. Those are then taken by garbage collector for selling. Therefore it is risk free for waste pickers.
13. In the community hospitals glass syringes are reused after sterilization, Needle used for medicine mixing is also reused.
14. Some hospital has its own guideline for waste management.
15. Community hospital worker uses special dress, gloves, musk, and boot as safety measure.



Appendix figure 16.4 Medical Waste Disposal System in most Government Hospital in Phitsanulok

Source: Adsavakulchai, 2000

Appendix 17 SWOT Analysis Matrix for Medical Waste Handling by Government and Private Sector

Strength	Weakness	Opportunity	Threat
- Authority to bring up rules and regulation - Authority of enforcement - Centralized system, easy to control - Sets of organization responsible for different activities - Regular assessment/ monitoring is done or possible - Long term and sustainable - Established infrastructure	- No plan and guidelines - No training on medical waste handling or disposal - Lack of coordination and cooperation with different departments and organization - Lack of resources and manpower - Lack of institutional and technical capacity of local planning authorities to formulate and implement a set of effective and enforceable waste management plan - Top down approach of management - Insufficient knowledge and information in regard to the medical waste management and planning - The technical plans are unsuitable for the local situation (specially for Bangladesh) - Insufficient and inefficient collection and transport - Inadequate organization and planning - The financial planning and management is very poor: i.e. the high operation cost and the low income from waste collection charges. - Insufficient consideration of Municipality to joining forces with neighboring local authority in waste collection and disposal operations.	- Cooperation with informal or private sectors - Building local public and political awareness in planning and management - Develop an overall, short- and long- term, cost-effective strategy for solid waste management, and ensure efficient financial management of the system. - Combine community self - management, private contractors and the Municipality's own resources in the most efficient way. - Ensure correct choice of collection technology. The technology must be affordable and maintainable. - The municipal shall encourage the private contractors to carry out the collection and disposal work under its control. - Recycling strategy and market. - Building the capacity of local planning authorities by organizing, special training and sending staff members to other districts to exchange experiences on planning and management of medical waste - Improving the partnership among stakeholders involved in medical waste handling and management - Financial resource mobilization: - From central government - Municipal services fees (appropriate) - Promote solid waste recycling market	- Lack of political will in implementation and enforcement of the policies - Less importance on medical waste - Lack of public awareness, - Lack of peoples participation, - People's behavior - Miss use of the facility and Corruption - Required skill personnel for modern technology will increase management cost - Slow process to take action or decision - Health hazard if not properly handled - Not enough space for waste disposal - It is technically difficult and comparatively expensive to install any treatment facility and other infrastructure, after an area has been built up. - Pollution of local environment from waste dumping in canal, on vacant lots and waste incineration - The changing composition of waste (toxic and hazardous) - The public is not willing to co-operate with the waste management system, Either because of ignorance, or because it has no confidence in the management authorities

Appendix 17 (Contd.) SWOT Analysis Matrix for Medical Waste Handling by Government and Private Sector

	Strength	Weakness	Opportunity	Threat
P r i v a t e s e c t o r	• Modern and efficient • Bottom up approach of management. • Autonomous/Decentralized • Can take quick decision • Acceptance to the community • Accountability/responsibility • Well organized/managed • Community co-operation and Partnership	• Donor dependant • Small scale operation • Project specific/based • Short time frame • Need to follow government rules and regulation	• Can reach to the interior and door to door • Launch educational campaigns to promote cleanliness, waste minimization, material reuse and recycling • Income generation through reuse and recycle • Improve techniques (reuse, recycle, recover) • Promote segregation of infectious and non-infectious waste and to recycle the waste (paper, bottle glass, etc.) • Can encourage Self-awareness of Communities. Example, for slum communities, organizes self-help groups. • Train and provide the necessary tools and equipment so that they can collect the waste from their own areas, and take it to a designated site (Bangladesh). • Financial resource mobilization: - From NGO's donor - Services fees (appropriate) - Promote solid waste recycling market	• Extra service charge may hamper public demand • Project specific, limited time period, therefore it would not be sustainable if can not run for long time. • Competition among different private or informal sectors. • Potential health and environmental hazard related to alternative use of waste if is not properly handled. • Introduction of modern technology may have adverse impact on the society and environment (c.g. Incineration) • It might not be cost effective