Medical Waste Management: A Review

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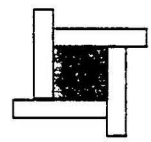

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Abstract

A review of medical waste management systems was performed to understand (a) the various handling and disposal procedures in different countries, (b) the knowledge and awareness of individuals involved in medical waste generation, handling and disposal, and (c) the potential impacts of the waste stream on both human health and the natural environment. The purpose of the study is to provide direction for further study. Information was collected mainly from literature review and online search. It was found that a variety of methods were used by the medical facilities to dispose their wastes including burning, burial, entombing, selling, dumping, and removal by municipal bins. The waste disposal practice was found to be quite unsafe, and both clinical and non-clinical wastes were found to be thrown together. There was insufficient awareness of the magnitude of the medical wastes issue by concerned individuals at different levels from director or divisional head to tokai (waste pickers). One study (Akter et *al*, 1998) showed that the hospital staff including high officials, and waste "haulers" were not aware of the safe disposal and handling of hospital waste. Laboratory analysis showed severe contamination of infectious wastes to the environment. Children, adults, and animals all have the potential to come into contact with these wastes which may pose severe health risks to them. There was no safety measure observed in dealing with waste disposal or laboratory analysis of infectious or hazardous diseases. 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.

Hospital wastes pose a significant impact on health and environment. From this study it can be said that there is an urgent need for raising awareness and education on medical waste issues. Proper waste management strategy is needed to ensure health and environmental safety. For further study, it is needed to collect more information on impacts, disposal and management to draw a clear conclusion. Need to collect information and examples from developed country or the country, which has sound medical waste management system. Find alternatives and appropriate technologies for developing countries. Need extensive study on this medical waste and its management aspects as well.

INTRODUCTION

One estimate shows that some 5.2 million people (including 4 million children) die each year from waste-related diseases. 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 Janerio in June, 1992, set the following goals and targets with regard to waste management in cities:

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

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 on November 1, 1988. Much of the outcry ignored the specifics of medical waste, its small quantities and its nature. 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 worker safety (Agarwal, 1998 and BAN & HCWH, 1999).

Any anthropogenic activity generates some waste. For example, many industrial activities generate toxic waste and effluents while consumption activities generate waste of various types. A large part of hospital 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. The soil associated or under the disposed wastes is one of the main reservoirs of microbial life, and contaminated water contains pathogenic microorganisms, which are causative agents of different types of disease.

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, and radioactive and pathological wastes. Liquid waste contain chemicals used in laboratory, pathogen containing urine, blood and other sample for testing disposed off to the wastewater (detail explained in next section).

OBJECTIVES

- *To collect information on the collection, , treatment, handling, hauling, and disposal of medical wastes*;
- *To determine the level of knowledge and awareness of individuals involved in the medical waste industry in Bangladesh*;
- To identify the potential impacts that medical wastes pose to both human health and the natural environment due to improper disposal and management techniques;
- To collect available information on medical waste management system in different countries;
- To direct further study (recommendations).

METHODS

This study is based on the review of available information on medical waste. *as relates to their nature. impacts and management techniques. The techniques described are either practiced or recommended by different countries. Information was obtained* through literature review. online search. and discussion with thesis committee members. Study has also included the authors work experience and field data collection.

DEFINING MEDICAL WASTE

Healthcare Wastes are wastes arising from diagnosis, monitoring and preventive. curative or palliative activities in field of the veterinary and human medicine. "Very broadly medical waste is defined as any solid or liquid waste that is generated in the diagnosis. treatment or immunisation of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals" (BAN & HCWH, 1999).

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

MEDICAL WASTE CLASSIFICATION

Different authors introduce different ways of medical waste classification. These are based on medical waste state or form (solid. liquid), character. source and effects. Some of those are described below.

1. Classification of Hospital waste by Eigenheer & Zanon (1991). They classified medical waste according to their liquid and solid state. This is shown in following table.

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

2. Medical Wastes are also classified into four different categories based on their sources and potential hazards they may cause.

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 present a high risk of infection to the general population and to the staff.

B) **Laboratory Waste:** This is also high risk category waste. This 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 that has not been in contact with patient body fluid.

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

NATURE 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 generated is actually infectious or hazardous. Infectious or hazardous hospital 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. Most hazardous and toxic waste is coming from clinical and hospital. Only a small amount is from domestic or industrial sources. According to World Health Organization (WHO) (BAN & HCWH, 1999) approximately 85% or hospital wastes are actually non-hazardous, 10% are infectious, and around 5% are non-infectious but hazardous. In the US for example, about 15% of hospital waste are regulated as infectious waste. In India this could range from 15 to 35% depending on the total amount of waste generated (BAN & HCWH, 1999). In Pakistan about 20% of hospital waste is found to be potentially infectious or hazardous (Agarwal, 1998). The total garbage generation in Dhaka city is 3500 mt per day from which only 5.7 % comes from medical establishment (Asaduzzaman & Hye, 1997). Around 200 metric tons of hospital wastes are generated per day in the city of Dhaka, Bangladesh. Of this amount, roughly 20% is infectious and hazardous (Kazi, 1998).

Estimated quantities of medical waste generated in each country
This table 1 is tentative and from International Healthcare Waste Network (IhcWaN) members and various publications. It includes:

* Infectious Medical Waste (IMW) produced in the country
* Total Medical Waste (TMW) produced in the country
* National ratio of productions in kg/day/bed, kg/inhabitant/year, Ton/bed/year of IMW or TMW

Table 1. Estimated quantities of medical waste generated in each country

Country Name -	IMW (tonnes/year) -	TMW (tonnes/year) -	Production ratio
Afghanistan	150	unknown	0.15 kg/bed/day IMW
Antigua and Barbuda	unknown	unknown	2.5 kg/bed/day IMW
Argentina	32850	unknown	0.21/t/bed/year IMW
Austria	24500	unknown	0.8kg/bed/day IMW
Bangladesh	4400	unknown	40kg/year/bed IMW
Belgium	13700	110000	1.4kg/inh/year IMW
Bolivia	unknown	unknown	3kg/bed/day IMW
Brazil	109 960	unknown	0.2t/year/bed IMW

Bulgaria	14000	unknown	0.1kg/bed/day IMW
Burundi	430	unknown	0.3kg/bed/day IMW
Chile	unknown	unknown	2.7 kg/bed/day IMW
China	875000	unknown	70kg/bed/day IMW
Cuba	11010	unknown	0.2t/bed/year IMW
Cyprus	580	unknown	0.4kg/bed/day IMW
Czechoslovakia	27000	unknown	0.4kg/bed/day IMW
Denmark	10000	10000	1.95kg/inh/year IMW
Djibouti	100	unknown	0.2kg/bed/day IMW
Egypt	35000	105000	0.2t/bed/year IMW
France	105000	700000	1.9kg/inh/year IMW
Gabon	50	unknown	0.1kg/bed/day IMW
Germany	33000	92000	0.4kg/inh/year IMW
Ghana	850	unknown	0.1kg/bed/day IMW
Greece	14600	73000	1.4 kg/inh/year IMW
Guatemala	1700	unknown	0.3kg/bed/day IMW
Haiti	350	unknown	0.2kg/bed/day IMW
Hungary	unknown	unknown	0.3 kg/bed/day IMW
India	49000	unknown	0.2kg/bed/day IMW
Indonesia	7500	unknown	0.2kg/bed/day IMW
Iran	3300	unknown	0.1kg/bed/day IMW
Iraq	1200	unknown	0.1kg/bed/day IMW
Israel	5700	unknown	0.6kg/bed/day IMW
Italy	60000	210000	1.0 kg/inh/year IMW
Jamaica	1260	unknown	0.2t/bed/year IMW

Japan	420000	unknown	0.8 kg/bed/day IMW
Kenya	1500	unknown	0.1kg/bed/day IMW
Lebanon	550	unknown	0.5kg/bed/day IMW
Libya	1500	unknown	0.2kg/bed/year IMW
Luxembourg	unknown	unknown	6.4 kg/bed/day TMW
Malaysia	8200	unknown	0.5kg/bed/day IMW
Mauritania	75	unknown	0.1kg/bed/day IMW
Mauritius	20	unknown	0.1kg/bed/day IMW
Mexico	13160	unknown	0.2t/bed/year IMW
Mongolia	2700	unknown	0.3kg/bed/day IMW
Morocco	3500	unknown	1.5 kg/bed/day TMW
Nepal	110	unknown	0.1kg/bed/day IMW
Nicaragua	365	unknown	0.2kg/bed/day IMW
Pakistan	2500	unknown	0.1kg/bed/day IMW
Panama	1200	unknown	0.4kg/bed/day IMW
Peru	2700	unknown	0.2kg/bed/day IMW
Philippines	11000	unknown	0.3kg/bed/day IMW
Portugal	15000	50000	1.5 kg/inh/year IMW
Qatar	220	unknown	0.6kg/bed/day IMW
Rwanda	400	unknown	0.1kg/bed/day IMW
Saudi Arabia	3300	unknown	0.3kg/bed/day IMW
Singapore	2400	unknown	0.4kg/bed/day IMW
South Korea	10000	unknown	0.4kg/bed/day IMW
Spain	23000	213000	0.6 kg/inh/year IMW
Sri Lanka	1800	unknown	0.1kg/bed/day IMW

Sudan	10	unknown	0.1kg/bed/day IMW
Syria	1500	unknown	0.3kg/bed/day IMW
The Gambia	100	unknown	0.2kg/bed/day IMW
The Netherlands	8500	155500	0.6kg/inh/year IMW
Turkey	13000	unknown	2 kg/day/bed TMW
Uganda	900	unknown	0.1kg/bed/day IMW
United Arab Emirates	1100	unknown	0.4kg/bed/day IMW
United Kingdom	308000	308000	5.5 kg/inha/year IMW
United States	504000	3361100	8 kg/bed/day TMW
Uruguay	1400	unknown	0.4kg/bed/day IMW
Venezuela	47200	unknown	0.2t/bed/year IMW
Vietnam	18000	unknown	0.2kg/bed/day IMW
Zaire	2200	unknown	0.1kg/bed/day IMW

Source: web site of IhcWaN (International Healthcare Waste Network), Last modified, 22 June 1998.

STATUS IN CASE OF BANGLADESH
(Disposal, management and knowledge)

In Bangladesh, all types of waste that are generated in most urban and rural areas are disposed of by open dumping in either low depressions or high areas. Waste decomposition occurs by means of natural degradation. One type of waste that has been completely ignored in Bangladesh is medical waste. These wastes are a source of contamination and pollution to both humans and the natural environment. There is not much study done on medical waste disposal in Bangladesh. A survey was conducted by Dr. Salim Rashid (1996) and his students from North South University on Medical Waste Disposal in Dhaka City. The survey found that government hospitals placed all wastes in open dustbins (i.e. open waste containers that are accessible to the general public) and the wastes were left in the open for one to two days. Other hospitals left their wastes outside in open dustbins for two to three days at a time before a municipal truck would remove them. At the Orthopaedic Hospital, parts of human bodies were found in dustbins. It was also found that revenue was generated by medical staff through the sale of medical wastes. Syringes and other medical wastes were re-sold and clinical waste sold for 20Tk/kg at most hospitals and clinics visited. Dr. Salim Rashid (1996) concluded that there is a lack of knowledge and interest in safe waste disposal by most health workers and an absence of adequate funding to effectively implement safe waste disposal. The study made neither recommendations for the proper disposal of such wastes nor ways to protect human health.

BRAC's (a non-governmental organization) Environment Group has conducted a study on medical waste disposal at BRAC Health Centre (Akter *et. al.*, 1997). 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. This was apparent not just at BRAC's Health Canters but also at the government hospitals, private laboratories, and private clinics. Clearly, well conceived waste disposal systems are severely lacking in both government hospitals and private clinics.

Bangladesh lacks both effective and adequate waste management facilities and an inadequate government policy to guide health providers and punish offenders. The Bangladesh Government's Environmental Policy of 1992 (BELA 1996 a & b), has six general goals which have been further detailed into priority objectives for different sectors. Applicable to medical waste disposal practices are 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, odour 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."

The findings from one study (Akter *et. al.*, 1999) were as follows: A variety of methods were used by the medical facilities to dispose of waste. These included burning, burial, selling, dumping, reuse and removal by municipal bins. Table 2 below is the summary of waste disposal practices at Government hospitals and clinics, private clinics and laboratories. There was no clear guidance to segregate wastes and ensure their proper disposal. Most hospitals collected all wastes together and dump in a common place. 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.

Table 2. Item disposed by different disposal system

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

There were several mode of waste transport. Waste was primarily 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; Pit near hospital (dig a hole); Open field / road way / by the road side; Canal water/ river/Lake/ditch; Own net house / closed house/ own closed dustbin. Notably, most wastes were disposed of in municipal bins (59%) without any treatment or separation.

Also, saline bags, x-ray water, syringes, vials, slides, empty packets and bottles were collected and sold. Medical waste was collected by hospital authority, *tokai* (waste picker), cleaners and sold to whole seller, hawkers. Wastes were sold and the following list (Table 3.) shows the prices received for such waste.

Table 3. The following list shows the prices received by Mymensingh Medical College Hospital for selling their waste (as of 1997).

PRICE LIST OF MEDICAL WASTE	
X-ray water	Tk 11.25/litre
Poly-bag or jute bag	Tk 0.50/bag
450 ml bottle	Tk 1.50/piece
250 ml bottle	Tk 0.25/piece
100 ml bottle	Tk 0.10/piece
saline bag (1000 ml - 500 ml)	Tk 20/kg
ampoule or vial	Tk 2/kg

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 pickers are in constant danger of becoming contaminated and injured.

There has been no formal training of staff, to teach them how to deal with the disposal of medical wastes. Though they have received training on laboratory analysis, it is done in an adhoc method. Medical officers are generally aware that medical waste could pose a problem, however most thought they were handling the situation sufficiently. Nurses, lab technicians, and *aya's* (maids'), however, had no training (formal or non-formal) on handling procedures and disposal methods.

According to Akter *et al.* (1999), there was insufficient awareness at different levels, from the director or divisional head to the waste pickers, about the potential threat posed by medical wastes. Given that 82.24 percent respondents described medical wastes as general waste, it is clear that most people are simply unaware of and unclear about what constitutes medical wastes. Most of the respondents did not know the harmful impact of medical waste; they also did not know the harmful impact of recycling of wastes. Also, they are not aware of the environmental effect of medical wastes. Study also showed that the hospital staffs including high officials and waste collectors were not aware of the safe disposal and handling of hospital waste. Laboratory analysis shows high levels of contamination from infectious wastes at various sources in the environment (table 4). Children, adults, and animals all have the potential to come into contact with these wastes which may pose severe health risks to them. Samples were collected from several sources including dustbins (where medical wastes are dumped), wastewater from hospital drains, and laboratory basins from different hospitals in Bangladesh. Laboratory analysis showed improper disposal of medical waste and severe contamination of these infectious wastes to the environment.

Table 4. Pathogens (number) in hospital waste analyzed from different sources (source: Akter *et al*, 1999).

Source of waste sample	Salmonella	Shigella	Mycobacteria	Amoeba
Dustbin	2.5x10	6.4x10	2.3x10	3.8x10
Basin water	2.7x10	1.1x10	1.1x10	3
Dustbin	3.2x10	3.6x10	4.7x10	5.3x10
Basin water	3.2x10	1.7x10	15	<1
Basin water	1.6x10	35x10	5	<1
Dustbin	2.3x10	7.7x10	1.8x10	6.2x10
Basin water	1.8x10	0.5x10	2.9x10	1.3x10
Dustbin	1.2x10	2.0x10	3.5x10	7.4x10
Dustbin	1.1x10	1.0x10	2.5x10	5.0x10
Basin water	4.0x10	1.0x10	18	<1
Soil	3.1x10	7.2x10	3.4x10	2.7x10
Water	6.8x10	1.2x10	7	5
solid	2.5x10	2.0x10	5.6x10	3.9x10
water	2.9x10	3.1x10	3	1.2x10

There was no safety measure observed in dealing with waste disposal or laboratory analysis of infectious or hazardous diseases. 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. This is due to lack of environmental awareness among the respondents, which is true for maximum people of the country.

The study findings indicate that there is a need to improve medical waste handling and disposal methods. This is necessary at government hospitals, private laboratories, and clinics as well. In most government hospitals, private laboratories, and clinics waste is disposed in municipal bins without proper regard to the harmful effects they may pose to human health and the environment. None of these institutions have proper waste disposal systems in place to manage their medical wastes. Most hospitals visited believed that they were disposing of their waste in an appropriate manner. Though some medical officers did show their concern and generally wanted to improve the situation. Most health care workers have only a basic understanding of health care and don bot perceive handling or disposal of medial waste as a hazard at all.

POTENTIAL IMPACTS (RISKS) ASSOCIATED WITH MEDICAL WASTE

A. Health hazards related to medical waste could be the following

i. Injuries and accidents

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.

Akter *et. al.*, (1998) reported that, there were several incident (10 cases out of 17) of injury due to exposure to medical wastes inside or outside of hospital premises. 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
- Ulcer on legs

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

ii. Infectious medical waste risk

Infectious hospital waste represents only a small part of total medical 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 if it is not properly disposed. Table below shows few examples of different pathogen and diseases caused by them.

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, ankylomastomiasis, taeniasis, echinococcosis, malaria, leishmaniasis, filariasis etc.
Fungal infections	Various fungal infections like candidiasis, cryptococcoses, coccidiodomycosis etc.

Infected hospital waste can transmit diseases, espicially if it finds portals of entry. "There is strong epidemiological evidence from Canada, Japan and the USA, that the main concern of infectious hospital waste is the transmission of HIV/ AIDS virus and more often of Hepatitis B or C virus (HBV) through injuries caused by syringes contaminated by human blood." Other than these, there is potential risk of TB/ Throat infection, Typhoid, Dysentery, Diarrhoea, Bacterial/ Viral diseases, ARV (Rabies), VDRL (Sexually transmitted disease), UTI/ all C/S, and Leprosy etc. as the pathological laboratories do all these analysis to diagnose the diseases (Akter *et. al.*, 1998).

iii. Hazardous medical waste risk

This class of hospital waste, while largely ignored, poses risk to workers handling them. Hazardous medical waste consists primarily of chemicals and discarded cytotoxin drugs.

The pathological laboratories of medical center 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. Children, adults, and animals all have the potential to come into contact with these chemicals. Xylene, phenol, methylene blue, hydrochloric acid, chlorine and carbol fuchsin are all used, and some can have very damaging effects (Akter *et. al.*, 1998). Other than these, a large number of chemicals also used 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 5.

Table 5. Types of chemicals used in medical facilities, pharmaceuticals industries, and their uses and effects (few available examples only).

Chemical	Purpose of Use	Properties	Potential Effects
Xylene	removal of seederwood oil for TB slides	toxic	inhalation of vapours can cause: headaches; euphoria; light-headedness; dizziness, drowsiness; nausea vapour 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(Polychlorinated 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).

The main health risks of medical wastes are summarized below (modified from WHO, 1999).

- 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.

B. Environmental hazards related to medical waste

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 biomagnify 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 also have the potential to carry 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 labour 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 number of sites necessary for disposal of wastes (degradation of habitat)

- plastic-bags, plastic containers, if not properly destroyed may contaminate the soil and also reduces the chance for water percolation into the soil during precipitation.
- Open air burning does not guarantee proper incineration, and releases toxic fumes (dioxin) into the atmosphere from the burning of plastics i.e., PCB's.

CONSEQUENCES OF IMPROPER DISPOSAL OR NON-DISPOSAL OF MEDICAL WASTE

Medical wastes are a source of contamination and pollution to both humans and the natural environment as discussed in this paper. Improper disposal may be hazardous if it leads to contamination of water supplies or local sources used by nearby communities or wildlife. Sometimes exposed waste may 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 also 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 micro-organisms into the food chain. Medical wastes therefore pose a risk to individuals, communities, and the environment if not carefully handled (Akter *et. al*, 1998).

Wastes attract scavenging animals and bats. As it ferments 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 among which are methane (CH4), nitrogen (N2) and occasionally hydrogen sulfide (H2S). If burnt, carbon di-oxide (CO2) is released. CH4 and CO2 are greenhouse gases and 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 cause public nuisance by clogging sewers and open drains, encroaching on roadways, diminishing landscape aesthetics and giving off unpleasant odours and dust (World Bank, 1991).

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 past their expiry date become less efficacious and a few may develop a different adverse drug reaction profile.

Medical waste incinerations are 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. When one eats these foods, one adds to the existing dioxin and mercury body burdens. Other than these, the ash from incinerator consists of both fly ash and bottom ahs. The ash contains high levels of toxic substances such as heavy metals, dioxins and furans. Ironically, as the air pollution equipment becomes more effective in removing particulate matter, the toxicity of the fly ash increases. One of the largest hospitals in Delhi, India 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 not only destroys the pathogen but also the material on which the pathogen resides. Thus, those materials go under a process of transformation and dematerialization. In the process they transform solid and liquid toxic waste into gaseous emissions, 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.

TECHNOLOGY AND MANAGEMENT

As can be seen from the foregoing discussion, there is no proper waste management system in place in most developing countries. On-site incineration, autoclaving, and steam disinfection are a few processes currently in use for treating very small amounts of hazardous wastes. The countries found to practice incineration is Brazil, Argentina, 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. 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. There are some techniques practiced by different countries all over the world such as: Incineration, Autoclave Disinfection, Microwave Disinfection, and Mechanical/Chemical Disinfection. Each of this technique has limitations in terms of technological aspect, environmental condition and waste composition. Parameters influencing selected treatment technique and it's advantages and disadvantages are summarized in table 6. However, most of the developed countries have defined policy and regulations to handle and manage medical waste such as Germany, France, Canada, and USA.

Table 6. 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

GUIDE LINES PROPOSED BY WORLD HEALTH ORGANISATION (WHO)

WHO (1999) has proposed disposal methods for unwanted pharmaceuticals disposal in and after emergencies. Types of waste and suggested disposal methods are summarized in table 7 and 8 below.

Table 7. 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 temp. 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.	
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.

Table 8. Summary of pharmaceutical categories and disposal methods in and after emergencies

Category	Disposal methods	Comments
Solids Semi-solids Powders	Landfill Waste encapsulation Waste inertization Medium and high temperature incineration (cement kiln incinerator)	No more than 1% of the daily municipal waste should be disposed of daily in an untreated form (non-immobilized) to a landfill.
Liquids	Sewer High temperature incineration (cement kiln incinerator)	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: Guidelines for safe disposal of unwanted pharmaceuticals in and after emergencies (WHO, 1999)

CONCLUSION AND RECOMMENDATIONS

Medical wastes pose a significant impact on health and the environment. There is not enough information on medical waste management technologies and impacts in developing countries. Practice of proper medical waste disposal and management is also inadequate. However, from this study it can be said that there is an urgent need for raising awareness and education on medical waste issues. Proper waste management strategy is needed to ensure health and environmental safety.

Recommendations for further study:

- Need more information on impacts, disposal and management to draw a clear conclusion.
- Need to collect information and examples from developed countries or the country, which has sound medical waste management system.
- Find alternatives and appropriate technologies for developing countries.
- Need extensive study on this medical waste and its management aspects.
- A careful evaluation of training programs offered in other countries, and how they can be applied in Bangladesh.

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