A Syntheitic Review of Literature on Bio-Medical Waste

Prof. Krishna Kant Dave, Nalini K Bhatt

Abstract - The Bio-medical Waste (Management and Handling) Rules, 1998 and further amendments were passed for the regulation of bio-medical waste management. On 28 March 2016, Biomedical Waste Management Rules 2016 were also notified by Central Government. Each state's Pollution Control Board or Pollution control Committee will be responsible for implementing the new legislation. ["Disposal of Medical Waste" Press Information Bureau. 25 July 2014].

In India, though there are a number of different disposal methods, the situation is desultory and most are harmful rather than helpful. If body fluids are present, the material needs to be incinerated or put into an autoclave. Although this is the proper method, most medical facilities fail to follow the regulations. It is often found that biomedical waste is dumped into the ocean, where it eventually washes up on shore, or in landfills due to improper sorting or negligence when in the medical facility. Improper disposal can lead to many diseases in animals as well as humans. For example, animals, such as cows are consuming the infected waste and eventually, these infections can be transported to humans who consume their meat or milk. Large number of unregistered clinics and institutions also generate bio-medical waste which is not controlled. This paper will explain various implementations done by government till now for bio-medical waste management. A synthetic review is done by through his paper taking into consideration of various contribution made by earlier studies for biomedical waste.

Key words: Bio medical waste management rule 1998, Bio medical waste management rule 2016, Pollution control board and Synthetic review.

INTRODUCTION

Due to the competition to improve quality and so as to get accreditation from agencies like ISO, NABH, JCI, many private organizations have initiated proper bio-medical waste disposal but still the gap is huge. Many studies took place in Gujarat, India regarding the knowledge of workers in facilities such as hospitals, nursing homes, or home health. It was found that 26% of doctors and 43% of paramedical staff were unaware of the risks related to biomedical wastes. After extensively looking at the different facilities, many were undeveloped in the area regarding biomedical waste. The rules and regulations in India work with The Bio-medical Waste (Management and Handling) Rules from 1998, yet a large number of health care facilities were found to be sorting the waste incorrectly.

The latest guidelines for segregation of bio-medical waste recommend the following color coding - ["Archived copy". Archived from the original on 2017-11-28]

Red Bag - Syringes (without needles), soiled gloves, catheters, IV tubes etc. should be all disposed of in a red colored bag, which will later be incinerated.

Yellow Bag - All dressings, bandages and cotton swabs with body fluids, blood bags, human anatomical waste, body parts are to be discarded in yellow bags.

Cardboard box with blue marking - Glass vials, ampules, other glass ware is to be discarded in a cardboard box with a blue marking/sticker.

White Puncture Proof Container (PPC) - Needles, sharps, blades are disposed of in a white translucent puncture proof container.

Black Bags - These are to be used for non-bio-medical waste. In a hospital setup, this includes stationary, vegetable and fruit peels, leftovers, packaging including that from medicines, disposable caps, disposable masks, disposable shoe-covers, disposable tea cups, cartons, sweeping dust, kitchen waste etc.

BAN & HCWH [1999] on the topic "Medical Waste in Developing Countries-An analysis with a case study of

India, and a critique of the Basel -TWG guidelines" explained that biomedical waste is any waste in the form of solid or liquid, including its containers and any product, which are generated during the treatment, diagnosis and immunization of human beings and animals in research. Basically bio medical wastes refer to those wastes which are produced for health care and discarded after use of it. It is not used again.

There are many names given to medical waste and known by different names in different parts of the world and in research journals. According to Moritz (1995) these are known as clinical waste, hospital waste and bio-medical waste. "Healthcare waste" is used by WHO in their reports and other official publication. Al-Mutair et al., (2004) defined medical waste as any solid or liquid waste capable of causing infectious diseases generated as a result of patient diagnosis, treatment or in related research through the immunization of humans and animals.

Phillips (1999) defined clinical waste as - waste arising from the investigation, treatment or in medical care of patients. According to Pruss et al. (1999), health care waste is defined as the total waste generated in health care facilities and in addition to hospitals and clinics includes waste generated by blood banks, research facilities and laboratories irrespective of the volumes, characteristics and composition.

Abor and Bouwer (2008) focus their definition to include all types of wastes produced by health facilities such as general hospitals, medical centers and dispensaries. WHO (2005) considered the BMW is a byproduct of hospitals that includes sharps, non-sharps, body parts, blood, chemicals, medical devices, radioactive materials and pharmaceutical products.

Medical wastes constitute a larger part of hazardous wastes **(**Chul- Jang et al., 2006). The generation of these wastes is an ongoing phenomenon as long as human civilization persists.

Kaiser et al. [2001], depicted that hospital waste is sub-divided into health care general waste (HCGW) and health care risk waste (HCRW). The health system is under pressure to dispose of health care waste in such a way as to avoid unnecessarily high levels of environmental degradation. The aim of health care facilities worldwide is beginning to subscribe to the social goals of a cleaner and safer environment. To manage health care waste optimally, health care providers should consider all stages or whole life cycle of the medical product by looking at the medical product's upstream and down-stream activities

Determining which portion or components of clinical waste is infectious is challenged by its inherent heterogeneous nature and definitional problems (OTA, 1988). No tests currently exist to objectively determine whether waste is infectious or not infectious is defined by (Rutala and Mayhall 1992).

The U.S.EPA, 1986 and Centers for Disease Control, despite their discrepancies in clarifying the term infectious waste, have designated pathological waste, blood and blood products, contaminated sharps (scalpels, needles and blades) and microbiological waste (cultures and stocks) as infectious (OTA, 1998). In general, for waste to be infectious, it has to contain enough virulence capable of causing an infectious disease including a portal of entry in a susceptible host.

Biomedical wastes are considered a special area where hazards and risks not just confined to the health of generators and operators of hospitals but also the health of general people. In general hospital waste is broadly grouped into infectious waste and non-infectious waste.

CHARACTERIZATION AND CLASSIFICATION OF BMW

According to Eigenheer & Zanon (1991) and Biomedical Waste (Handling & Management Rules, 1998) amended in 2000 (Table-2.1), biomedical waste has been categorized under 10 categories with respect to its collection.

Table-2.1: Categories of Biomedical waste

Waste Category	**Type of Waste Category**
Category-1 Human anatomical waste	Human organs and body parts etc.
Category-2 Animal waste	Organs, body parts, body fluid, blood, waste generated by veterinary hospitals, carcasses etc of experimental animals, animal houses medical colleges and discharge from hospitals.
Category-3 Biotechnology and Microbiology waste	Waste from Laboratory cultures, stocks, human and anima cell culture used in research, specimens o microorganisms, infectious agents from research and industries etc. culture used in vaccines, waste from the production of biologica toxins and devices used for transfer of culture.
Category-4 Waste sharps	Used and unused sharps e.g. needles, syringes, scalpels, blades, broken glasses etc.
Category-5 Cytotoxic and discarded drugs.	Waste comprises outdated, contaminated and discarded drugs.
Category-6 Solid waste	Waste comprises cotton, dressing, soiled plasters casts contaminated with blood and body fluid, linen and other material contaminated with blood etc.
Category-7 Solid waste (ward procedure waste)	Waste generated from disposable items other than sharps such as: I.V. sets, tubing and catheters, cut opens etc.

Category-8 Liquid waste	Waste generated from washing, cleaning, house-keeping, disinfecting activities etc.
Category-9 Incineration ash	Ash produced from incineration of any biomedical waste.
Category-10 Chemical waste in liquid forms	Chemicals used in the production of disinfection and chemicals used in biological etc.

Source: (Ministry of Environment & Forests, Government of India, 2011)

According to Prüss et al., 1999, The Department of Health, Government of India, 2011 and The Royal College of nursing, 2007, hospital wastes may be categorized into the following groups:-

i. Infectious Waste:
The waste which consists of pathogens in sufficient concentrations could cause diseases in the human beings.

Some examples of the infectious wastes which are produced after the handling of different hospital workers are:

- Discarded syringes and needles used to draw blood or give vaccination to the patients.
- Production of culture dishes, petriplates, glassware, test tubes and other glass instruments used in laboratory work.
- Removed body organs like placenta, limbs, appendices, uterus and other body parts etc.
- Swabs used to inoculate cultures and stocks.
- Discarded surgical gloves and surgical instruments.
- Contaminated blood-soaked bandages and cotton plugs.
- Specimens and laboratory cultures etc.
- Blood contaminated materials, sharps and other instruments etc.

ii. Chemical Wastes:
This type of waste category includes discarded liquid, solid and gaseous chemicals which are used in disinfecting the products, in cleaning and in housekeeping.

iii. Pathological wastes:
It includes body organs, human foetus, placenta, blood and body fluids etc.

iv. Sharps:
It includes those waste materials which could be infectious to people taking care of it. Sharps can also cut or puncture the skin. They can include blades, needles, nails, saws, scalpels and broken glasses etc.

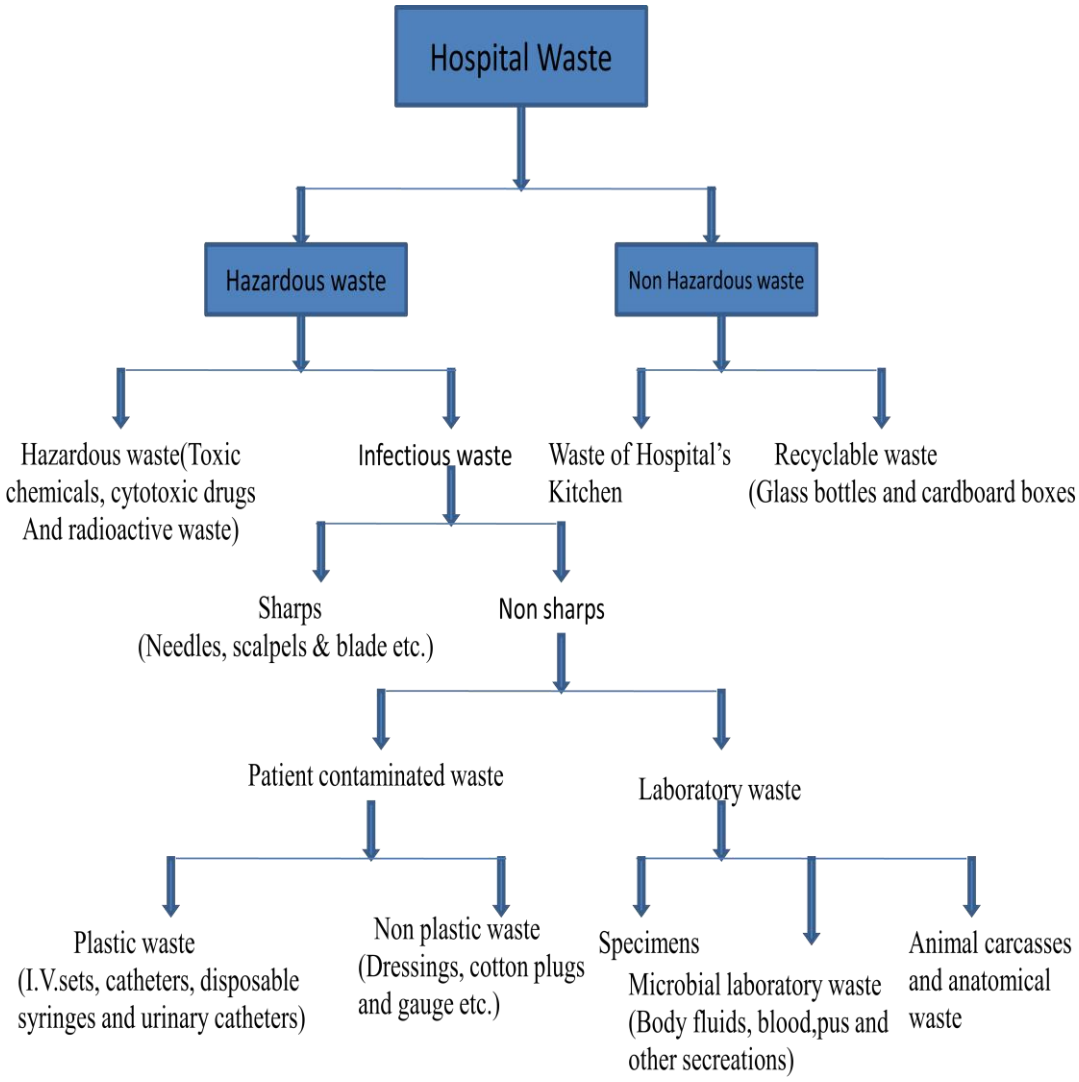
v. Radioactive waste:
It consists of radionuclide in the form of solid, liquid and gaseous waste form used in in-vitro analysis of body tissues and body fluid and in-vivo body organ imaging and tumour location and therapeutic procedures.

vi. Pharmaceutical wastes:
It comprises outdated drugs and chemicals which have been discarded from different wards. These outdated chemicals and drugs contaminate the environment.

vii. General wastes:
These types of wastes are mainly composed from household wastes such as wrappers, Packaging material, kitchen waste, paper and plastics etc. It is to human beings.

A detailed classification of Hospital waste shown in Fig- 2.1

Fig- 2.1: Classification of hospital waste



Source:http://www.WHO.int/water/_sanitation_health/medical waste

According to Gupta and Boojh (2006), the typical compositions of biomedical wastes are as follows:-

Table-2.2: Characteristics or composition of biomedical waste

S.no.	Type of waste	Components	Moisture Content (%)	Heat Value (Kcal/Kg)
1.	Kitchen waste	Food and peelings	70	1400

2.	Paper waste	Packings and packing boxes	0-10	4700
3.	Plastic waste	LDPE, HDPE, and PET items	0-01	9000-11000
4.	Anatomical waste	Human tissues	70-90	50-800
5.	Waste cotton	Cotton	0-10	4700
6.	Clinical Waste	Gauze and bandages	0-30	3600-4500

Sources of Biomedical Waste:

Generally Health Care centers produce different types of wastes, which have been increasing over the years in its type and amount. The hospital waste, in addition to the risk for workers and personnel who handle them also poses a threat to public health and their environment **(The Gazette of India, 1998)**. **Prüss et al., 1999,** classified the sources of health care waste into two groups as major or minor according to the quantities of waste production. These are listed below:

(i) **Major Sources:** Major sources for biomedical waste production are:

- Waste produced from Govt. hospitals, nursing homes, dispensaries and private hospitals **(Anonymous, 1998; Chitnis et al., 2005)**.
- Waste produced from Medical colleges, paramedical services and from research centers.
- Waste produced from Primary health centers.
- Waste generated from Blood banks, mortuaries and autopsy centers.
- Waste from Veterinary colleges and animal research centers.
- Waste also generated from Production units.
- Waste produced from Biotechnology institutions.

(ii) **Minor Sources:** Minor sources for biomedical waste production are:

- Waste from physicians and dentists clinics.
- Waste from animal houses and slaughter houses.
- Waste produced from blood donation camps.
- Waste from vaccination centers.
- Waste from acupuncturists, psychiatric clinics and cosmetic piercing centers.
- Waste produced from funeral services.
- Waste from institutions for physically challenged.

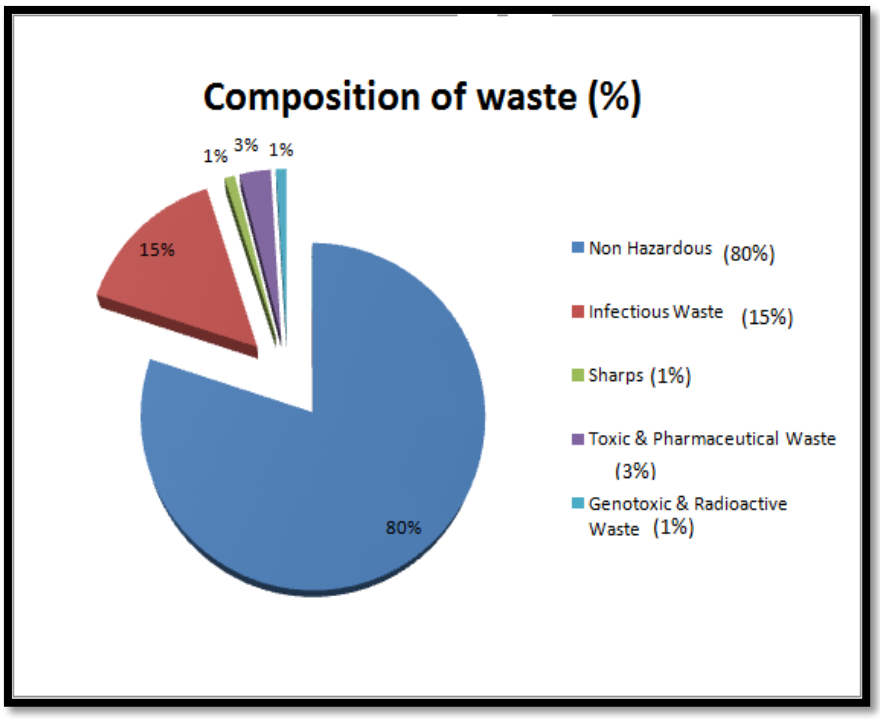
Quantity and composition of waste production in different countries:

Hospitals, nursing homes and the private clinics are places to serve patients but they also generate a huge corpus of dangerous or hazardous wastes. Since the beginning, hospitals have been made for the treatment of sick people, though during that time we neither knew about the adverse effects of garbage produced by the health care units nor did we have a clue that it poses serious health problems and that filth is also generated on human body and their environment.

Biomedical waste is a small fraction of municipal waste. There should be a greater concern on how much of the waste produced is actually contagious or unsafe. Infectious hospital waste represents only a small fraction of total medical waste. Mostly hazardous and infectious waste is coming from hospitals and clinical activities. Only small amount is coming from industrial and domestic sources. According to World Health Organization **(BAN & HCWH,**

1999) and **(WHO, 2002)** approximately 85% hospital wastes are non-hazardous in nature, 10% consist of infectious waste, and around 5% waste are non-infectious but come in hazardous category . In the U.S.A. for example, about 15% of medical waste are regulated as infectious category. According to **Agarwal, 1998** in Pakistan about 20% of hospital waste is found to be potentially hazardous. By **Akter et al., 1999** around 200 metric tons of hospital wastes are generated daily in Dhaka city and in Bangladesh. Of this amount around 20% is infectious and hazardous waste. The total waste generation in Dhaka city is 3500 metric tons for every day from which only 5.7 % comes from medical organizations **(Asaduzzaman & Hye, 1997)**. The quantity of BMW generated will vary, depending on the hospital policies, practices and the type of care being provided. In India this range could vary from 15% to 30% depending on the total corpus of waste produced **(BAN & HCWH, 1999) (Anonymous, 1998; Chitnis et al., 2005; Glenn and Garwal, 1999).**

Figure-2.2: Composition of Biomedical waste



Acharya & Singh (2000) have given an estimated solid waste composition. According to **Agarwal et al. (2005)**, if general waste from wards of patients admitted for review & follow-up are excluded, the average waste generation amounts to 135.38 grams per patient per day. Table-2.3 shows the quantity, types and composition of waste.

Table-2.3: Quantity, types and composition of waste:

(i) Quantity of waste produced in different countries:	
Country	**Quantity (Kg/bed/day)**
U.S.A	4.5

Spain	3.0
France	2.5
U.K.	2.5
India	1.5
(ii) Type of waste:	
Hazardous waste	15%
(a) Hazardous and infectious	10%
(b) Hazardous but not infectious	05%
(iii) Composition of waste: (By weight)	
Plastic waste	14%
Combustible waste	63%
(a) Wet cellublostic solid	18%
(b) Dry cellublostic solid	45%
Non-Combustible waste	20%

Source: http://isebindia.com/95_99/99-07.2 html

The major components of total plastic wastes constitute cafeteria plastics, medical packaging, sharps, blood bags, I.V. bags and tubing. The major sources of plastic wastes generated by the hospitals were laboratory facilities, operating rooms, and cafeterias **(Lee, et al. 2002)**.

A number of factors contribute to the volume of HCW generated by health care facilities. These factors include size of health care facilities, management policy of waste, the degree of economic development of a country and the type of medical specialties practicing in a particular country **(Yimer, 2005).**

Since health care establishments differ in ways previously mentioned, including the size of medical staff and proportion of reusable items used in the establishment such a technique produces results relative to each healthcare establishment **(Tsakona et al., 2007)**.

An audit on Hospital waste is necessary to understand the types and volumes of HCW generated so that an appropriate HCW management policy can be formulated **(Chitnis et al.; 2005 and Almuneef & Memish, 2003).**

Public sector clinics in Gauteng produced hospital waste at a rate of 0.002 kg/patient/day to 0.5 kg/patient/day, while private sector clinics generated 0.06kg/patient/day to 0.48 kg/patient/day **(Dacel, 2000)**.

According to **Azage and Kumie (2010)** 25% of clinical waste produced in Pakistan is hazardous, 26.5% in Nigeria and 2-10% in other sub-Saharan African countries.

Manyele and Lyasenga (2010) state that urban health centers in Tanzania generate 50% of the country's clinical hazardous waste.

Sakar et al. (2006) identified higher clinics and diagnostic centers as being responsible for 36.03% of hazardous hospital waste produced in Bangladesh. Recording daily average production of hospital waste, including the specific amount produced per bed/day and factoring this amount in to relative mathematical equations is a major way of quantifying the amount of clinical waste produced in hospitals.

U.S. hospitals generate an estimated 6,670 tons of clinical waste per day **(Rutala and Mayhall, 1992).** 3.8 kg/bed/day in Portugal **(Alvim Ferraz et al., 2000)** and 1 kg/bed/day is generated in Thailand **(Kerdsuwan, 2000)**. It is important to bear in mind that only a fraction of healthcare institutions contribute to the aforementioned figures as data from private physicians, offices, dentists, veterinarians, medical clinics, laboratories, long-term health care facilities and free standing care blood banks are unreliable and often unavailable by **Rutala and Mayhall, 1992**.

Status of Biomedical Waste Management:

a. Lack of proper Biomedical Waste Management practices in different health care centers:

In all over the world, the management of hazardous wastes has received many much attention since the early1980s due to its toxicity and infectious nature. Hospitals and other healthcare facilities are responsible for the delivering the health care services to the patient. In the process of curing the disease of patient, healthcare waste is also generated. According to **WHO, 2000, Almuneef & Memish, 2003; Acharya & Meeta, 2000,** the incorrect management of healthcare waste can have direct impacts on the community, individuals working in hospitals and their natural environment.

b. Lack of Segregation Practices:

Segregation practice prevents infectious waste to get mixed with non- infectious waste. Lack of segregation techniques significantly increases the quantity of infectious hospital waste as mixing of infectious component with the general non-infectious waste, makes the entire waste potentially infectious. (Gupta and Boojh, 2006).

There is inadequate practice of segregation of the waste starting from generation to disposal as seen in hospitals of India. Even if the segregation of waste at the point of generation is effective, waste handlers or auxiliary staff is found mixing it together during at the time of its collection and results in loss of ultimate value of segregation. (Athavale and Dhumale, 2010).

c. Lack of Adequate Facilities:

Efforts to provide facilities for collection, storage, treatment and disposal of hospital wastes as well as appropriate techniques have so far been limited in India. To add adequate and requisite number of sanitary landfills is lacking in India. Therefore the medical waste are openly dumped in, into the open bins on the road sides or they are directly dumped into the water bodies through which severe disease causing agents are spread into the air, soil and water (Dwivedi et al. 2009).

Personnel of Health care centers including doctors, nurses and paramedical staffs are considered as guardians of the community. It is the duty of the entire health-care centers to ensure the speedy recovery of their patients by maintaining infection free and clean environment. Basic sanitation and cleanliness have always been a mandatory need in the health care establishments. Generally collection and disposal of biomedical waste are often ignored in those centers which are directly responsible for the spread of many contagious diseases in the general public and specifically among health care personnel (Shayamala, K. Mani, 2003).

Thorough segregation and temporal storage of clinical waste into its infectious and non-infectious components is an important process in any efficient common waste management effort. The process guarantees reduction in the amount of infectious waste requiring special treatment and curbs potential occupational and operational risks to health care employees and by extension, the general public. Despite these merits, the process of segregation is overwhelmed with challenges that are pretty obvious in health care settings in the developing world. (Patil and Shekdar, 2001) reported that lack of awareness and training in clinical waste segregation technique is the major reason for clinical waste being collected in mixed form in India.

Similar observations were reported by (Phengxay et al, 2005) in Lao PDR, (Mbongwe et al, 2008) in Botswana and (Bdour et al, 2006) in Jordan.

d. Treatment and disposal technologies:

In selecting clinical waste management technologies, the terms ‘treatment’ and ‘disposal’ are often wrongly used interchangeably. (Luttrell et al., 2003) clarify treatment as an alteration of a waste stream or contaminated site in order

to reduce, eliminate or immobilize hazardousconstituents, while disposal implies disregard for return and is thus considered to be permanent storage or release.

Pruss-Ustun et al. (2005) suggested that strategies such as education of HCWs on the risks and precautions, reduction of invasive procedures, use of safer devices, and procedure and management of exposures are available to prevent infections due to sharps injuries. According to the authors, efficient surveillance and monitor of occupational health hazards related to blood borne pathogens in the industrialized world help to reduce the risk of transmission. On the other hand the authors have noted that similar surveillance and monitoring systems are weak and dysfunctional or sometimes completely absent in developing countries.

Potential impacts (risks) associated with medical waste:

(i) Hazards related to infectious sharps:

If biomedical waste and their disposal is largely ignored, it will pose risk to workers and those human beings who, while handling them, come in contact with them. The pathologcal laboratories of medical centres examine blood, urine, stool and sputum. Infectious waste contains different types of microbes which are pathogenic in nature. The pathogenic microbes which are present in infectious waste may enter into the human body accidently through mucous membrane, cuts in the skin, a puncture or by inhalation and ingestion causing different kinds of fatal diseases.

There is strong evidence that the main concern about the infectious hospitals waste is the transmission of HIV-AIDS viruses and more often of hepatitis B virus (HBV) through the injuries caused by syringes and needles contaminated by HBV in human blood, **(WHO, 1999).**

Sharps may not only cause cuts and punctures but also infect the wounds they are contaminated with pathogenic microbes. So sharps are considered as a very harmful because this hazardous waste poses double risk of causing infections and injuries both. There is a risk of injuries related to medical waste handling and carrying by waste operators, workers and cleaners. Some of those examples are cut, injury, punctured wound , strain and sprain of the joint of limbs and backache due to handling of overloaded waste**. Akter et al. (1998)** reported that there were several incident of injuries due to exposure to medical wastes inside and outside the health care centers. Some of those are as follows:

- Injuries by needle may damage the body organs.
- Hands, legs or body became paralyzed by the injury of needles.
- Skin diseases in legs and hands or in whole body.
- Due to improper handling of sharps and broken glasses could produced injury resulting pus formation in the wounds.
- Ulcer in legs.

Talaat et al (2003) reported that of the 1485 Health care workers interviewed, 529 (35.6%) were exposed to at least one needle stick injury during the past 3 months with an estimated annual number of 4-9 needle sticks per worker.

As **BAN & HCWH (1999)**, sharps, which include needles and syringes, have the highest disease diffusion potential amongst all categories of hospital waste. Almost 80-85% of injuries related to sharps are caused between their usage and subsequent disposal. More than 20% of those who handle them encounter the stick injuries. The study also mentioned that injuries from needle-stick and sharps occur frequently in developing countries.

If the used syringes, needles and other sharps are not destroyed properly and are being recirculated in the market it will adversely affect the human and animal life. In the same way improper practices such as dumping of BMW in municipal dust bins and on open spaces leads to spread of diseases **(Sreelatha, 1999).**

Among health care centers particularly Nurses are at high risk of infection and injury from biomedical waste. The most common accident that takes place in health care establishments is needle stick injury **(NIOSH, 2000).**

(ii) Infectious medical waste risk:

Poor management of healthcare wastes in hospitals, nursing homes, clinics and other facilities adversely affects the public health and poses risks to health workers, waste handlers, haulers patients and general public etc **(Kishore and Ingle, 2004)**. When it burn it may lead to air pollution,

when it dump, the water and soil quality affected resulting the risk of life of living organisms. In addition, if waste is not managed properly, members of the poor family specially rag pickers may have an opportunity to collect disposable medical equipment for selling in the market (recycle) which are hazardous for human beings.Improper waste management can cause environmental pollution and multiplication of vectors like worms, insects and rodents which may lead to the transmission of diseases like cholera, typhoid, hepatitis and AIDS etc. consideration must be given to the impact on environment, especially to the risks of all type of pollution like air, water and soil etc.

According **(Abdulla et al., 2008) b**io medical wastes constitute a big portion of infectious wastes which are potentially hazardous in nature because they contain many pathogenic microbes. These pathogenic micro organisms are very dangerous and hazardous in nature because they may be resistant to treatment and have ability to cause many harmful diseases**.**

The bio medical waste generated from different health care centers and hospitals is now recognized as a very serious problem that may have detrimental effects either on the environment or on human beings through direct or indirect contact. Some of the health impacts generating from exposure to harmful hospital wastes include carcinogenic, mutagenic and tetragenogenic effects, respiratory damage, central nervous system effects, reproductive system damage and others **(Felicia, et al.,2008).**

Although there is no particular definition of 'hazardous wastes' has received wide acceptance, hazardous substances are considered to be those substances which are harmful to the health of humans, other organisms and the environment **(Kaseva and Mato, 1999).**

According to **(Kishore et al. 1999)** biomedical waste such as pathological waste, blood, blood products, tissues, swabs, disposable gloves, surgical dressing, and cotton soiled dressing from treatment sites and waste from operation theaters directly dumped without proper treatment, which posing a serious threats not only to hospital employees but also to the general public and their surrounding environment. Whoever coming in connection with biomedical waste is easily infected with the hazardous waste and may suffer with diseases like HIV/AIDS, Typhoid, Hepatitis B and Hepatitis C etc.

(i) Hazards related to pathological waste:

There are many diseases which are caused by injurious pathogens present in the contaminated hospital waste are as follows:

Table: Examples of infections that can be caused by hazardous medical waste

S. No.	**Types of infections/ Diseases**	**Causative agents**	**Transmission Vehicles**
1	Skin infections	Streptococcus spp.	Pus
2	Genital infections	Neisseria gonorrhoeae, herpesvirus	Genital secretions
3	Ocular infections	Herpesvirus	Eye secretions
4	Respiratory infections	Mycobacterium tuberculosis, measles virus, streptococcus pneumonia	Inhaled secretions saliva

5	Haemorrhagic fevers	RNA virus of Arena viridae Family	All bloody products and secretions
6	Anthrax	Bacillus anthracis	Skin secretions
7	Gastroenteric infections	Enterobacteria Example: Salmonella, Shigella spp., Vibrio cholerae, helmenths	Faeces vomit and from
8	AIDS	Human immune deficiency virus (HIV)	Blood and sexua Secretions
9	Meningitis	Neisseria meningitides	Cerebrospinal fluid
10	Hepatitis A	Hepatitis A virus	Faeces
11	Hepatitis B& C	Hepatitis B and C virus	Blood and body Fluids
12	Bacteraemia	Staphylococcus aureus, Enterobacter, Kiebsiella and streptococcus spp.	All bloody products and secretions
13	Candidaemia	Candida albicans	Blood
14	Dengue	Arboviruses	Aedes mosquito
15	Encephalitis	Enterovirus, Rabies virus, Polio virus and Measles virus	Human excreta, soiled linen
16	Tick-borne fever	Rickettsia	Ticks of caster bean tick (lxodes ricinus)
17	Tetanus	Clostridium tetani	Surgical blades
18	Louse born fever	Borrelia species (B. recurreltis)	Head lice
19	Girardiasis	Giardia lamblia	Human excreta

20	Cutaneous leishmaniasis/ Kala azar	Leishmania tropica/ Leishmania donovani	Sandfly
22	Malaria	Plasmodium	Mosquitoes.

Source: (Pruss et al; 1999; Saurabh and Sikka ; 2006)

(ii) Hazards related to pharmaceutical and chemical waste:

Many chemicals and pharmaceuticals used in health care centers are hazardous in nature for example, toxic, reactive, flammable, corrosive and explosives substances etc. These substances are commonly present in small quantities in medical waste. Larger quantities may be found when unwanted or outdated chemicals, disinfectants and pharmaceuticals products in the form of antibiotics, antiseptic and their derivatives etc. are disposed of in open dumping areas. The chemicals used for staining and preparation of slides and for the sterilization and cleaning of equipment are potentially harmful to the laboratory workers and to the environment. Most of the chemicals are poured down into the sink and drain off. Children, animals and the people all have the potential to come in contact with these chemicals. Some chemicals like methylene blue, phenol, xylene, chlorine, hydrochloric acid, and carbol fuschin are used in the laboratory analysis in which some have very hazardous effects **(Akter et al., 1998; modified form WHO, 1999).** They may cause intoxication, either by chronic or by acute exposure, injuries and burns. Insecure and unprotected land filling may pose health risk to inhabitants and people at the vicinity.

The dumping of untreated biomedical waste together with general waste in municipal bins may increase the possibility of survival of pathogens, which may lead to spreading an epidemics & increased incidence & prevalence of communicable diseases in the community.

(iii) Hazards related to genotoxic wastes:

Exposure to genotoxic substances in hospitals may also occur during the preparation of and treatment with particular chemicals and drugs. The main pathway of exposure are inhalation of dust and aerosols, absorption through the skin, ingestion of food accidentally contaminated with cytotoxic drugs, chemicals or waste and ingestion as a result of wrong practice such as mouth pipetting etc. Exposure may also occur through contact with the body fluids, blood and secretions of patients undergoing treatment. Some drugs are given in Table-2.5.

Table-2.5: Name of Cytotoxic drugs and their Nature

S.No.	Name of drugs	Nature of drugs
1	Vincristine, vinorebine, vindesine, Vinblastine	Vinca alkaloids and derivatives, Vesicant drugs

2	Streptozocin, Carmustine,, melphalan cyclophosphamide, ifosfamide , thiotepa, dacarbazine. Mitomycin, Chlormethine, aclarubicin, cisplatin.	**Alkylating agents (i)**Irritant drugs **(ii)**Vesicant drugs
3	Mitoxantrone. Amsacrine, doxorubicin, daunorubicin, dactinomycin.	**Intercalating agents** Irritant drugs Vesicant drugs

(iv) Hazards related to radioactive waste:

The diseases which are caused by radioactive waste are determined by the type and extent of exposure of radioactive elements. It can cause headache, dizziness, nausea, vomiting and much more serious problems and finally resulting in death. Radioactive waste are genotoxic in nature and may cause serious injuries such as damaging the tissues and necessitating amputation of body parts and should, therefore, require utmost care. Healthcare workers and waste cleaning helpers exposed to this radioactive waste are at the risk of acquiring many fatal diseases e.g. Benign and malignant cancer.

(b) Environmental hazards related to medical waste:

The improper management in health care waste causes severe environmental problems that causes air, water and soil pollution. There are several legislations and guidelines in India concerning environmental troubles, which can be addressed. Some of the effects of pollution on air, water and land hazards are discussed (Sadhu and Singh, 2003).The following are environmental impacts associated with the improper disposal of medical wastes:

(i) Air Pollution:

Air pollution can be contaminating both indoors and outdoors atmosphere. Biomedical waste which can be generated by air pollution has been classified into three categories namely-Biological, Chemical and radioactive **(http: //kspcb. kar.nic.in/BMW).**

- **In-door air pollution:**
Pathogens present in the biomedical waste can enter and remain in the atmosphere for a long period of time in the form of spores. Segregation of waste at source can reduce this problem to a great extent. Sterilization of rooms will help in checking the indoor air pollution problem **(Askarian et al 2004b; Baveja et al. 2000)**. The indoor air pollution caused due to the chemicals from poor ventilation can cause Sick Building Syndrome (SBS) problems. So over use of chemicals should be avoided and used as per prescribed norms **(Bdour, 2004, Saurabh &Ram 2006)**.

- **Out-door air pollution:**
Outdoor air pollution can also be caused by pathogens. The biomedical waste without treatment if transported outside the health care institution and if dumped as it is in open areas, pathogens can go through into the atmosphere. Open burning and incineration of bio-medical waste is the most harmful practice and causing outdoor pollution. When inhaled these pollutants can cause respiratory problems. Some organic gases like furans and dioxins are carcinogenic in nature **(Burd, 2005)**. The design parameters, maintenance and disposal techniques of such treatment plants should be happened as per the prescribed standards **(Bdour, 2004)**.

- **Radioactive emissions:**
Research and radio-immunoassay actions may produce small amount of radioactive gases. These radioactive gaseous materials released out directly to the outside. The

use of treatment devices required for maintenance which trap these pollutant gases **(Malviga, 1999)**.

(ii) Water Pollution:

The liquid medical waste reach into sewer system can cause water pollution if they are not treated properly **(Rao & Garg, 1994)**. Water pollution can change the parameters such as: pH, BOD, DO, COD, etc. prescribed by pollution control board. There are some instances where dioxins are reported from water systems near incinerator plants. Dioxins can also enter into the water body from the air **(Chitnis et al, 2000; Ravikant et al, 2002; Saini & Dadhwal 1995).**

- **Radioactive effluent:**

Radioactive waste in form of liquid can come from chemical or biological research activities like from patient's urine and from scintillation liquids used in radioimmunoassay, from body organ imaging and from decontamination of radioactive spills **(Patil & Pokhrel, 2004; Shah et al., 2001).**

(iii) Land Pollution:

Soil pollution from bio-medical waste is caused due to disposal of discarded medicines, infectious waste, chemicals used and waste generated in treatment processes. Medical waste which consist of heavy metals such as lead, mercury and cadmium etc., will get absorbed by the plants and can enter into the food chain. Some effects of biomedical waste disposal on land surface are:

- The dusts particles blown by wind which are produced by indiscriminately dumping of hospital waste have the potential to carry hazardous particulate matter.
- Pathogenic microbes may lead to long term accumulation of toxic chemicals which reduce the fertility of soil.
- Indiscriminate and repeated application of chemicals over a long period of time can pose adverse effects on microbial population of soil, reducing the rate of decomposition and generally decrease the fertility of soil.
- If plastic containers, plastic bags and other materials used in disposal techniques are not properly destroyed they may contaminate the soil and also reduce the chance for percolation activity of soil during precipitation time.
- Pollutants like heavy metals and PCBs are persistent in the nature produced by improper disposal of bio medical waste.
- 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 bio medical wastes.

(c) Ecological Disturbance:

- Accumulation of toxic chemical in the soil, agricultural fields, in soil organisms and in wildlife etc.
- With domestic animals being allowed to graze in open dumps, there is the additional risk of reintroducing pathogenic organisms into the food chain of human beings **(Mehta, 1998)**.
- Bio accumulation of toxic chemicals in the fatty tissues of the organisms and it becomes bio magnify through food chains.
- Improper dumping of medical waste producing nuisance like odor, block the path way, scenic view and aesthetic sites.

So, from the above discussion it is clear that the accumulation of huge amount of biomedical waste generates quite serious health hazards that no hospitals worth its name can afford to ignore **(Silva et al 2005)**. Thus every hospital should evolve proper management techniques for biomedical waste disposal with the aim of protecting environment and human health from biomedical waste hazard **(GOI notified the management and Handling Rules in 1998).**

Disposal of harmful medical waste requires special attention since this can create major health hazards. Blood, skin, respiratory and eye infections could spread due to spread of contagious medical waste. Different diseases that results from the bites of animals feeding on the waste also occurs in rag pickers eg: rabies. Intestinal infections that are transmitted by flies feeding on the waste may occur among rag pickers eg: Anchylostores infestation, Amaebiasis, girardeasis etc. through sole Anchylostorres may enters into the body causing anemia among rag pickers. Infecting wounds resulting from contact with sharp objects also

observed among peoples **(Al-Khatib, 2006).**

Research gaps identified in the proposed field of investigation:

Until at present time medical waste in Udaipur was not segregated before disposal at the dumping site or at the time of incineration. Traditionally, recycling in Udaipur is conducted from the dumping grounds of large amount of waste, where rag pickers scour the waste manually and sort for recyclable material. These workers then contact relevance industries or place which acquire or take the waste from them. Most of these rag pickers belonging to low socio-economic level and whose level of awareness about the health risks by biomedical waste are poor. As a result many of them suffer with various diseases from syringes and needles and other biomedical waste. These biomedical waste is also create great health risk to the general population.

Bio-medical waste is one of the major environmental health concerns for the Udaipur city. A great majority of Udaipur hospitals not have policies and regulations governing the management of medical waste The present method of biomedical waste management are potentially hazardous and pose health risk to hospital workers, hospital sanitation workers, the general public, solid waste handlers and the environment. The Udaipur city as a city is known for its "Lakes" and large numbers of tourists come in Udaipur and they are on high risk of viral, bacterial and protozoal infection rate and hence requires a greater urgency to ensure effective management of biomedical waste to contain the spreading of contagious diseases.

At the same time there is no study which has been conducted at private as well as government hospital simultaneously. The study will indicate the factors affecting biomedical waste disposal amongst health care employees in health care industry.

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Prof. Krishna Kant Dave[1] and Nalini K Bhatt[2]

[1]Director Academics, Pacific University, Udaipur. [2]Research Scholar, Pacific University, Udaipur