Chapter - I
Introduction to Bio Medical Waste
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1.1. Introduction

Twentieth century is a century of the greatest phenomenon in terms of growth and development of human existence at an accelerated rate of change. Intellect and technology could contribute to the immense change in terms of materialistic wellbeing, economic growth, education, healthcare etc. At the same time, the same phenomenon could contribute to over exploitation of resources, pollution, population explosion, ecological imbalance, conflict and warfare with sophisticated technology, disease and distress.

Healthcare is an important area of human care. The very process of modern healthcare is also ridden with risk and unhealthy practices. One of this is Bio Medical Waste generation in treatment of human beings; apart from other species. This Bio Medical Waste generation warrants proper Bio Medical Waste management.

Bio Medical Waste is defined as waste that is generated during the diagnosis, treatment or immunization of human beings and is contaminated with patients body fluids such as syringes, needles, dressings, disposables, plastics and microbiological wastes.

Proper disposal of hospital waste is of paramount importance because of its infectious and hazardous characteristics. Therefore the Government of India promulgated the Bio Medical Waste Rules in 1998 and it became mandatory for all the hospitals to follow the above rules and the standards laid down under the statutory regulations. Healthcare is vital and hospitals are considered to be healers and protectors of health and wellbeing. But the waste generated from treatment and diagnosis can be hazardous, toxic and even lethal because of their high potential for disease transmission. The hazardous and toxic materials of health care waste comprise of infectious waste, radioactive material waste and sharp wastes like scalpels, knifes, needles and blades etc. (Keene, 1991). These materials constitute a grave risk, if these are not properly treated / disposed or allowed into the natural environment through Municipal waste. It encourages growth of various pathogens and vectors, as a result, non-hazardous and non toxic Municipal waste becomes toxic and hazardous and also jeopardizes the efforts undertaken for overall Municipal waste management.
Healthcare waste handling workers and rag pickers, besides public, are often knowingly or unknowingly are the worst affected, as they rummage through all types of toxic material while trying to segregate items which they can sell for reuse (Neveu and Matus, 2007). However, this kind of illegal and unethical segregation for reuse can be extremely dangerous and sometimes proved to be fatal for the biotic and abiotic environment. Opportunistic infections like AIDS (HIV), Hepatitis B, Tuberculosis and Cholera would prevail as a result of unplanned disposal of healthcare waste among healthcare workers as well as public (Yoshikawa et al., 2013 and 2007, Fitzsimons et al., 2008). The health risk for occupational employees and public can be considerably reduced with judicious planning and management. Previous research reports clearly indicate that about three fourths of the total waste generated in healthcare establishments is non-hazardous and non-toxic, rest is infectious and hazardous. Therefore rigorous regime of segregation of hazardous waste at source is essential to reduce health risk.

Similarly, better planning and management will reduce the overall expenditure on waste management. Institutional set up, training and motivation are given great importance these days. However, proper training of healthcare establishment personnel at all levels coupled with sustained motivation can improve the waste management considerably.

The rules framed by the Ministry of Environment and Forests (MOEF), Government of India, known as Bio-medical waste (Management and Handling) Rules, 1998, notified on 20th July 1998, provide uniform guidelines and code of practice for the whole nation. It is clearly mentioned in this rule that the occupier (a person who has control over the concerned institution) of an institution (e.g., hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank etc.,) generating Bio Medical Waste shall be responsible for taking necessary steps to ensure that such waste is handled without any adverse effect to human health and the environment.

I.2. Categories of Bio Medical Waste as per EPA, USA

In November, 1988, the U.S. Congress enacted the Medical Tracking Act, requesting EPA (Environmental Protection Agency) to establish a demonstration program to track medical waste and provide information to Congress on Medical Waste Tracking Act. Subsequently, EPA has categorized medical waste subject to the demonstration
program. EPA listed seven categories of medical waste which were designated as regulated medical waste. Recently EPA reexamined the list of regulated medical waste to determine if the list accurately identifies waste types or categorizes that pose a significant potential risk to human health or the environment. As a result of this assessment, EPA is also considering two new waste types on the basis of their potential hazards. These waste types are (i) Cytotoxic Wastes and (ii) Low Level Radioactive Wastes (Fed Regist, 1981).

1.2.1. Cytotoxic Wastes

Seven cytotoxic drugs are listed as hazardous under the resource conservation and Recovery Act due to toxicity and ability to cause mutagenic and teratogenic effects when discarded or spilled. These include Melphalin, Streptozotocin, Uracil, Mustard, Daunomycin, Chlorambucil, Mitomycin C and Cyclophosphamide. Cytotoxic drugs are considered hazardous when discarded or spilled. However, there are many cytotoxic drugs that were approved by the Food and Drug Administration which are similar in structure and mechanism to those listed as hazardous wastes (Sharma et al., 2013).

1.2.2. Low Level Radioactive Wastes

Wastes containing low level radiation from medical procedures to visualize and monitor the function of animal and human body organs and systems and to treat conditions or diseases requiring the destruction of diseased or malfunctioning cells, tissues or organs are called low level radioactive wastes. For example X-ray units, CT Scans and MRI Scans emit radioactivity and after usage, the materials are to be disposed properly to avoid radiation disasters to the biotic environment. The disposal must be monitored by trained employees who are certified and undergone training in Nuclear Sciences (Saad, 2013).

1.2.3. Regulated Medical Waste

Regulated Medical Waste means a special category of solid waste that includes specific types of medical waste subject to handling and tracking requirements. As per EPA regulated medical waste is any waste, as defined in these regulations, generated in the diagnosis, treatment, or immunization of human beings or animals, in research pertaining thereto, or in the preparation of human remains for burial or cremation, or in the
production or testing of biologica ls, or in the development of pharmaceuticals. Regulated medical wastes mixed with nonhazardous solid wastes must be considered as regulated medical wastes. The following are categories of Regulated Medical Waste:

- Cultures and stocks of infectious agents and associated biologicals.
- Pathological wastes including tissues, organs, and body parts that are removed during surgery or autopsy, or other medical procedures.
- Human blood, body fluids and blood products.
- Sharps.
- Animal waste.
- Isolation wastes including biological waste and discarded materials contaminated with blood, excretion, exudates or secretions from humans who are isolated to protect others from certain highly communicable diseases or isolated animals known to be infected with highly communicable diseases.
- Spill/cleanup material including any material collected during or resulting from the cleanup of a spill of regulated medical waste.

I.3. Categories of Healthcare Waste as per the Ministry of Environment & Forests, India

Environment (Protection) Act, 1986 (29 of 1986) was published in the Gazette vide S.O. 746 (E) dated 16 October, 1997 inviting objections from the public within 60 days from the date of the publication of the said notification on the Bio-Medical Waste (Management and Handling) Rules, 1998, and whereas all objections received in time were duly considered. Now, therefore, in exercise of the powers conferred by section 6, 8 and 25 of the Environment (Protection) Act, 1986 the Central Government notified the rules for the Management and Handling of Bio Medical Waste. As per schedule 1, Rule: 5, categories of Bio Medical Waste are as follows:

The ten categories of BMW generated in the process of treating human beings are to be managed properly by handling them in specified ways to be treated technically and scientifically and to be safely disposed (Table I.1 & Fig I.1.).
<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Categories</th>
<th>Waste Type</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Category - 1</td>
<td><strong>Human Anatomical Waste:</strong> (Human tissues, organs, body parts)</td>
<td>Incineration or Deep burial</td>
</tr>
<tr>
<td>2</td>
<td>Category - 2</td>
<td><strong>Animal Waste:</strong> (Animal tissues, organs, body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals colleges, discharge from hospitals, animals)</td>
<td>Incineration or Deep burial</td>
</tr>
<tr>
<td>3</td>
<td>Category - 3</td>
<td><strong>Microbiology &amp; Biotechnology Waste:</strong> (Wastes from laboratory cultures, Stocks or Specimens of micro organisms live or Attenuated Vaccines. Human and animal cell cultures used in research and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used for transfer of cultures)</td>
<td>Local Autoclaving, Microwaving and Incineration</td>
</tr>
<tr>
<td>4</td>
<td>Category - 4</td>
<td><strong>Waste Sharps:</strong> (Needles, Syringes, Scalpels, Blades, Glass, etc. that may cause puncture and cuts. This includes both used and unused Sharps)</td>
<td>Chemical Treatment, Autoclaving/ Micro- waving and Shredding</td>
</tr>
<tr>
<td>5</td>
<td>Category - 5</td>
<td><strong>Discarded Medicines and Cytotoxic drugs:</strong> (Wastes comprising of outdated, contaminated and discarded medicines)</td>
<td>Incineration or Destruction and Land filling.</td>
</tr>
<tr>
<td>6</td>
<td>Category - 6</td>
<td><strong>Solid Waste:</strong> (Items contaminated with blood and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood)</td>
<td>Incineration/ Microwaving/ Autoclaving</td>
</tr>
<tr>
<td>7</td>
<td>Category - 7</td>
<td><strong>Solid Waste:</strong> (Wastes generated from disposable items other than the waste sharps disinfection by chemical such as Tubing’s, Catheters, Intravenous sets etc).</td>
<td>Autoclaving/ Shredding</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Disposal Method</td>
<td></td>
</tr>
<tr>
<td>----------</td>
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</tr>
<tr>
<td>8</td>
<td><strong>Liquid Waste:</strong> (Waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities)</td>
<td>Local disinfection by Chemical Treatment and discharge into drains.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><strong>Incineration Ash:</strong> (Ash from incineration of any biomedical waste)</td>
<td>Disposal in Municipal landfill</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td><strong>Chemical Waste:</strong> (chemicals used in production of biologicals, chemicals used in insecticides, etc.)</td>
<td>Chemical Treatment or Disinfection and discharge liquids into drains and solids into secured landfills</td>
<td></td>
</tr>
</tbody>
</table>

1. Chemicals treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent must be ensured, so that chemical treatment ensures disinfection.

2. Shredding is to avoid or prevent unauthorized reuse.

3. Deep burial shall be an option available only in towns with population less than five lakhs and in rural areas.
Figure I.1: Prescribed Strategy for Management of Bio Medical Waste

(BIO MEDICAL WASTE SEGREGATION)

Categories of Bio Medical Waste

- Category No.1 Human Anatomical Waste
- Category No.2 Animal Waste
- Category No.3 Microbiology & Biotechnology waste
- Category No.4 Waste Sharps
- Category No.5 Discarded Medicines and Cytotoxic
- Category No.6 Solid Waste (Contaminated with blood and body
- Category No.7 Solid Waste (Tubings, catheters, intravenous sets etc.
- Category No.8 Liquid waste
- Category No.9 Incineration Ash
- Category No.10 Chemical Waste

Collection in Bags/Sewer

- Yellow Bag Cat.1, Cat.2, Cat.3, Cat.6
- Red Bag Cat.3, Cat.6, Cat.7
- Blue/White Translucent Bag Cat.4, Cat.7
- Black Bag Cat.5, Cat.9, Cat.10 (solid)

Treatment/ Disposal Options

- Incineration
- Deep burial
- Autoclaving
- Microwaving
- Chemical
- Shredding
- Secured Landfill
- Sewage/Effluent Treatment Plant

(Source: Surjit Singh Katoch, Investigation on Common Treatment Technologies for some BMW, Dept. of Chemical Engineering, Patiala)
I.4. Occupational Safety and Health Administration (OSHA)

The Occupational Safety and Health Administration (OSHA) Act (29 U.S.C. 651 et seq.) was enacted by Congress in 1970 in USA (OSHA Act, 1990). The intent as stated by the Act is to “assure safe and healthful working conditions for working men and women by authorizing enforcement of the standards developed under the Act, by assisting and encouraging the States in their efforts to assure safe and healthful conditions, by providing research, information, education and training in the field of occupational safety and health, and for other purposes”. The OSHA Act is implemented and enforced by OSHA of the U.S. Department of Labor and by States that have been authorized to conduct their own programs by OSHA.

The Occupational Safety and Health administration (OSHA) published its final rule on blood borne pathogen safety standards in the workplace on December 6, 1991 (U.S. Dept. of Labor, 1991). The rule entitled “Occupational Exposure to Blood borne Pathogens” was developed to protect healthcare and other workers exposed to blood on the job from blood borne infections. Such protection is based on the concept of universal precautions, defined by the rule as an approach to infection control. According to the concept of universal precautions, all human blood and certain human body fluids are treated as if known to be infectious for HIV, HBV and other blood borne pathogens”. OSHA determined that occupational blood borne infection hazards can be reduced substantially by adhering to a combination of engineering and workplace practice controls, use of personal protective clothing and equipment, employee training, medical surveillance and hepatitis B vaccination, signs and labeling systems and other control measures (Okulicz et.al., 2013). In writing the rule, OSHA directly addressed how infectious waste should be defined and managed to protect workers from exposure to blood borne pathogens.

I.5. Management of Hospital Waste and Short Comings in India

Hospital is a place where curative and palliative treatment is given to the patient. Treatment is technically called therapy and different types of therapies like Chemotherapy, Hydrotherapy, Vitamin therapy, Radiation therapy, Behavioral therapy and Physiotherapy
are given to the patient depending on the need. The modus operandi of the treatment depends on the physical, financial and emotional status of the patient and his/her relatives. Although these various methods of treatments give physical and emotional solace to the patient, they generate tremendous quantities of Hazardous Wastes which in turn damage the public health (Paudel and Pradhan, 2010). Many hospitals throughout the length and breadth of India treat their patients scientifically and effectively but they fail to give proper treatment to the wastes generated due to therapeutic surgical and clinical processes in the hospitals.

Many hospitals are reluctant to establish the necessary infrastructure to manage the hospital wastes, because they feel that it is an unnecessary drain of their valuable financial resources. Due to all these factors health and disease coexist in the hospital wards especially in the developing countries like India. The health interests of the patients and the public have been made contradictory instead of complimentary by the present hospital managements. In ancient India all the drugs and medicines used were extracted from natural resources like plants and animals as a result they used to generate biodegradable and eco friendly by products. Surgeries were also very rare in ancient India, but modern India after the British rule experienced a phenomenal shift in the nature of drugs, medicines and other hospital materials that are used presently. Now a days, as the patients approach the doctors with multiple problems and diseases, prescriptions resemble monthly household grocery list. Due to this, after a little recovery from the ailment the patients are forced to discontinue the course of medicines prescribed by the doctor preserving the same for imaginary future use. This leads to the accumulation of outdated drugs. Total body check up, lipid profiles, ECG, Endoscopy, etc., have become status symbol for the present day patients as the expenses for all these tests are met by corporate companies and Governments in some States; employees are tempted to go for all these tests. Although it is not warranted, this tendency leads to the generation of disposable laboratory wastes along with infectious wastes.

The replacement of traditional systems of medicines like Homeopathy, Ayurveda, Siddha, Unani, Chinese systems, etc., with Allopathy is one of the major reasons for accumulation of medicinal wastes in the form of outdated drugs. Increased percentage of
accidents, murders and suicides also adds to the bulk of hospital wastes generated due to the studies based on autopsy.

Unlike Municipal wastes, hospital wastes are hazardous due to their inherent potential to spread infections among the public which in turn affect the physical, psychological and economic well being of an individual. Health profile of the society can be worst hit due to the increased accumulation of hospital wastes. If these hospital wastes are not properly treated, Indian hospitals continue to be the breeding places for various disease causing organisms. Due to population explosion the threats posed by these hospital wastes have reached gigantic proportions. India, being a developing country, has to take appropriate steps to manage Bio Medical Waste to avoid health hazards of the people and environment.

As the Indian constitution happens to be the paradise of lawyers and politicians the corporate hospitals which normally violate the environmental laws in managing the hospital wastes often escape stringent punishment. This has invariably weakened the spirit of environmental awareness in India.

As the health care units in India function under different heads at different places the Indian government has failed to evolve a centralized plan that can be effectively implemented by the Government, corporate, urban, rural, hospitals and diagnostic centers. The nature of hospital wastes generated in rural and urban areas is also diverse and it is a greater hindrance to design a common plan for the disposal of these wastes.

Health information statistics reveal that 20% of total beds are in rural hospitals and 80% are in urban hospitals. The average quantity of hospital waste generated is estimated to range between 0.5 and 2.0Kg/bed/day (Patil and Pokhrel, 2005). Hospital waste generated in India is estimated to be around 0.33 million tons annually. But it is very difficult to estimate the exact quantity of wastes generated by the hospitals in India because many of the hospitals do not maintain any data pertaining to the generation of wastes. Although the waste generated by rural hospitals is far less when compared to urban hospitals this negligible quantity is sufficient to spread dreadful infections in villages due to poor sanitary conditions.
The quantity of hospital waste generated differs from one place to other depending on the ratio of in and out patients. Majority of corporate hospitals in India provide clinical services in the areas of General Medicine, Surgery, Orthopedics, Ophthalmology, Anesthesia and Radiotherapy along with non clinical services in the fields of Anatomy, Physiology, Pathology, Microbiology, Pharmacology, Biochemistry and Forensic Medicine (Alam, et al., 2008). Thus, major hospital whether in public or private sector has nearly 15 wards along with its own kitchen, mortuary, laundry and medical shops.

Until the breakdown of certain epidemics like Severe Acute Respiratory Syndrome worldwide, management of health care waste was not given proper attention in India. A writ petition, filed in the apex court regarding the issue of ‘improper hospital waste management’, forced the Government to frame Bio-Medical Waste Management and Handling rules in 1998 under the provision of Environment Act 1986.

1.6. Characteristics of Hospital Waste

Hospital wastes generated in Indian hospitals differ widely in their physical form, composition, reactivity, persistence, pathogen load, mobility and solubility. All these factors along with local conditions like temperature, humidity, ground water levels and soil texture determine the degree of hazard caused by different hospital wastes.

Highly toxic and mobile persistent wastes with greater potential for bio magnification are treated as high risk wastes. Metal hydroxide sludges are considered as intermediate risk wastes where as low hazard wastes are considered as low risk wastes.

Depending on the presence of infectious material, hospital wastes are categorized into infectious and non infectious wastes. Any hospital waste with potential Viral Bacterial and Parasitic load can be termed “Infectious waste”. The pathological wastes like organs, mutilated body parts, body fluids and tissue debris can be categorized as infectious waste. The wastes generated by kitchen laundry, canteen stores in the hospitals and food brought by the visitors are considered general wastes and these are treated on par with Municipal wastes. These general wastes are non-toxic. Hospital wastes generally contain 80-90% of nontoxic material (Orias and Perrodin, 2013). General wastes comprise paper containers, disposable coffee and tea cups, wrappers and left over food like slices of bread etc.
The wastes containing toxic chemicals, drugs and medicines due to their potential to damage public health are considered as hazardous wastes. Outdated drugs are the best examples of hazardous wastes (Saussereau et al., 2013). The bulk production of different drugs in the form of generics has contributed considerably to the accumulation of outdated drugs globally.

Wastes in the form of solids, liquids and gases contaminated with radio nuclides are categorized as radioactive wastes. The mushroom growth of X-ray centers and other radioactive based diagnostic centers have contributed much to the generation of radioactive wastes (Ravichandran et al., 2011).

Depending on the sharpness, the wastes are also classified as sharp and non sharp wastes. Sharp wastes like needles, scalpels are generally infectious. However in the Gazette of India published in 1998, the Ministry of Environment and Forests for the first time made an attempt to identify, classify the Bio Medical Wastes generated in all the health care units. They are: Human Anatomical Wastes, Animal wastes, Microbiology and Biological wastes, Waste sharps, Discarded medicines and Cytotoxic drugs, Soiled wastes, Solid wastes, Liquid wastes, Incineration ash and Chemical wastes.

The various types of waste differed and discussed are schematically presented in figure I.2. reflecting the process of healthcare waste management.
Fig I.2: Management of Health Care Waste in India

**Health Care Waste Management**

- **Infectious Waste**
  - Anatomical
  - Pathological
  - Animal
  - Sharps
  - Soiled

- **Hazardous Waste**
  - Chemical
  - Pharmaceutical
  - Infected Solid
  - Incineration ash
  - Radioactive*

- **Non-Infectious Waste**
  - Food
  - Packaging
  - General

- **Liquid Waste**
  - Treatment
  - Sewerage

**Source Separation:** Storage in Color coded Containers

**Destruction and Treatment**

**Disposal:** Incineration/microwaving/controlled landfill/deep burial

**Mixed with municipal solid waste for disposal**

**Disinfection**

**Mutilation of sharps and plastic disposables**

*Source: Patil and Shekdar (2001)*
1.7. Super Bug: A Threat to the Market of Medical Tourism

Hospitals and different health care units throughout the world have developed infinite potential to create heaven or hell by themselves on earth. In the three categories of wastes namely domestic, industrial and medical wastes, the last one poses the greatest threat to the society. The trans boundary movements of medical wastes across the countries due to increased medical tourism has changed the dimensions and definitions of hospital wastes. Due to increased cost of medical treatment especially in the field of cosmetic surgery and organ transplant, the patients of advanced countries are forced to come over to developing countries like India for medical treatment. India is one of the best places for the medical treatment or any other health care. Every year India is attracting thousands of visitors for medical checkups and other types of surgeries related to bone, liver and heart etc., when compared to developed countries, the quality treatment is available at lower cost in India. This type of medical tourism has become the main culprit in the generation of traditional and modern forms of hospital wastes. The wastes like anatomical, microbiological, cytotoxic and chemical wastes constitute the traditional forms of wastes. But the most modern forms of wastes in the hospitals have been generated in the form of super bugs according to Antibiotic Resistance Monitoring and Reference Laboratory. These super bugs generated in the health care units are now branded as hospital bugs (Collignon, 2013). The bacterium carrying several resistance genes to antibiotics is called Super Bug (Raich and Powell., 2013). Evolutionary stress might have led to the evolution of these super bugs. The excessive use and abuse of potential antibiotics is the main reason for the origin of these antibiotic resistant bugs through natural selection. Hospitals and their wastes have become the most resourceful breeding places for these super bugs which pose threat to immunosuppressive human beings like infants, old persons and surgically operated patients. Thus super bug has attained the status of potential crisis in hospitals and it throws the greatest challenge to hospital waste management (Velkov et al., 2013).

According to Langone Medical centre at New York University, 2.5 million super bug infections are recorded annually worldwide. The Centre for Disease Control and Prevention, USA, observes that Methecillin Resistant Staphylococcus Aureus (MRSA) is causing 19,000 deaths every year in the US (Klein et al., 2013). The death rate in the
MRSA infections is calculated to be 20%. After extensive studies the following eight categories of super bugs are found to be generated in the hospitals spread throughout the world. Methicillin Resistant Staphylococcus aureus, Vancomysin Resistant Enterococcus, Resistant Klebsiella Pneumonia, Resistant Pseudomonas aeruginosa, Resistant E.coli, Resistant Acinetobacterbaumannii and Clostridium difficile.

Many of these super bugs are resistant even to the most potent antibiotic like Carbapenem. It is recorded that Carbapenem Resistant Klebsiella Pneumonia (CRKP) was originated in 2006 in Israel hospitals and its presence is also reported in the health care units of Southern California.

India is not an exception to super bugs due to its enormous potential for medical tourism as well as improper Medical waste disposal practices. Recently, Lancet Medical Journal has reported the presence of super bug by name NDM1 that stands for New Delhi Metallo Beta Lactamase1 (Kanungo, 2010). This strain exhibits resistance to the most potent carbapenem. This hospital bug has dragged the attention of the world as it is found in the seepage and sewage waters in and around Delhi due to the leakage of hospital wastes into the water bodies (Mullot et al., 2010). This NDM1 belongs to gram negative type. As many antibiotics are designed to work on Gram positive bacteria, they do not work on NDM1. Thus, this super bug in Indian hospitals undoubtedly poses a threat to medical tourism which is one of the sources of foreign exchange. As per the news given by the economic times, in a couple of years the medical tourism market would cross Rs: 11,000/- crores in India. This is due to reliable and high quality treatment at low cost. The cost difference is 35% to 40% when compared to developed countries like USA. Recently Indian traditional Ayurvedic treatment is gaining importance and attracting large number of visitors especially to South India. In view of medical tourism it is of dire necessity to protect hospitals from superbug invasion.

Unfortunately India lacks appropriate technology to identify the presence of super bugs. Nearly 140 cases of NDM1 infections were recorded in India and Pakistan in the year (Nazir, 2012). Ironically this super bug is named after our capital only with the intention of damaging the medical tourism potential of India. But the market analysts are confident that Indian medical tourism will not be affected by this bug due to exorbitant
medical costs in foreign countries. Whatever may be the speculations, it is now obligatory on the part of Indian hospitals to include this super bug monitoring system as an integral part of hospital management due to its potential to damage the health profile of Indian society at large. This super bug is known to cause cholera and dysentery. As the waters of New Delhi are found to be contaminated with this super bug, the natives should be properly screened for its presence. The spreading of this super bug may be faster in India and China where antibiotics are often misused due to commercial reasons and also due to the indiscriminate disposal along with medical waste. The irreversible infection of this NDM1 may result in the increased mortality rate of the patients suffering from cholera and dysentery. Symptoms like urinary tract infection, nausea, high fever and hemoptysis may be seen in NDM1 infections which are also common to many other bacterial infections. Thus the persons infected with this NDM1 bacteria do not show any specific diagnostic symptoms from ordinary bacteria except the lack of response to antibiotics (Lee, et al., 2011). This NDM1 gene has also been found in multiple types of bacteria due to its enormous spreading potential. The hospital managements functioning in India should concentrate on the preventive and curative measures to inhibit the proliferation of NDM1 gene multiple types.

Thus the origin of this super bug although poses a great challenge, it can be properly tackled by scientific and systematic hospital waste management methods and new guidelines for the management and prevention of super bug are to be developed by the Ministry of Environment and Forest.

I.8. Nosocomial Infections due to Hospital Waste

Health-care waste management is an integral part of hospital hygiene and infection control (Ayliffe et al., 1992). Healthcare waste should be considered as a reservoir of pathogenic microorganisms, which can cause contamination and give rise to infection. If waste is inadequately managed, these microorganisms can be transmitted by direct contact, in the air, or by a variety of vectors. Infectious waste contributes in this way to the risk of nosocomial infections, putting the health of hospital persons, and patients, at risk (de Albuquerque et al., 2013).
Nosocomial infections known as hospital-acquired infections, hospital-associated infections and hospital infections are infections that are not present in the patient at the time of admission to hospital but develop during the course of the stay in the hospital (Chincha et al., 2013 and Kaye et al., 2014). There are two forms of nosocomial infections which are as follows:

1. Endogenous infection, self-infection, or auto-infection: The causative agent of the infection is present in the patient at the time of admission to hospital but there are no signs of infection. The infection develops during the stay in hospital as a result of the patient’s altered resistance (Hassane et al., 2012 and Hauck & Zhao, 2011).

2. Cross-contamination followed by cross-infection. During the stay in hospital the patient comes into contact with new infective agents, becomes contaminated, and subsequently develops an infection (Fleury-Souverain et al., 2013 and Pérez-Ayala et al., 2013).

While there is no clinically significant difference between the endogenous self-infection and the exogenous cross-infection, the distinction is important from the standpoint of epidemiology and prevention. Healthy people are naturally contaminated (Mayhall, 1996). Feces of human beings contain about $10^{13}$ bacteria per gram, and the number of microorganisms on skin varies between 100 and 10,000 per cm$^2$. Many species of microorganisms live on mucous membranes where they form a normal flora. None of these tissues, however, is infected. Microorganisms that penetrate the skin or the mucous membrane barrier reach subcutaneous tissue, muscles, bones, and body cavities (e.g. peritoneal cavity, pleural cavity, bladder), which are normally sterile (i.e. contain no detectable organisms). If a general or local reaction to this contamination develops, with clinical symptoms, there is an infection (Daschner, 1997).

Whether or not a tissue will develop an infection after contamination depends upon the interaction between the contaminating organisms and the host. Healthy individuals have a normal general resistance to infection. Patients with underlying disease, newborn babies, and the elderly have less resistance and will probably develop an infection after contamination. Health-care workers are thus less likely to become infected than patients (Wenzel, 1997). Local resistance of the tissue to infection also plays an important role, the
skin and the mucous membranes act as barriers in contact with the environment. Infection may follow when these barriers are breached. Local resistance may also be overcome by the long-term presence of an irritant, such as a cannula or catheter. The likelihood of infection increases daily in a patient with an indwelling catheter.

The most important determinants of infection, however, are the nature and number of the contaminating organisms. Microorganisms range from the completely innocuous to the extremely pathogenic: the former will never cause an infection, even in immune compromised individuals, while the latter will cause an infection in any case of contamination.

When only a few organisms are present on or in a tissue, an infection will not necessarily develop. However, when a critical number is exceeded, it is very likely that the tissue will become infected. For every type of microorganism, the minimal infective dose can be determined. This is the lowest number of bacteria, viruses, or fungi that cause the first clinical signs of infection in a healthy individual. For most causative agents of nosocomial infections, the minimal infective dose is relatively high. For Klebsiella and Serratia spp. and other Enterobacteriaceae, for example, it is more than 1,00,000, but for hepatitis B virus it is less than 10.

With nearly 100 million procedures performed at hospitals each year, litigation arising from nosocomial infections is increasing nationwide. These infections can be acquired in the hospital, nursing homes, rehabilitation centers, as well as extended care facilities. Immuno compromised patients, the elderly and young children are usually more susceptible than others. These infections are transmitted through direct contact from the hospital staff, inadequately sterilized instruments, aerosol droplets from other ill patients or even the food or water provided at hospitals. Besides, improper disposal of hospital waste, long time intervals for taking out the waste from hospital, spillages while transporting, etc., were shown as major causative factors for Nosocomial infections (Parker, 1978).

The most common pathogens that cause nosocomial infections are Staphylococcus aureus (Ruiz et al., 2014), Pseudomonas aeruginosa (Willmann et al., 2013), and E. coli (Beuk et al., 2013). Some of the common nosocomial infections are urinary tract infections, respiratory pneumonia, surgical site wound infections, bacteremia,
gastrointestinal and skin infections. Nosocomial infections are not just limited to bacteria; certain fungi such as Candida albicans and Aspergillus (Agbetile, 2013), as well as, viruses such as Respiratory Syncytial Virus (Jacobs et al., 2013) and influenza (Taylor et al., 2014) have also been implicated in a number of hospital acquired infections.

In the United States of America, the Centre for Disease Control and Prevention estimated roughly 1.7 million hospital-associated infections, from all types of microorganisms, including bacteria, cause or contribute to 99,000 deaths each year (Klevens, 2009). In Europe, where hospital surveys have been conducted, the category of Gram-negative infections are estimated to account for two-thirds of the 25,000 deaths each year. Nosocomial infections can cause severe pneumonia and infections of the urinary tract, bloodstream and other parts of the body (Simor et al., 2010). Many types are difficult to attack with antibiotics, and antibiotic resistance is spreading to Gram-negative bacteria that can infect people outside the hospital.

Among the categories of bacteria most known to infect patients are the category MRSA (resistant strain of *S. aureus*), member of Gram-positive bacteria and *Acinetobacter* (*A. baumannii*), which is Gram-negative. While antibiotic drugs to treat diseases caused by Gram-positive MRSA are available, few effective drugs are available for *Acinetobacter*. *Acinetobacter* bacteria are evolving and becoming immune to existing antibiotics, so in many cases, polymyxin-type antibacterials need to be used. "In many respects it’s far worse than MRSA," said a specialist at Case Western Reserve University.

Another growing disease, especially prevalent in New York City hospitals, is the drug-resistant, Gram-negative *Klebsiella pneumoniae*. An estimated more than 20% of the *Klebsiella* infections in Brooklyn hospitals "are now resistant to virtually all modern antibiotics, and those super germs are now spreading worldwide.

The bacteria, classified as Gram-negative because of their reaction to the Gram stain test, can cause severe pneumonia and infections of the urinary tract, bloodstream, and other parts of the body. Their cell structures make them more difficult to attack with antibiotics than Gram-positive organisms like MRSA. In some cases, antibiotic resistance is spreading to Gram-negative bacteria that can infect people outside the hospital. "For Gram-positives we need better drugs; for Gram-negatives we need any drugs," said Dr.
Brad Spellberg, an infectious-disease specialist at Harbor-UCLA Medical Center, and the author of *Rising Plague*, a book about drug-resistant pathogens. One-third of nosocomial infections are considered preventable. The CDC estimates that 2 million people in the United States are infected annually by hospital-acquired infections, resulting in 20,000 deaths (Ly et al., 2012). The most common nosocomial infections are of the urinary tract, surgical site and various pneumonias (Klevens *et al.*, 2007).

Two basic principles govern the main measures that should be taken in order to prevent the spread of nosocomial infections in health-care facilities:

1. Separate the infection source from the rest of the hospital
2. Cut off any route of transmission.

The separation of the source has to be interpreted in a broad sense. It includes not only the isolation of infected patients but also all aseptic techniques, the measures that are intended to act as a barrier between infected or potentially contaminated tissue and the environment, including other patients and persons. In recent years, increasing attention has been paid to the protection of the persons, in particular against the transmission of blood borne infections, e.g. AIDS and viral hepatitis B and C. Preventive measures are known as universal or standard precautions.

I.9. Hand Hygiene Methods to Control Nosocomial Infections

As the hands of hospital waste handling people and workers are the most frequent means of transport for Nosocomial infections, the hand hygiene methods like hand washing and had disinfection are essential and these act like primary preventive measures to stop the spread of infections (Salmon *et al.*, 2013). Thorough hand washing with adequate quantities of water and soap removes more than 90% of the transient, i.e. superficial, flora including all or most contaminants (Marra and Edmond, 2014). An antimicrobial soap will further reduce the transient flora, but only if used for several minutes. Hand washing with (non-medicated) soap is essential when hands are dirty and should be a routine after physical contact with a patient. Killing all transient flora with all contaminants within a short time (a few seconds) necessitates hygienic hand disinfection, where only alcohol or alcoholic preparations act sufficiently fast. Hands should be
disinfected with alcohol when an infected tissue, body fluid, hospital waste is touched without gloves (Duerink et al., 2013).

Hand washing frequently is called the single most important measure to reduce the risks of transmitting skin microorganisms from one person to another or from one site to another on the same patient. Washing hands as promptly and thoroughly as possible between patient contacts and after contact with blood, body fluids, secretions, excretions, and equipment or articles contaminated by them is an important component of infection control and isolation precautions. The spread of nosocomial infections, among immune compromised patients is connected with health care workers hand contamination in almost 40% of cases, and is a challenging problem in the modern hospitals (Cure et al., 2013).

The best way for workers to overcome this problem is conducting correct hand-hygiene procedures; this is why the World Health Organization (WHO) launched the Global Patient Safety Challenge in 2005. Two categories of micro-organisms can be present on health care workers hands: transient flora and resident flora. The first is represented by the micro-organisms taken by waste handling workers from the environment, and the bacteria in it are capable of surviving on the human skin and sometimes grow. The second group is represented by the permanent micro-organisms living on the skin surface. They are capable of surviving on the human skin and can grow freely on it. They have low pathogenicity and infection rate, and they create a kind of protection from the colonization from other more pathogenic bacteria (Salmon et al., 2013).

The skin of workers is colonized by $3.9 \times 10^4$ – $4.6 \times 10^6$ cfu/cm$^2$ microbes (Paulson et al., 1999). The microbes comprising the resident flora are: *Staphylococcus epidermidis*, *S. hominis*, and *Micrococcus*, *Propionibacterium*, *Corynebacterium*, *Dermobacterium*, and *Pitosporum* spp., while in the transitional could be found *S. aureus*, and *Klebsiella pneumoniae*, and *Acinetobacter*, *Enterobacter* and *Candida* spp. The goal of hand hygiene is to eliminate the transient flora with a careful and proper performance of hand washing, using different kinds of soap, (normal and antiseptic), and alcohol-based gels. The main problems found in the practice of hand hygiene are connected with the lack of available sinks and time-consuming performance of hand washing. An easy way to
resolve this problem could be the use of alcohol-based hand rubs, because of faster application compared to correct hand washing.

Although hand washing may seem like a simple process, it is often performed incorrectly. Healthcare settings must continuously remind practitioners and visitors on the proper procedure to comply with responsible hand washing. Simple programs such as Henry the Hand, and the use of hand washing signals can assist healthcare facilities in the prevention of nosocomial infections. All visitors must follow the same procedures as hospital staff to adequately control the spread of infections. Visitors and healthcare persons are equally to blame in transmitting infections. Moreover, multidrug-resistant infections can leave the hospital and become part of the community flora if steps are not taken to stop this transmission.

In addition to hand washing, Gloves play an important role in reducing the risks of transmission of microorganisms. Gloves are worn for three important reasons in hospitals. First, they are worn to provide a protective barrier and to prevent gross contamination of the hands when touching blood, body fluids, secretions, excretions, mucous membranes, and non intact skin. In the USA, the Occupational Safety and Health Administration has mandated wearing glove to reduce the risk of blood borne pathogen infections. Second, gloves are worn to reduce the likelihood microorganisms present on the hands of persons will be transmitted to patients during invasive or other patient-care procedures that involve touching a patient's mucous membranes and non intact skin. Third, they are worn to reduce the likelihood the hands of persons contaminated with micro-organisms from a patient can be transmitted to another patient. In this situation, gloves must be changed between patient contacts, and hands should be washed after gloves are removed.

Wearing gloves does not replace the need for hand washing, because gloves may have small, in apparent defects or may be torn during use, and hands can become contaminated during removal of gloves. Failure to change gloves between patient contacts is an infection control hazard. During a surgical intervention, a high proportion of gloves become perforated. Hands should therefore be disinfected with a long-acting disinfectant before gloves are put on. This will not only kill the entire transient flora, but will also prevent the microorganisms of the resident (or deeper) flora from taking the place of the
transient flora during the intervention. For this purpose, hands should be washed for 3-5 minutes with an antibacterial detergent containing chlorhexidine or an iodophore, or rubbed twice for 2 minutes with an alcoholic solution of one of these antiseptics to prevent hospital borne infections. In 1985, the Centre for Disease Control (CDC), USA, has published Guidelines for Hand washing and Hospital Environmental Control, which replaced all previously published hand washing and environmental control statement issues by CDC or the hospital infectious program, Centre for Infectious Diseases and CDC (Miller, et al., 2012 and Kalenić, 2011). The guidelines prescribed by CDC have a three-category ranking scheme for its recommendations which are now being followed by all hospitals (Garus-Pakowska, et al., 2013).

I.10. Health and Environmental Hazards due to Hospital Waste

The potential health hazards caused by hospital waste to an individual depends on various factors like dosage, age, gender, body mass index, emotional status, genetics, immunological status and prevailing climatic conditions following heat anomalies caused by hospital wastes were recorded (Bendjoudi, et al., 2009) as given below.

- Carcinogenesis: Dioxins and furans present in hospital wastes are proved to be carcinogenic. The animal carcasses containing heavy doses of diclofenac sodium is supposed to cause cancer but it is yet to be proved. Diclofenac sodium is a pain killer used to treat both animals and humans (Babich, 1985).

- Mutagenesis: Radioactive isotopes and other radioactive waves cause genetic defects in the persons who are exposed to this and these defects are heritable.

- Embryological abnormalities: Teratological abnormalities may be caused by the hospital wastes Containing pthalibdamide and radioactive materials.

- Immunological abnormalities: wastes containing the diseases of corticosteroids may suppress the immune system.

- Respiratory abnormalities: sprays of disinfectants carbon monoxide, aero pathogens cause respiratory disorders

- Nosocomial infections: Hospital wastes (especially) during improper burning may cause various infections like Tuberculosis, Pneumonia, tetanus, cholera, HIV,
Hepatitis. Clinical wastes generated in the hospitals have the potential to generate many blood borne, respiratory, enteric and epithelial infections.

The phosphorus residues present in the fecal matter of inpatients, if it is not properly disposed off by underground drainage system may enter into the surrounding water bodies like ponds and streams directly or indirectly through pigs due to their coprophagous lifestyle (Leduc-Souville, et al., 2013). In such cases the phosphorous excreted through the fecal matter of pig is quantitatively heavy due to bio magnification. Such residues of phosphorous that are washed off into the neighboring ponds may lead to Eutrophication (Sharma, et al., 2013).

In case of “shallow burial” of hospital wastes, the drums or plastic containers used for toxic hospital wastes disposal cause more damage to the environment more than the original wastes. Although closed landfills of hospital wastes prevent the contamination of neighboring water bodies due to their secluded nature they may lead to contamination of ground water due to infiltration of leachate (Lee, et al., 2010).

The wastes disposed in open landfills may get washed off along with rain water transporting wastes and their by products into surrounding water pools.

*Risk groups*: The risk groups with greater probability of exposure to hospital waste are as follows: Doctors/ Medical personnel, Nurses, Lab technicians, Patients, Visitors and Supporting staff of Waste handling workers, Waste pickers.

**I.11. Health Risk and Waste Management**

The total amount of medical wastes generated normally depends on the type and size of health care unit. Due to heterogeneity of health care units in India ranging from super specialty hospitals to small clinics in rural areas, stringent legal actions cannot be imposed on them uniformly due to social and economical constraints.

Although the hospital authorities who are the generators of wastes are now made accountable for the management of the same according to biomedical waste management rules 1998. These rules are not properly publicized, due to this many medical and paramedical staff are kept in ignorance regarding the implications of the rules and complications of mismanagement.
The documentation of wastes generated and disposed is not properly maintained by the hospitals due to their busy schedule. Lack of skilled persons at various levels of waste management like collection, segregation, transport and disposal is another major constraint to improve waste management techniques.

Both infectious and noninfectious categories of wastes are being generated by Indian hospitals in greater quantities but these are not properly segregated during collection, transport and disposal.

Even the infectious wastes in local hospitals are disposed without disinfection. The disposable needles in rural hospitals are disposed off without disinfection and crushing which are again packed and sold to Reserve Medical Practitioners for reuse in villages increasing the spread of infections.

Many waste pickers are illegally employed in India to collect the hospital wastes that are disposed off without any proper treatment for the purpose of reuse (Sharma, et al., 1995). This lucrative business has reached the dimensions of mafia in its market area (Gupta and Boojh, 2006). The researcher identified one such illegal waste collection scenario and indiscriminate disposal of BMW that became a roosting site for livestock which was presented in Fig. I.3 and I.4.

In many primary health centers due to lack of incinerators many infectious wastes are burnt in open air on any available waste land. Due to this unscientific disposal many visitors in due course get admitted in the same hospitals as patients. Hospital security in many hospitals failed miserably to prevent the entry of waste pickers to the disposal site.

Segregation of hospital wastes is not properly done in Indian hospitals. Due to incomplete segregation of the tissue and cellular debris, the occurrence of multiple diseases is on the rise. This improper segregation may also lead to incompatible and fatal combinations of various drugs and hospital chemicals which in turn affect the health profile of the surrounding area.

Many incinerators installed in Indian hospitals are not designed in and environment friendly manner and they lack pollution control devices leading to the formation of polycyclic hydrocarbons and dioxins. Although the guidelines issued by biomedical waste
management, clearly prohibit the incineration of any hospital waste disinfected with chlorinated disinfectant due to its potential to release furans and dioxins, it is not properly adhered to (Thacker, et al., 2013). Using of open carts for transporting the wastes is still practiced. Color coding of different hospital wastes during collection and transport is not properly done even today.

I.12. Good Waste Management Measures

Treatment of hospital wastes should be given equal priority along with the treatment of patients because the sustainable maintenance of the health of the patient and the public invariably depends on the efficacy of hospital waste management.

At the outset the hospital management should avoid the generation of waste material and if it is not possible it should at least aim at the minimization of hospital wastes. However negligible may be the quantity of waste generated, it should be properly recovered and recycled to reduce toxic nature.

Persistant toxic compounds should be treated effectively, when compared to non persistent toxic compounds as the effect of former category of wastes on the environment is long lasting the exposure pathways of these toxic compounds both outside and inside. The living systems should be properly identified and chalked out to minimize their impact at every possible step (Gautam, et al., 2010).

The hospitals located at river banks and seashore should follow more environmental friendly techniques to treat their wastes as these wastes if not properly managed enter into aquatic food chains and ultimately reach human being through different trophic levels. Thus damaging the total health pattern of those particular areas and ill-treated hospital wastes that are drained into the rivers pose greater damage to flora, fauna and human populations during floods specifically.

As the generation of hospital wastes is directly proportional to the population growth, the hospitals located at the areas with greater population whether floating or static should implement innovative technologies to manage the hospital wastes at each level. The nature of patients visiting the hospitals located at pilgrim centers and tourist spots differ both qualitatively and quantitatively.
Thus the hospital management strategies adopted at such areas should be highly specific with reference to time and space. Lapses may lead to outburst of epidemics, in such cases such hospitals should initially aim at waste volume reduction followed by waste segregation.

The documentation of wastes should be periodically done and the annual report pertaining to the generation and disposal of hospital wastes in form 11 should be submitted to the respective State Pollution Control Boards on or before 31st January every year as per the guidelines of biomedical paramedical and supporting staff regarding handling of hospital wastes laid down by CPCB, New Delhi.

Intramural and extramural transportation of wastes should be done in closed and locked carts to avoid spillage and leakage. The carts loaded with clinical wastes if left in corridors of the patient wards, spread infections rapidly to the inmates and visitors, such unscientific parking of carts should be strictly prohibited.

- Snapshot appraisal of bulk waste handling should be done by the Pollution Control Board authorities.
- Shifting from single usage pattern to multiple usage patterns also reduces the quantity of hospital wastes.
- The wastes should be collected in different containers coded with prescribed colors.
- Waste collection from the wards of dialysis and surgical operation should be carried out more than twice a day due to their heavy potential to generate bulk hospital waste.
- While packing the hospital wastes rodent proof containers should be used.
- Tips of sharps should be destroyed before incineration by shredding or crushing. Sharps should be transported to the incinerators site in puncture proof containers.
- Incinerated ash containing toxic chemicals should be properly collected and disposed for land filling.
- The bins used for storage should be sufficiently big and they should not be filled up to the brim at any point of time.
High quality incinerators should be installed in hospitals which can maintain the temperature of nearly 800 °c during incineration (Chavhan, et al., 2012), because it is proved that incinerators maintaining temperatures below 300°c emit more quantity of toxic gases into the environment (Singh, et al., 2007). According to Bio Medical Waste Management Rules, combustion efficiency of incinerators should be at least 99% to check the emission rates of furans and dioxins.

The waste handlers should be provided with masks and gloves which prevent their exposure to infectious agents. Any injury occurring to the waste handlers at work should be properly treated by the competent medical authority without delay.

Any infectious solid waste should not be stored more than 18 hrs off site.

Log book should be maintained at the sites of collection and incineration.

Waste pickers who illegally and unethically collect infectious material from hospital wastes should be provided with proper rehabilitation so that they can discontinue this unhealthy practice.

Cost effective and eco friendly methods like photochemical degradation can be adopted in rural hospitals for waste treatment. Centralized incinerators sites can be used by hospitals in area wise manner.

All said and done management of hospital wastes requires highly skilled personnel with greater environmental awareness and concern rather than sophisticated technology. If the short comings are properly met with the remedies suggested, hospitals can be in a position to extend their hospitality even to the general public. This type of scientific management of hospital wastes ensures the safety of the patient on specific and public at large.

I.13. Hospital Waste Handling Human Resources

For hospital waste handling, head of each hospital has to take authorization for generation of waste from appropriate authorities as notified by the concerned Government or State/U.T. of India, well in time and to get it renewed as per time schedule laid down in the rules prescribed by Ministry of Environment and Forests, India. Each hospital should
constitute a Hospital Waste Management Committee, Chaired by the Head of the Institute and having wide representation from all major Departments. This committee should be responsible for making hospital specific action plan for hospital waste management and its supervision, monitoring and implementation. The annual reports, accident reports, as required under BMW rules should be submitted to the concerned authorities as per BMW rules format given in their websites (Chethana, et al., 2013).

The smaller Nursing Homes and Clinics, which cannot make their own arrangements due to high costs involved in waste treatment facilities, require some alternative modalities. To solve the problems of Nursing homes/Clinics/Blood Banks/Diagnostic Laboratories etc., Government has taken initiatives to establish centralized waste treatment facilities. Keeping in view the difficulties faced by private hospitals/nursing homes in treatment of biomedical waste, the Government of India has set up Common Bio medical Waste treatment facilities allover India. This was started as an interim arrangement, later it has been centralized to entire India (Pant, 2012).

In Delhi there are 26 Hospitals under the Government control, out of which 11 are under DHS. Six hospitals are having Incinerators and nine hospitals are having Autoclaves and Shredders for Scientific Management of Bio-Medical Waste. Bio-Medical Waste from the Hospitals, where such facilities are not available are segregated and transported in special vans to Hospitals where such facilities exist. Under Biomedical Waste (Management & Handling) Rules 1998, all health care institutions are required to handle biomedical waste in a specified manner. Delhi is generating approximately 6000 metric tons of waste out of which 60 tons are Biomedical Waste. The Government hospitals and major private hospitals have their own arrangement for treatment of biomedical waste. Total no of beds in hospitals under Government of NCT of Delhi is 5641 (Verma, et al., 2008).

All the 26 Delhi Govt. hospitals and 167 Dispensaries under this Directorate have obtained authorization from DPCC under Bio-medical Waste (Management & Handling) Rules 1998.

The Government of the national capital and Union territory of Delhi had made adequate arrangements for meeting any contingencies arising out of the handling, treatment
and disposal of bio medical waste much before any other State Government could do. Funds were made available to the hospitals to procure incinerators, and state-of-the-art autoclaves and shredders were imported so that the prescribed methods of medical waste treatment under the law could be met. The vacuum type of autoclaves procured by Delhi Government are the best available anywhere. These are ideal to disinfect plastic, PVC and other categories of medical waste. Adequate funds have always been provided to all hospitals for purchasing accessories such as bags, trolleys and the disinfectants. So there should be no excuse for not properly disposing bio medical waste.

Delhi Government had signed a Memorandum Of Understanding (MOU) with the Government of Australia in 1998 to have experts visiting from that country for advising and assisting Delhi hospitals to learn and understand a variety of issues related to bio medical waste management. This collaborative programme resulted in developing training modules, which have been made available to all (Verma et al., 2008).

In India, hospitals and other health care establishments are not well equipped to handle the enormous amount of biomedical waste. There is an urgent need to raise the awareness amongst all concerned. Information can be disseminated through organizing seminars, workshops, practical demonstrations, group discussions, lectures etc. It is vital to formulate an effective education and training programs specific for different target groups involved in biomedical waste handling and management (Verma, 2010).

I.14. Hospital Waste and Pollution Management

Environmental pollution is now one of the major human concerns and medical wastes constitute an important component of environmental hazards. Apart from direct health risks to human health, it also possesses indirect threat to the environment due to its infectious and hazardous characteristics. In recent years the significance of proper medical waste management has also been felt in developing countries, but the progress in this field is still limited. This problem is now being intensified as Health Care Establishments (HCEs) such as hospitals, clinics and diagnostic centers are growing at a rapid pace (Singh, et al., 2004).

Hospital waste is a potential health hazard to the health care workers, public and flora and fauna of the Ecosystem. Hospital acquired infection, transfusion transmitted
diseases, rising incidence of Hepatitis B, and HIV, increasing land and water pollution lead to increasing possibility of catching many diseases. Air pollution due to emission of hazardous gases by incinerator such as Furan, Dioxin, Hydrochloric acid etc. have compelled the authorities to think seriously about hospital waste and the diseases transmitted through improper disposal of hospital waste (Kaiser, et al., 2001). This problem has now become a serious threat for the public health and ultimately the Central Government had to intervene for enforcing proper handling and disposal of hospital waste and an Act was passed in July 1996 and Bio Medical Waste (Handling and Management) Rule was introduced in 1998.

A modern hospital is a complex, multidisciplinary system which consumes thousands of items for delivery of medical care and is a part of physical environment. All these products consumed in the hospital leave some unusable leftovers i.e. hospital waste. The last century witnessed the rapid mushrooming of hospital in the public and private sector, dictated by the needs of expanding population. The advent and acceptance of “disposable” has made the generation of hospital waste a significant factor in current scenario.

According to a study by Waste Concern (2009) it was found that in 2008, there were about 590 Government hospitals, 1809 private hospitals and clinics and 1719 diagnostic laboratories in Bangladesh (Chowdhury, et al., 2011). Over the last ten years number of beds has increased from 38,108 to 69,313 having an increase of 31,205 beds recording annual growth of 8.18%. Considering this growth rate as base projection indicates that the hazardous waste generation would be 16,972 tons/year by 2013 and 21,681 tons/year by 2017 (Patwary, et al., 2009 & Varma, 2010).

Proper management of hospital waste is essential to maintain hygiene, aesthetics, cleanliness and control of environmental pollution. The hospital waste like body parts, organs, tissues, blood and body fluids along with soiled linen, cotton, bandage and plaster casts from infected and contaminated areas are very essential to be properly collected, segregated, stored, transported, treated and disposed of in safe manner to prevent nosocomial or hospital acquired infection.
Various communicable diseases, which spread through water, sweat, blood, body fluids and contaminated organs, are important to be prevented. The Bio Medical Waste scattered in and around the hospitals invites flies, insects, rodents, cats and dogs that are responsible for the spread of communication disease like plague and rabies. Rag pickers in the hospital, sorting out the garbage are at a risk of getting tetanus and HIV infections. The recycling of disposable syringes, needles, Intravenous sets and other article like glass bottles without proper sterilization are responsible for Hepatitis, HIV, and other viral diseases. It becomes primary responsibility of Health Administrators to manage hospital waste in very safe and eco-friendly manner.

With the proliferation of blood born diseases, more attention is being focused on the issue of infectious medical waste and its disposal. Health care institutions must be aware of the potential risk in handling infectious waste, and adhere to the highest standard of transport & disposal. Education of the staff, patients and community about the management of the infectious waste is crucial in today’s health care arena (Abdulla, et al., 2008).

At present, in India, there is no proper or systematic management of medical waste except in some specialized private HCFs that segregate their infectious wastes. Some cleaners were found to salvage used sharps, saline bags, blood bags and test tubes for resale or reuse. Moreover, proper care is not being taken in collecting, handling, separating, carrying, storing and disposing of hospital waste by the workers, who are thus exposed to a wide range of hazards.

No proper segregation has been practiced in majority of hospitals where non hazardous waste is treated as general solid waste (Gupta and Boojh, 2006). This large portion of non-hazardous waste is mixed up with hazardous waste due to lack of segregation. Besides, there is no separate collection bin for hospital waste and all kinds of waste from hospitals including clinical and sharp wastes, is dumped in the Municipal waste collection bins. This ill practice creates the possibility of contamination of whole mass of solid waste by infectious hospital waste. To make the matter worse, poor scavengers, rummage through the pile, earnestly searching for saleable items like syringes needles, saline drips, discarded food, gauze, vials, and ampoules. These are collected, washed,
repacked and resold to the public despite of the deadly health risks. Thus, the vicious cycle of transmission continues.

A study conducted by the Central Pollution Control Board (CPCB), New Delhi, an apex pollution monitoring body of Government of India, on incinerators in Delhi Hospitals, concluded that the incinerators were found to spew a high level of deadly residues and toxic emissions such as cancer-causing dioxins and furans besides chemicals which cause neonatal abnormalities, reproductive and skin disorders, endocrine disruption and suppression of the immune system (Patil et al., 2005).

The environmental hazards due to medical wastes are even more deleterious. The accumulation of toxic waste within soil will have serious adverse effects on soil microbial population, reducing the rate of decomposition, and generally lowering the soil fertility. This leads to ground water contamination by infiltration and also there is an added risk of reintroducing pathogenic micro-organisms into the food chain. There is an urgent need for raising awareness and education on medical waste issue as well as establishing proper guidelines and training facilities on the disposal of medical wastes to save our health and surrounding environment.
Fig I.3. Illegal segregation of BMW at Disposal site

Fig I.4. Indiscriminate Disposal of BMW that became Feeding ground for Live Stock


18. Fitz Simons D, Francois G, De Carli G, Shouval D, Pruss-Ustun A. ‘Hepatitis B virus, Hepatitis C virus and other blood borne infections in healthcare workers:


