The occurrence of E.coli in water and soil sediments is novel in the sense that the organism is found in faecally contaminated water and its presence in soil sediment too is reported by few researchers. Erning et al. (2011) in their study of quality of underground water in Benin found E.coli to be the major contaminants at abnormal levels. There have been reported cases of waterborne enteric diseases as reported in the findings of Tulchinsky et al. (2000) and Huerta et al. (2000).

Pseudomonas species which was isolated from soil nearby foma river has been implicated as health risks in water for human consumption as supported by the finding of De-Victoria and Galvan (2001).

CHAPTER-5

MANAGEMENT TECHNIQUES OF BIOMEDICAL WASTE

For a long time, health care services have been rendered without taking into consideration the impact, that waste can have on the environment and public health. The responsibility is on health care workers to apply the principle of caring, by ensuring proper disposal of health care waste.

Research in other parts of the world has demonstrated that improving the standard of health care waste management is practical and economically efficient (Jameton & Pierce, 2001).

The basic reasons for indiscriminate management and handling of biomedical waste can be outlined as follows:-

- The main issue is the lack of priority in policy and funds on biomedical waste management.
• Lack of training and managerial skill of staff for dealing with management of bio medical waste.

• Lack of appropriate technologies for storage, treatment and disposal of bio medical waste.

• Lack of awareness about adverse effects of biomedical waste among medical staff, patients, attendants and in general public.

• Lack of coordination among hospital management, municipality, state and central pollution board and hospital authorities.

• Majority of the municipal authorities, not just in our state but also in other states of the country, has not taken biomedical waste management as their agenda.

• The implementation status of management & handling of biomedical waste rule is also unsatisfactory.

• Lack of accountability of person involved in the management of bio-medical waste.

At present, most of the health care centres dispose their biomedical waste directly in the open areas which causes many threats to the environment and the human beings. Some time they burnt their waste in open air.

5.1. Some Possible Management techniques for Biomedical waste:

• All the needle sharps should be mutilated and discarded in puncture proof containers, which should be handed over to common central biomedical waste management facility. In absence of common treatment facility, the sharps could be disposed in metal container,
which can be disinfected in oven and in autoclave and finally sent to secured landfill.

- All the health care units generating biomedical waste shall strictly ensure segregation techniques, color coding system and other provisions related to biomedical waste (Management and Handling) rules, 1998 and amendment thereof.

**Figure: 5.1: Different colored bins for different types of waste**

- The autoclavable plastics, glass equipments like petriplates and petridishes or after disinfection it can be reused after washing. The disinfected plastic waste material could be shredded and then passed on for plastic recycling. For the fear of the reuse or its unauthorized usage, the mutilation or shredding of glass equipments is also suggested in the biomedical waste management rules. However shredding glass bottles results into sharp that are likely to be hazardous while storage, collection and handling. Hence, we feel that
the contaminated glass bottles could be disinfected but mechanical crushing could be avoided before sending for recycling (Pruss; et al, 1999).

- Incinerators, which do not confirm to the design and emission norms as per rules, must be modified and air pollution controlled system may be retrofitted to minimize the emission level. Proper working of operators and management of incinerators through attainment of required temperature in both the chamber should be ensured. Regular operation of the incinerator, proper maintenance and storage of the waste in separated area should be undertaken.

- Use of plasma pyrolysis technique: It is an eco-friendly technology, which converts organic waste into commercially useful products. The intense heat generated by the plasma enables it to dispose all the types of waste including biomedical waste, municipal waste, and hazardous waste in a safe manner. Through pyrolysis, Medical waste is converted into CO, H₂, and HCs when it comes in contact with plastic arc, these gases are burned and produce a high temperature which of about 1200°C.

- Cooperation of municipal party: State and the central government need to become and construct centralized facilities for recycling, treatment and disposal of biomedical waste. Large scale enterprises should be encouraged to recycle, treat and dispose waste by means of centralized facilities and to have extra capacities available in reasonable and minimal fee.
• Common Biomedical waste Treatment Facility (CBWTF) is set up in every city.

• Medical waste poses adverse impact on human health and their environment. Proper medical waste disposal and management is also inadequate. However, from this study it can be said that there is an urgent need for raising awareness and education on medical waste issue. Proper waste management strategy is needed to ensure health and environment safety. A policy needs to be formulated to reduce, recover, reuse and disposal technology. The study concludes that the health care waste management should go beyond complication, enforcement of regulation and acquisition of better equipment. It should be supported through appropriate training, education and commitment of health care staff, management and healthcare managers within an effective policy and legislative frame work.

5.2: Environmental management strategies for disposal of biomedical waste:

   The Management of Biomedical Pollutants: The systematic management of biomedical waste can be described as a multistage process that include minimization, training, effective legislation, proper handling techniques like collection, segregation, storage, transportation, treatment and finally safe disposal  (Rao et al., 2003), (WHO, 2007), (Soncuya, Matias & Lapid, 1997) and (Pruss, et al., 1999).

5.3. Safety measures involved in biomedical waste management:
• All the producers of biomedical waste should adopt universal precautions and appropriate safety measures while doing diagnostic, treatment, therapeutic activities and handling of the bio-medical waste.
• Providing protective wears like gloves and apron and instructions regarding handling the waste are given by the health Care centres (Fig-5.2).

Figure: 5.2: Chart shows the protective wears used at the time of patient care

It should be ensured that collectors, drivers, health care workers and other waste handlers are aware about the nature and risk related to biomedical waste.
• Development of non poly vinyl chloride plastics as a substitute for plastic which is used in the manufacture of disposable items.

• To search for cost effective and environmental friendly technology for treatment of bio-medical and hazardous waste.

5.4: Training:

• In every health care centres all the medical professionals like doctors, nurses, paramedical and administrative staff must be aware about the Biomedical Waste (Management and Handling) Rules 1998.

• Training is must for all categories of staff in appropriate medium or language and in an acceptable manner.

5.5: Role of Hospital administration in management of biomedical waste:

Heads of every health care centres will have to take authorization for generation of waste from appropriate authorities as notified by the concerned State Government, well in time and to get it renewed as per time schedule laid down in the rules. Each hospital should constitute a hospital waste management committee, chaired by the head of the hospital 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 accidental reports, annual reports should be filled in biomedical waste rules format and submitted to the concerned authorities.

5.5.1. Coordination with other agencies:

• Co-ordination Health care centres with Municipal authority: A very large percentage (approximately 85%) of waste generated in Indian
hospitals, belong to general category (non-toxic and non-hazardous). So, hospitals should have constant interaction with municipal authorities so that this category of waste is regularly taken out from the hospital premises for treatment and landfill.

- **Co-ordination with Pollution Control Boards:** For searching better methods, provision of facilities for testing, better technologies, approval of certain models for hospital use in conformity with standards laid down. Hospitals must seek help from PCBs.

### 5.6: Systematic approach for hospital waste management:

Based on Bio-medical Waste Management and Handling Rules 1998, notified under the Environment Protection Act by the Ministry of Environment and Forest (Government of India) following techniques should be followed:

#### 5.6.1. Segregation of waste:

Segregation is necessary for waste management and should be done at the source of generation of Bio-medical waste like all patient care activity areas, diagnostic centres, labour rooms and operation theatres etc. The main responsibility of segregation should be with the producers of biomedical waste i.e. doctors, nurses and other staff like technicians etc.

#### 5.6.2. Collection of bio-medical waste:

Collection of bio-medical waste should be done as per Bio-medical waste (Management and Handling) Rules *(Annexure-4, Schedule-II)*.
collected waste should not be stored at ordinary room temperature for more than 24 hours.

5.6.3. Transportation:

- Within medical centres, waste path must be designed to avoid the route of waste through patient care areas.
- Separate time should be marked for transportation of biomedical waste to reduce chances of its mixing with general waste.
- Desiccated wheeled containers and trolleys should be used to transport the waste plastic bags to the site of storage for treatment.
- Trolleys should be thoroughly cleaned and disinfected in the event of any spillage.
- The wheeled containers should be designed in this way that the waste can be easily loaded.
- Hazardous biomedical waste needed to be transported to a long distance should be kept in containers with proper labels.
- The transport is done through desiccated vehicles specially constructed for the purpose, having fully covered body, lined internally with stainless steel to provide smooth and impervious surface which can be cleaned easily.
- The load compartment should be separated from the driver’s compartment.

5.6.4: Treatment of hospital waste:

The main purpose of treatment of waste is:
• To reduce the volume of the waste.
• Waste should be disinfected so that it is no longer the source of infection.

5.6.4.1 Treatment of General waste:

85% of the waste produced in the hospitals belongs to general group. The safe disposal of this waste is the responsibility of the local authority.

5.6.4.2 Treatment of bio-medical waste (15% of hospital waste):

5.6.4.2.1: Deep burial: The biomedical waste under explain category of 1 and 2 only can be disposed with deep burial and only in the cities having less than 5 lakh populations.

The disposal of untreated healthcare waste in an uncontrolled dump is not recommended and must only be used as a last resort. It can be disposed of in a sanitary landfill, subjected to certain precautions. It is important that health-care waste should be covered rapidly. One technique is to dig a trench down to the level where old municipal refuse (over three months old) has been buried and to immediately bury health-care waste that is discarded at this level under a 2-metre layer of fresh municipal refuse.

Whenever a municipal landfill is being used, the water and habitat engineer must inspect the site before hazardous medical waste are discarded there. A purpose-built burial pit could also be used, preferably on the hospital site. Ideally, the pit should be lined with low permeability material such as clay to prevent the pollution of shallow groundwater and should be fenced in so as to prevent scavenger access. Health-care wastes must be buried immediately under a layer of soil after each unloading operation. It is suggested to spread lime on the waste for added health protection (in the
event of an epidemic, for example) or to eliminate odour. The pit should be sealed once it has been filled. Examples of burial pits or wells for anatomical waste or sharps are presented in Figure-5.3

**Figure:5.3: Method using in deep burial**

![Diagram of a deep burial method](image)

Source: (Rushbrook, Philip, and Pugh Michael, (1999))

5.6.4.2.2: Autoclave and microwave treatment: Standards for the autoclaving and microwaving are also mentioned in the Biomedical waste (Management and Handling) Rules 1998. The waste under category 3,4,6,7 can be treated by these techniques.

**Autoclaving:**

- The steam generated at high temperature penetrates waste material and kills the entire micro organism.
- The autoclave works on the principle of the standard pressure cooker.
- The process involves using steam at high temperatures.

**Figure: 5.4: An Autoclave**

![Image of an autoclave](image)
Microwave Irradiation:

- The microwave is based on the principle of production of high frequency waves.
- This heat generated from within kills all pathogens.
- The micro waves produce the particles within the waste material to vibrate and generating heat.

Figure: 5.5: Disinfection of biomedical waste by microwave irradiation

Source: (Recommended by the Robert Koch Institute, Germany)

5.6.4.2.3: Shredding:

The plastic waste like I.V. bottles, syringes, catheters and sharps like blades, needles and glass etc. should be shredded but only after chemical treatment or by autoclaving. Needle destroyers can be used for disposal of needles directly.

Shredders cut the waste into small pieces. This technique requires competent staff for operating and maintaining the device, since some of
these rotary devices are industrial models. They are often built into closed chemical or thermal disinfection systems. However, grain mills can be converted into simple shredders, but due to the risk for staff while the shredder is running only disinfected waste should be treated in these devices. Shredding, which in certain circumstances provides a means of recycling plastics and needles, should be considered whenever needles and syringes are available in large quantities, which involves a centralized system for collecting and transporting wastes from the various facilities.

5.6.4.2.4: Secured landfill: The discarded medicines, incinerator ash, solid chemical waste and cytotoxic substances should be treated by this option.

5.6.4.2.5: Incineration:
The incinerator should be installed and made operational as per specification under the biomedical waste rules 1998 and a certificate may be taken from CPCB and State Pollution Control Board and emission levels should be defined. In case of small hospitals, facilities can be shared. The waste under category 1,2,3,5,6 can be incinerated.

Incineration is a process of high temperature oxidation reaction that involves combustion of the organic matter present in bio medical waste, which produces gaseous emissions and inorganic solid residues. These types of emissions include steam, particulate matter, carbon dioxide, toxic substances like metals and halogenic acids etc. In addition, under sub optimal combustion, carbon monoxide and hazardous pollutants like furans and dioxins may be released. Incineration significantly reduces
approximately 85-95% waste volume and eliminates pathogenic microbes from biomedical wastes. The polythene bags made of chlorinated plastics, waste with mercury or cadmium like broken thermometers, mercury batteries, used lead and radiographic waste should not be incinerated.

The following best practices must be borne in mind with a view to minimizing pollutant emissions:

- Reduction of waste generated and sorting of wastes at the source.
- Good design incinerator ensure optimal combustion conditions like extension of the chimney (if the height of the chimney is doubled from 3 to 6 metres, the concentrations of pollutants in the air are 5 to 13 times lower).
- Installation of incinerators far away from inhabited or cultivated areas.
- Best operating practices: appropriate startup and cooling, care to obtain a sufficiently high temperature before feeding the wastes in, adherence to the correct quantity of waste and fuel, regular removal of ash; the incinerator should be lit with paper, wood or fuel oil; after 30 minutes, small quantities of waste should be loaded at regular intervals (5-10 minutes), wet waste must be mixed with drier waste, sharps containers must be loaded one by one, the incinerator must run for long periods (at least 2 hours), heavy-duty gloves, a body protector, and goggles must always be worn and respirator must also be used whenever ash is being removed.
  - No incineration of PVC plastics or other wastes containing chlorine.
  - Regular planned maintenance: replacement of faulty parts, inspection and inventory of spare parts.
  - Regular training for operators, operating manual.
And lastly, the burning of hazardous medical waste must be avoided at all times because of the risk for staff, which is due not only to the emission of toxic gases but also to the fact that infectious wastes are not fully burnt. In an emergency, however, incineration in a barrel can be a temporary solution until a better solution is found. In this case, care must be taken to use a barrel with sufficient air intake below the combustion flame and to protect the top with fine wire mesh (to contain the ash). Ash obtained after incineration must be disposed of in a secure landfill.

5.6.4.2.6: Chemical disinfection:

Generally 1% hypochlorite solution is commonly used in health care facilities to kill microorganisms on medical equipment, has been extended to the treatment of health-care wastes. Chemicals are added to the wastes to kill or inhibit pathogens. However, the chemicals that are used, themselves entail a health risk for the people who handle them and there is also a risk of environmental pollution. This type of treatment is suitable mainly for treating liquid infectious wastes such as blood, urine, faeces or hospital sewage. Generally 1% bleach (sodium hypochlorite) solution or a diluted active chlorine solution (0.5%) is used for disinfection.

Other disinfectants like Ozone, lime, per acetic acid and ammonium salts are also used. Ethylene oxide, Formaldehyde and glutaraldehyde must no longer be used because of their toxicity, carcinogenic or sensitizing nature. All strong disinfectants irritate the eyes, skin, and respiratory system. They must be handled with caution in particular, personal protective equipment must be used and they must be stored correctly. Solid medical waste can be chemically disinfected, but they must first be
shredded. This practice poses a number of safety problems, and the wastes are only disinfected on the surface. Thermal disinfection must be preferred over chemical disinfection for effectiveness and ecological reasons.

5.6.4.2.7: Needle extraction or destruction:

Needles can also be removed from syringes immediately after the injection by means of small manually operated devices. The needles are then discarded into the sharp pits. Plastic syringes must be disinfected before being disposed of in the household refuse chain or in plastics recycling. Some appliances run on electricity (destroying the needles by melting) and cannot be used, particularly in remote areas. Furthermore, these appliances require regular maintenance and have to be handled with care.

5.6.4.2.7: Encapsulation:

Encapsulation or solidification: In encapsulation technique there is having a small number of hazardous items or materials in a mass of inert material. The purpose of the treatment is to prevent humans and the environment from any risk of contact.

Encapsulation involves filling containers with waste, adding an immobilizing material, and sealing the containers. The technique uses either cubic boxes made of high-density polyethylene or metallic drums, which are three-quarter filled with sharps, chemical or pharmaceutical residues, or incinerator ash. The containers or boxes are then filled up with a medium such as plastic foam, bituminous sand, lime, cement mortar, or clay. Once
the medium has become dried, the containers are sealed and disposed of in a sanitary landfill or waste burial pit.

The following proportions are recommended, for example: 65% pharmaceutical waste, 15% lime, 15% cement, 5% water. The main advantage of the process is that it is very effective in reducing the risk of scavengers gaining access to the hazardous waste. Encapsulation of sharps is generally not considered to be a long-term solution.

**5.6.5: Disposal of liquid wastes in the sewage:**

In general, the sewage system should not be used to dispose chemicals. It is strictly prohibited to dilute wastewater discharges so that the concentration falls below the exemption thresholds in force in the particular country. Scientific or legislative data on exemption thresholds are rare.

Photographic developing liquids as a rule should not be poured down the drain, since they contain substances that are toxic or even carcinogenic (silver, hydroquinone, formaldehyde). If it is not possible to have them recycled by an approved firm but as an exception small quantities may be discharged within the limits set out above. Fixers and developers must be mixed and stored for one day (neutralization process) and then diluted (1:2) and emptied slowly into the sink. Non-hazardous pharmaceutical wastes (syrups, eye drops and vitamins etc.) may be poured down the drains, unless otherwise stated by national legislation. Liquid biological waste (small quantities of blood, rinsing liquids from operating theatres, etc.) may be poured down the drain without being pre-treated, unless the patient is suffering from an infectious disease. In all other cases, it must be first inactivated – preferably by autoclave or by means of a chemical disinfectant...
(undiluted bleach or chlorine dioxide, contact time of more than 12 hours). In the situations where a septic tank is used, the quantity of disinfectant or biocide (silver and bleach, etc.) should be reduced, since these substances can actually disrupt the biological digestion of the wastes. Expired units of blood must not be emptied down the drain. They must be incinerated at high temperature (over 1000°C) or autoclaved. Where there are no such facilities, they must be disposed of in a waste burial pit.

5.6.7: Plasma Pyrolysis:

Plasma is the state of matter obtained by breaking down atoms into ions and electrons by the process of ionization. Plasma can quite easily reach temperatures of 10,000°C.

Plasma technologies offer unique solutions to meet the increasing demands of dematerialization to develop ecologically sensible industrial practices like high temperature, high energy density, high chemical reactivity and ability to process solids, liquids and gases. In plasma pyrolysis, production of heat is independent of chemistry of material used. It is quick heating; 5000°C temperature can be achieved in million seconds. It is fast quenching and consumes small quantity of gas. The high ultraviolet radiation flux destroys pathogens and waste to be treated, which can be dry or wet. It is possible to recover energy in the form of carbon monoxide and hydrogen.

Figure: 5.20: Process of Plasma pyrolysis
Non-Incineration Medical Waste Treatment Technologies:

The emphasis should be given to the use of non-incineration medical waste treatment technologies because a medical waste incinerator releases a wide variety of pollutants including dioxins and furans, metals (such as mercury, lead, and cadmium), particulate matter, acid gases like hydrogen chloride and sulfur dioxide, carbon monoxide, and nitrogen oxides. These emissions have serious adverse consequences on worker safety, public health, and the environment. Dioxins, for example, have been linked to immune system disorders, diabetes, cancer, birth defects, etc. It must be noted, however, that non-incineration technologies can also have toxic emissions, although research indicates that these occur in smaller amounts.

Non-incineration technologies include:

(i) Low-Heat Thermal Technologies:
Autoclaves, Microwaves, and Other Steam-Based Systems.
(ii) **Medium- and High-Heat Thermal Technologies:**
Depolymerization, Pyrolysis, and Other Systems

(iii) **Chemical-Based Technologies:**
Chlorine and Non-Chlorine Based Systems Irradiation, Biological, and Other Technologies: E-Beam, Biological, and Sharps Treatment Systems.

**5.7: Biomedical Waste Management Rules:**

Safe disposal of biomedical waste is now a legal requirement in our country. The Biomedical Waste Management & Handling Rules, 1998 came into work on 1998. In accordance with these rules, it is the duty of every occupier who has the control over the institution or its premises is required to take all steps to ensure that the waste generated is handled without any adverse effect to human health and environment. It consists of six schedules. These six schedules are attached in *(Annexure-4).*

**5.8: Benefits of Biomedical Waste Management:** Some benefits of Biomedical Waste Management rules are as follows:

- For Cleaner and healthier surroundings.
- For reduction in the incidence of hospital acquired and general infections.
- For reduction in the cost of infection control within the hospital.
- For reduction in the possibility of disease and death due to repackaging and reuse of infectious disposables.
- For less incidence of community and occupational health hazards.
- For improving the image of the healthcare centres and increasing the quality of life.