The Safe Disposal of Bio-Medical Waste  
(Case study of a Rural Medical Hospital)

Dr. D.S.Vyas

#1Associate Professor, Civil Engineering Department  
B.V.M. Engineering College, V. V. Nagar-388120  
e-mail : d4dipakvyas@yahoo.co.in

Mr. Urvij B. Dave

#2M.E. Environment, Civil Engineering Department  
B.V.M. Engineering College, V. V. Nagar-388120  
e-mail : swezlana@yahoo.com

Ms. Hemal B. Parekh

#3M.E. Environment, Civil Engineering Department  
B.V.M. Engineering College, V. V. Nagar-388120  
e-mail : hemalparekh2808@yahoo.com

Abstract—The safety and acceptability of many widely used health care waste management practices are of serious concern from public health point of view. Disposal methods, including terrestrial dumping, uncontrolled burning & dumping of hospital waste specially in landfills, remain a prominent means of disposal and many landfills remain primitive in their operation. Alternative treatment technologies for healthcare waste management include incineration with heat recovery and waste gas cleaning and accelerated composting, but both of these technologies are subject to criticism. To find out outcomes of practiced methodology, we made a case study of a rural medical hospital, starting from point sources segregation of waste to final disposal. This paper discusses the outcome of our case study findings. An innovative technology using plasma pyrolysis for treating hospital waste is suggested with its proposed benefits and appropriateness.

Keywords- Anatomical Waste, Bio-Medical, Disinfection, Incineration, Syringe.

INTRODUCTION

Unsafe handling and disposal of hospital waste together with domestic and commercial waste in the capital Delhi was very common for many years. This always posed threat and was actually the reason for a continued occurrence of certain diseases in the city for decades after independence till the rule of handling and dispose of medical waste came into existence in 1998. The problem of handling/disposal of hospital waste was then given due attention to safeguard the community health.

BIO-MEDICAL WASTE MANAGEMENT RULES, 1998  
(AMENDED IN 2000 AND 2003)[3]

Under the Environmental Protection Act 1986, the Bio-Medical Waste Management Rules were introduced. These Rules are directly relevant to the health sector. The salient features of these Rules are as follows:

- Bio-medical wastes mean waste that is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biological.
- It is the duty of every occupier of an institution generating bio-medical waste which includes a hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank by whatever name called to take all steps to ensure that such waste is handled without any adverse effect to human health and the environment.
- Bio-Medical waste shall not be mixed with other wastes.
- Bio-Medical waste shall be segregated into containers/bags at the point of generation in accordance with Schedule II of these Rules prior to its storage, transportation, treatment and disposal. The containers shall be labelled according to Schedule III of these Rules.
- Bio-Medical waste shall be treated and disposed of in accordance with Schedule I of these Rules, which gives the categories of waste and methods for treatment and disposal. The Rules also require compliance with the standards prescribed in Schedule V, which gives standards for different treatment technologies. These are covered in the Operational Framework of this IMEP Policy Framework.
- Every occupier of an institution generating, collecting, receiving, storing, transporting, treating, disposing and/or handling bio-medical waste in any other manner shall make an application in Form 1 to the prescribed authority for grant of authorization. This is NOT required for clinics, dispensaries, pathological laboratories, blood banks that provide treatment / service to less than 1000 (one thousand) patients per month.
- Each state or union territory in India is responsible for implementing the Bio-Medical Waste Management Rules, and State Pollution Control Boards in states or Pollution Control Committees in the union territories are designated as the prescribed authorities.

CPCB MANUAL ON HOSPITAL WASTE MANAGEMENT[3]

In 2000, CPCB brought out this technical guidance in the areas of bio-medical waste segregation, storage, transport and treatment. The CPCB manual gave special emphasis to
incineration, covering incinerator emissions, maintenance requirements, operational problems & solutions, and pollution control systems.

**GUIDELINES ON MERCURY-CONTAMINATED WASTES**

CPCB has recognized that there is a possibility of waste containing mercury and its compounds to be above the permissible limit in terms of the concentration, and hence has to be regarded as hazardous. In November 2005, CPCB has written to all State Pollution Control Boards to make the segregation of mercury-contaminated waste materials a condition for granting authorization to the healthcare facilities. CPCB also notes that new healthcare establishments will have to ensure the mercury-laden waste is properly segregated, treated and disposed.

**CPCB GUIDELINES ON CENTRAL WASTE TREATMENT FACILITIES**

CPCB Guidelines on Central Bio-Medical Waste Treatment Facilities sets out requirements for the location, land size, coverage area (maximum number of beds), treatment equipment, and infrastructure setup of the Central Waste Treatment Facilities, collection and transportation of bio-medical waste and disposal of treated bio-medical waste and other operational issues.

**CPCB GUIDELINES FOR BIO-MEDICAL WASTE INCINERATORS**

CPCB Guidelines for bio-medical waste incinerators include requirements for the incinerator design and its air pollution control device, physical structures (incineration and waste storage rooms), operator qualifications, personal protection equipment, and emergency procedures.

- Classification of health care waste:
  - Bio-medical Waste Management Rules – Schedule I

Notes:

1. Chemicals treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfection.
2. Mutilation/shredding must be such so as to prevent unauthorized reuse.
3. There will be no chemical pre-treatment before incineration. Chlorinated plastics shall not be incinerated.

- Option Waste Category
1. Human Anatomical Waste (human tissues, organs, body parts)
2. Animal Waste (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, animal houses)
3. Microbiology & Biotechnology Waste (wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biological, toxins, dishes and devices used for transfer of cultures.
4. Waste sharps (needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts. This includes both used and unused sharps)
5. Discarded Medicines and Cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)
6. Solid Waste (Items contaminated with blood, and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood)
7. Solid Waste (wastes generated from disposable items other than the waste sharps such as tubing, catheters, intravenous sets etc).
8. Liquid Waste (waste generated from laboratory and washing, cleaning, house-keeping and disinfecting activities)
9. Incineration Ash (ash from incineration of any biomedical waste)
10. Chemical Waste (chemicals used in production of biological, chemicals used in disinfection, as insecticides, etc.)

All sharps in their puncture proof containers should be disinfected and should be disposed of in the sharps pit, which is to be located within the premises of the healthcare facility. See also...

- Infected organic waste, after disinfection, should be taken to the onsite deep burial pits and covered with a layer of lime and soil.
- Infected recyclables such as plastics and metals should be first disinfected using bleach solution and / or autoclaved before sent for recycling.

If there is no organized collection of garbage / municipal solid waste, the general / communal waste – non-infected - should be managed as follows:

- Organic waste such as kitchen waste and leaf fallings put in a compost pit, which is to be located within the premises. Standard composting methods such as mixing the waste with leaf fallings and soil should be done. Compost will be available within a few days and this should be used for the garden. Care must be taken to ensure that the organic waste is not infected by segregating the infectious waste at source.
- Recyclable material such as packaging material and paper should be sold to authorized recyclers. Care must be taken to ensure that the recyclable waste is not infected and kept separated from infectious wastes at all times. All equipment used for bio-medical waste treatment should be periodically maintained. Both preventive and
corrective maintenance schedules and records should be retained in the health facility.

- Segregation of Waste and Onsite Storage:

Segregation of waste at source is a single most important step in bio-medical waste management. Once bio-medical waste mixes with general waste, the waste management problem magnifies and becomes unmanageable. It is critical that wastes be segregated at the point of generation itself. Bio-Medical Waste Management Rules 1998 gives the colour coding that should be used for the various categories of waste. Table 2-6 provides the information given in these Rules. All waste containers should be made of good quality plastics or other strong material. These should have smooth inner and outer surfaces to avoid dirt / dust sticking in indentations. They should be lined with non-chlorinated plastic liners and should be kept closed at all times. The onsite storage locations should be properly planned and be made available. Ideally, these should be nearest to the point of generation. Where potentially infected wastes are generated, 2% bleach solution (freshly prepared twice a day) should be put in the waste container and the waste should be put in the container having this solution. The quantity of waste in each of the waste containers should be weighed and a log should be maintained. This should be done prior to evacuating the container into the final onsite disposal.

**TABLE 1: CLASSIFICATION OF BIO-MEDICAL WASTE**

<table>
<thead>
<tr>
<th>Color Coding</th>
<th>Waste Category</th>
<th>Treatment option as per Schedule I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>Plastic bag Cat. 1, Cat. 2, and Cat. 3, Cat. 6.</td>
<td>Incineration / deep burial</td>
</tr>
<tr>
<td>Red</td>
<td>Disinfected container/plastic bag Cat. 3, Cat. 6, Cat. 7</td>
<td>Autoclaving / Microwaving / Chemical Treatment</td>
</tr>
<tr>
<td>Blue/White Plastic</td>
<td>Bag/puncture proof Translucent Cat. 4, Cat. 7</td>
<td>Autoclaving / Microwaving / Container Chemical Treatment and Destruction / shredding</td>
</tr>
<tr>
<td>Black</td>
<td>Plastic bag Cat. 5 and Cat. 9 and Cat. 10. (solid)</td>
<td>Disposal in secured landfill</td>
</tr>
</tbody>
</table>

- Bio-medical wastes have to be transported both within the health facility and from the facility to the final disposal location. Properly designed carts, trolleys and other wheeled containers should be used for the transportation of waste inside the facilities.

- Wheeled containers should be so designed that they have no sharp edges. Ergonomics must be taken into account in designing these wheeled containers by considering the different tasks, i.e. loading, securing and unloading. Transportation of waste has to be done in line with the Bio-Medical Waste Management Rules. One of the requirements is labeling and the typical contents of the label are included.

- Waste handlers must be provided with uniform, apron, boots, gloves and masks, and these should be worn when transporting the waste.

**CASE STUDY OF BIO-MEDICAL WASTE OF A RURAL HOSPITAL**

The survey of a medical hospital with 550 beds, 42 wards and 20 OPDs, attached to a medical college was carried out by our team during the time period between August-2010 to October-2010.

The data collected is tabulated as follows:

All Units are in Kg/day

**TABLE 2 : SEGREGATION OF BIO-MEDICAL WASTE OF GROUND FLOOR**

<table>
<thead>
<tr>
<th>Waste Category</th>
<th>Treatment option</th>
</tr>
</thead>
<tbody>
<tr>
<td>General waste</td>
<td>Disposal in secured landfill</td>
</tr>
<tr>
<td>Sharp waste</td>
<td>Autoclaving / Microwaving / Container Chemical Treatment and Destruction / shredding</td>
</tr>
<tr>
<td>Pathogenic waste</td>
<td>Incineration / deep burial</td>
</tr>
<tr>
<td>Infectious waste</td>
<td>Disposal in secured landfill</td>
</tr>
</tbody>
</table>

**TABLE 3 : SEGREGATION OF BIO-MEDICAL WASTE OF GROUND FLOOR**

<table>
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<tr>
<th>Waste Category</th>
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<td>Incineration / deep burial</td>
</tr>
<tr>
<td>Infectious waste</td>
<td>Disposal in secured landfill</td>
</tr>
</tbody>
</table>

- The waste from color-coded containers should be transported to the appropriate disposal points. All personnel responsible for the waste containers should wear gloves, masks, aprons and proper footwear. The personnel should wash their hands and feet with soap and disinfectant solution after every handling of these containers. Cleaning (sweeping and swabbing) should be undertaken twice daily and all the waste from the dust bins should be emptied twice a day.

- No infectious wastes should be stored beyond 24 hours.
Average ash generation is normally between 4-5% of the weight of the waste; as against that we have the ash generation as 13% which is on higher side.

For Preliminary Planning for waste management estimation is done on following basis:[2]

- 80%- General health care waste.
- 15%-Pathological & infectious waste.
- 1%-sharp waste.
- 3%-Chemical & Pharmacological waste.
- 1%-special waste (Cardio active, cytotoxic, Pressurized container)

**TABLE 8 : ACTUAL WASTE GENERATED AT THE HOSPITAL**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Type of waste</th>
<th>Actual waste from study in %</th>
<th>Waste in Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General</td>
<td>77.48</td>
<td>687</td>
</tr>
<tr>
<td>2</td>
<td>Pathological and infectious</td>
<td>12.06</td>
<td>107</td>
</tr>
<tr>
<td>3</td>
<td>Sharp</td>
<td>2.02</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>Chemical pharmacological</td>
<td>5.63</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>Special waste</td>
<td>2.81</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100.00</td>
<td>887</td>
</tr>
</tbody>
</table>

- As per Bangalore survey, waste generated in private nursing home is 2 to 4 kg/day while in government hospitals it is around ½ to 2 kg /day. Against which the hospital under study generated 0.58 kg/day.[2]
- Over all capacity of hospital is 550 beds and it generates around 687 kg per day.
- Over all waste generation of health care center is 887 kg per day.
- Out of which 192 kg (Refer: Table-8 ) need to be take care of and need extra precaution for disposal.
- Of these 192 kg of waste, 71.6 kg went for an incineration as it is highly infectious.
- Remaining 120.4 kg is disposed through sanitary landfill disposal method.
- As daily solid waste of hospital generated was in range between 190 to 230 kg out of which 70 to 115 kg went for the incineration and rest was put in to their own near-by sanitary land fill site.
- The domestic waste generated is managed by municipal disposal system.

**DISPOSAL SYSTEM PRACTICED BY RURAL MEDICAL HOSPITAL**

- The waste from color-coded containers is transported to the appropriate disposal points.
- No infectious waste is stored beyond 24 hours.
Properly designed carts, trolleys and other wheeled containers are used for the transportation of waste inside the facilities.

Treatment of sharps is done, i.e. by treating with 1% hypochlorite solution or any other equivalent chemical reagent. Shredder is used for disposal of sharp content.

“Incinex incinerator” (Double chamber pyrolytic incinerator established in 1981) with capacity of 35 Kg/hr is used by rural health care institution.

Motor of “Bharat bijli Limited” used is having capacity of 415 volt with speed of 1380 RPM.

Fuel: LDO(Diesel) is use whose consumption is around 400 litres for 15 days.

It means per day consumption is 25 to 27 litres.

Sanitary Land Filling is done at their own land fill site.

SUGGESTIONS FOR ADVANCEMENT [1]

In case of failure of current instruments and infrastructure of waste disposal, Hospital must have alternate plan for safe transportation of infectious waste to disposal.

Instead of Incineration it is suggested to use “Plasma parolysis” which is new widely used economical and environment friendly method.

PLASMA PYROLYSIS TECHNOLOGY [1]

Pyrolysis: Thermal disintegration process of carbonaceous material in oxygen starved environment.

Plasma is a means to convert electrical energy into heat energy efficiently. Plasma torch generate 20000°C at the core. No air/gas flow required.

Plasma pyrolysis conditions retard the process of POP(Persistent Organic Pollutants) formation.

These primary and secondary processes lower down the formation of Dioxin/Furan which mitigate the standard of USEPA/CPCB.

It is smoke free technology for safe disposal of chlorinated waste.

It is so compact that it can be installed in a small premises.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Plasma Pyrolysis (Compact System)</th>
<th>Incinerator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Source</td>
<td>Plasma Torch</td>
<td>Electrical/Oil fired burner</td>
</tr>
<tr>
<td>Temperature of primary</td>
<td>1100°C (Plasma zone)</td>
<td>650-850 °C</td>
</tr>
<tr>
<td>Space Requirement</td>
<td>5 m x 6 m (can be installed within hospital premises)</td>
<td>2-3 hrs (electrical)</td>
</tr>
<tr>
<td>Proheating time</td>
<td>45 minutes</td>
<td>10 mins (electrical)</td>
</tr>
<tr>
<td>Air &amp; Moisture dependency</td>
<td>Not dependent</td>
<td>Purely dependent (Excess air is added)</td>
</tr>
<tr>
<td>Unburnt organic residue</td>
<td>&lt; 0.2%</td>
<td>Approx. 4%</td>
</tr>
<tr>
<td>Chimney</td>
<td>Not required</td>
<td>30 m height (min.)</td>
</tr>
<tr>
<td>Foul odour removal systems</td>
<td>Not required</td>
<td>Required</td>
</tr>
<tr>
<td>Carcinogens (POP)</td>
<td>&lt;= 0.01 ng/Nm³ TEQ</td>
<td>Diesel Gas</td>
</tr>
<tr>
<td>Consumables</td>
<td>Electricity, Graphite Electrodes</td>
<td>ITI persons 2</td>
</tr>
<tr>
<td>Man Power (Operators)</td>
<td>1-2 operator</td>
<td>ITI persons 2</td>
</tr>
<tr>
<td>Per Kg Disposal Cost</td>
<td>Rs 25/Kg</td>
<td>&gt; Rs 25 per Kg when the disposal is done following CPCB norms</td>
</tr>
</tbody>
</table>

CONCLUSION

The study reveals that the hospital under study incinerates infectious waste only. Considering comparison and applicability of plasma pyrolysis with incineration, it can be concluded that all waste i.e. pathogenic, sharps and infectious except general waste can go for plasma pyrolysis where residue left over would be negligible with almost no additional cost of treatment and at the same time it would safeguard the environment.

REFERENCES
