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BIOMEDICAL WASTE MANAGEMENT TECHNIQUES: A REVIEW

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Abstract: This review basically deals with the researches done on national as well as international level on Biomedical Waste Management. Hospitals, clinics, polyclinics etc. generate large amount of wastes which are non-hazardous as well as hazardous. This is due to the fact that diagnosis, treatment and surgeries are conducted so wastes are generated. An Environmental Engineer dealing with various environmental threats also has to place great emphasis on biomedical wastes and their effective treatment so as to avoid spreading of diseases and infections in the hospital premises. The domain of biomedical waste management is of great importance and has to be followed strictly. The various techniques for effective Biomedical Waste management will be dealt in this review article.

Keywords: Biomedical waste, hazardous wastes

1. INTRODUCTION

If we take a look at hospitals, clinics and nursing homes, patients affected with diseases or any disorders are being treated, surgical operations are being carried out resulting in generation of wastes. These wastes are basically composed of organic as well as inorganic substances like soiled cotton, bandages, hypodermic needles, syringes, tubing which can be intravenous sets, and urinary catheters, any organ of humans etc.Such wastes if not segregated and disposed of in an engineered fashion may result in spreading of diseases as well as infections and hazards. Such wastes are technically known as Biomedical Wastes (BMW). Researches tell us that no less than 40 different types of Pathogens are being spread by means of BMW. Various diseases like Human Immunodeficiency Virus(HIV), Hepatitis B Virus (HBV) and Hepatitis Virus(HCV) are spread which are life threatening so they have to be avoided completely by adopting proper waste management as well as handling techniques. Biomedical waste disposal has to be given due consideration by the Biomedical Waste Management department which is made responsible for it. The Bio-Medical Waste (Management and Handling) Rules, 1998 of the Government of India makes it mandatory to dispose of the biomedical wastes by a certain procedure and regulations. It is incumbent upon the Hospital administration to make sure whether all arrangements for BMW treatment and disposal have been made by complying with the Government norms. [1]

2. Biomedical Waste and its types:

According to Biomedical Waste (Management and Handling) Rules, 1998 of India "Any waste which 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. [2]

The World Health Organization (WHO) classified medical waste into eight categories ´

1. General Waste
2. Pathological
3. Radioactive
4. Chemical
5. Infectious to potentially infectious waste
6. Sharps
7. Pharmaceuticals
8. Pressurized containers

3. Classification of Biomedical Wastes:

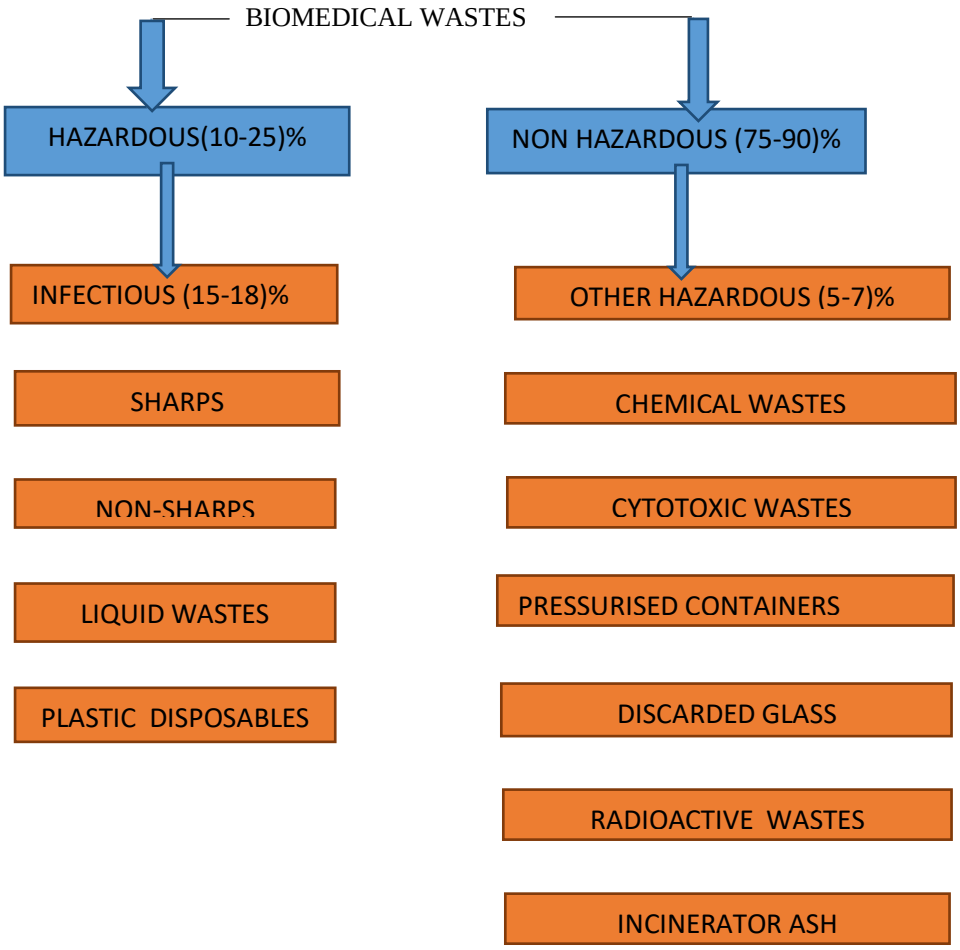

Fig. 1: Classification of Biomedical wastes

Schedule 1.Categories of Bio-Medical Waste

Cat. No. 1
Treatment: Incineration /deepburial
Waste Type:Human Anatomical Waste (human tissues, organs, body parts)

Cat. No. 2
Treatment: Incineration /deep burial
Waste Type: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)

Cat. No. 3
Treatment: Local autoclaving/ microwave treatment
Waste Type: Microbiology & Biotechnological waste waving/ incineration
(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)

Cat. No. 4
Treatment: Disinfection(Chemicaltreatment /autoclaving/micro waving and mutilation shredding
Waste Type: Waste Sharps (needles, syringes, scalpels, blades, glass etc. that may cause puncture and cuts. This includes both used & unused sharps)

Cat. No. 5
Treatment: Incineration / destruction & drugs disposal in secured landfills

Waste Type: Discarded Medicines and Cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)

Cat. No. 6
Treatment: Incineration, autoclaving/micro waving
Waste Type: Solid Waste (Items contaminated with blood and body fluids including cotton, dressings, soiled plaster casts, line beddings, other material contaminated with blood)

Cat. No. 7
Treatment: Disinfections by chemical Solid Waste (waste generated from. sharps such as tubing, catheters, intravenous sets etc.)

Cat. No. 8
Treatment: Disinfections by chemical treatment and discharge into drain autoclaving/micro disposable items other than the waste waving& mutilation shredding
Waste Type: Liquid Waste (waste generated from laboratory & washing, cleaning, housekeeping and disinfecting activities)

Cat. No. 9
Treatment: Disposal in municipal landfill
Waste Type: Incineration Ash (ash from incineration of any bio-medical waste)

Cat. No. 10
Treatment: Chemical treatment &discharge into drain for liquid and secured landfill for solids
Waste Type: Chemical Waste (chemicals used in for production of biological, chemicals, used liquid & in disinfect ion, as insecticides, etc) [3]

4. Biomedical Waste Management Techniques:

4.1 Handling:

S.No	Type of Waste	How to handle
1	Sharps(needles, lancets, blades, surgical knifes)	To be thrown in puncture-resistant bags kept in boxes with self-closing lids.
2	Other Potentially Infectious Materials	They should be wrapped up in a high quality bags with Biohazard symbol.

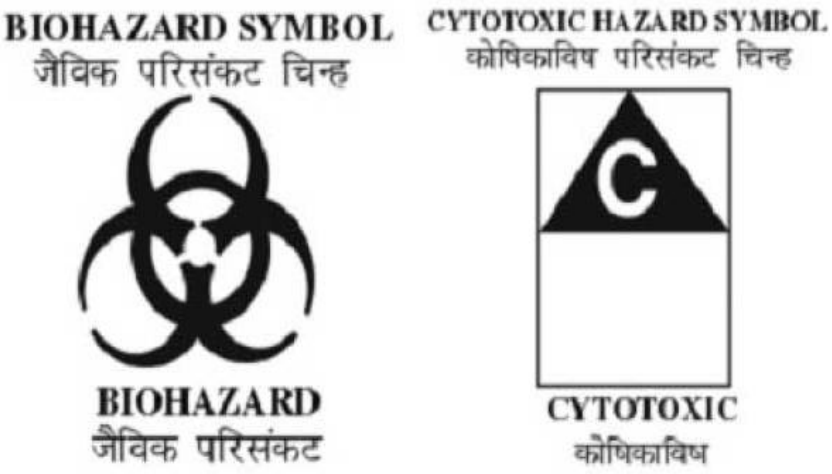

Fig. 2: Biohazard and Cytotoxic Hazard Symbol

Sharps like blades, needles, lancets etc should not be bent after usage but should be immediately thrown in bins with tear resistant bags. In case while handling bags one gets injured due to the infected sharps, one should immediately take medical help.

Always make use of three things:
1. Gloves
2. Gowns
3. Masks

If in case one is struck with any kind of sharp, he/she may allow the wound to bleed and then seal it with bandage and clean dressing. One may also have to give blood samples to be analysed for any infection so that prompt treatment can be carried out.[4]

5. *Different Processes in Biomedical Waste Management:*

Biomedical waste management involves various steps which are listed below:

1. **Waste collection:** The wastes generated at the source are collected so that segregation can be easily carried out. Wastes are collected in distinct containers and bags.
2. **Segregation (to sort out recyclable wastes):** One important step in Bio medical waste management which involves separating the dry and wet wastes broadly. Approximately 85% wastes generated from hospitals are non-infectious whereas remaining wastes are infectious and have to be dealt strictly. For this colour coded segregation is being implemented in hospitals via coloured bags.

COLOUR	TYPE OF WASTE	TREATMENT
Yellow	Human and animal anatomical waste, microbiological waste, Cotton,	Incineration/ deep burial
Red	Plastic wastes like tubing, catheters	Autoclave, microwave treatment, chemical treatment
Blue	Needle, lancets, syringes and other sharps	Autoclave, microwave treatment, chemical treatment, destruction, shredding
Black	Discarded medicines, cytotoxic drugs, incineration ash, chemical wastes	Disposal in landfill

3. Transportation and storage
4. Treatment & Disposal
5. Transport to final disposal site
6. Final disposal at site [5,6,7,8,9]

6. Various Technologies for BMW Management:

6.1 Converting Waste to Energy:

This is one of the smartest ways to tackle the issues pertaining to Biomedical Waste management. Blood as well as saliva can also be converted into energy as per recent studies. This results in reduction of waste and then reusing the energy derived by it instead of wasting it.

6.2 Steam Auto Clave Technology:

As incineration produces toxic gases like Carbon Mono-oxide, HCl etc which are really hazardous to the environment. So new technologies have emerged like use of steam autoclave which uses steam to sterilize Biomedical wastes. Steam Autoclaves are basically insulated pressure chamber which utilise saturated steam to raise the temperature inside the chamber. This technique is eco-friendly and cost effective and has no harmful effects to the environment.[10,11,12]

***7.Emerging Technologies in Bio Medical Waste Management*:**

Various technologies are being used for proper management of Bio medical wastes.

1. **Autoclaving**: This is a technique in which steam is introduced in the waste so as to disinfect it. It is widely used for sterilising reusable medical equipment. The gases generated during combustion are released in the atmosphere and the ashes left as residue are collected and thereby disposed in engineered landfills.

   The horizontal system is widely preferred as it is easy and effective. The temperature required for complete inactivation of microorganisms is 121^0C for a duration of 9 minutes. Autoclave is not meant for sterilising wastes.[13]

2. **Microwave Irradiation**: Electromagnetic rays (EMR) at a frequency of 300 to 300,000 MHz is used for destructing microbes. EMR at 2450 MHz proves to be effective in knocking down the microbes. This technique is seldom used in the field of BMW Management. It has a limited used most particularly in the process of shattering of pathogens.
3. **Chemical Methods**: Chemicals like Hydrogen Peroxide, Sodium Hypochloride etc. are used for treatment of BMW. Disinfection can readily be achieved but not sterilisation. Previously, chemicals were being used to treat floors, walls and equipment but now it finds great scope in BMW treatment. Chemicals cannot be used for high level treatment of biomedical wastes.
4. **Solar Disinfection**: With the exception of toxic and hazardous wastes, the use of solar radiation is found economical and effective especially in countries where costly treatment techniques cannot be afforded.
   Emerging technologies also include plasma pyrolysis, alkaline hydrolysis, superheated steam, ozone as well as Promession[14]
5. **Plasma Pyrolysis:** Ionised gas in the plasma state is being used to convert electrical energy in minimum or no air to higher temperatures (several thousand degrees) with the help of plasma torches or electrodes. It is used for the destruction of microbes associated with infectious wastes, pharmaceutical wastes, hazardous and toxic wastes. This method is safe and less pollution causing due to very emissions of dioxins and furans. It however requires maintenance of plasma torches and generates CO_2 gases. A clean alloyed slag formation takes place which acts as a residue which in turn can be used as a construction material and for metals.[14,15,16,17]
6. **Ozone**: This can be good for treating pharmaceutical wastes. Ozone oxidises and gets converted to a more stable O_2. Shredders and mixers are needed to expose the wastes to the bactericidal agent. This technique is also adopted in hospitals where the administration can afford. [14]
7. **Promession:** The cadavers are being freeze-dried by using liquid nitrogen and mechanical vibrations so as to cause disintegration for faster decomposition.[14]
8. **Nanotechnology:**It is used to improve quality of indoor air. A photo catalyst with wide spectrum of light proves to be bactericidal and fungicidal which makes use of energy from light to generate hydroxyl species and superoxide anion ($O2^-$) which in-turn decomposes and oxidises the toxic pollutants to CO_2 and H_2O.[18]
9. **Photo catalysis**: Use of solar energy and Ultraviolet radiations is being done to treat hospital wastes. This is safe and economical.[19]
10. **Membrane bioreactors**: This is a well known process and is basically a blend of biological-activated sludge process with membrane filtration for sludge water separation. Aerobic MBR, anaerobic MBR and organic MBR are being commonly used. Its basically a two in one process which involves biodegradation as well as filtration in the same tank. One of the advantages of this process is that it does not require too much manpower and is user friendly.[20,21]
11. Some more emerging technologies adopted are gas-phase chemical reduction, base-catalysed decomposition, supercritical water oxidation, sodium reduction, verification, superheated steam reforming, Fe-TAML/peroxide treatment (pharmaceutical waste), biodegradation (using mealworm or bacteria to eat plastics), mechanochemical treatment, sonic technology, electrochemical technologies, solvated electron technology and phytotechnology. They are used in special cases and generally cannot be used for routine BMW treatment. [20]

If we look at the various emerging technologies the Hospital waste management companies mostly adopt methods like microwave disinfection, autoclaving and incineration in order to reduce the quantity of wastes by about 70-80%. The reduction in the volume of wastes also reduces the transportation cost. Also the wastes become non-infectious and are ready to be disposed of in landfills. Developed countries face large generation of wastes as reusable items are manufactured.[21]Also much focus is been given on Waste to Energy conversion as this also helps in reducing the quantity of wastes and but obvious we can get back some amount of energy.
Incineration is the widely adopted technology in India in hospitals and medical colleges.

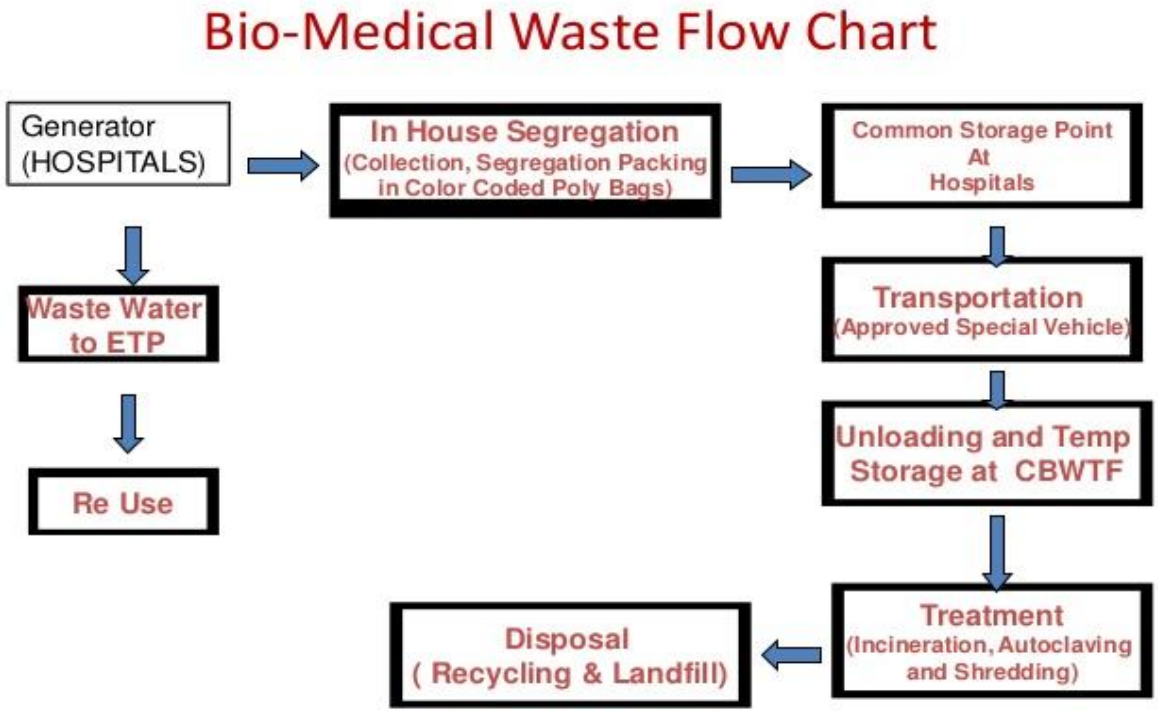

Fig.3 : Biomedical Waste management flow chart

8. CONCLUSIONS AND SUGGESTIONS FOR IMPROVEMENT IN THE SYSTEM OF BMW MANAGEMENT:

While doing an extensive survey on literature available on BMW, we see that incineration is the most widely adopted practise due to its effectiveness, although it generates harmful gases also. On the other hand solar radiation and UV rays are also used in conditions where cost cutting is to be done, and costly techniques cannot be afforded. Infectious and hazardous wastes require specialmethods.

8.*1 How to enhance the BMW Management system:*

1. At the very beginning, a proper waste management plan should be prepared and finalised.
2. Biomedical Waste Management is not only limited to legal aspects but it is a matter of great concern in the society.
3. Each individual should take the responsibility of handling and disposing BMW generated in houses to as far as Hospitals.
4. Each patient room, ward, doctors cabin, operation theatre, galleries and whatever area in a hospital or clinic we can think or imagine should have distinguished containers for collecting wastes.
5. Colour coded bags should be used so as to make sure that waste are properly segregated.
6. The hospital administration should give due consideration on such matters and should comply with the Biomedical waste management ordinances. A wide range of surveys conducted reveal that knowledge about BMW was not upto the mark prior to training. And some studies also revealed that majority of medicos seldom knew about the Government framed ordinances pertaining to BMW Management.[22-25]
7. Any new hospital or clinic should not be made functional until an audit has been done on the BMW treatment and disposal technique adopted by the hospital or clinic concerned.
8. Reusable items can be given preference so we can reduce the amount of wastes generated.
9. A great emphasis has to be given on BMW management to the undergraduate and most importantly the post graduate students who are pursuing Environmental Engineering.
10. Government approved vehicles for transporting the Biomedical Wastes (hazardous as well as non-hazardous wastes) should be used and their proper maintenance should be done and verified by the hospital administration.
11. Proper training to the hospital staff should be given to make them well acquainted with all sorts of information.[26]
12. A random check by the BMW management cell of the hospital should be conducted so as to make sure that wastes are being dealt as per ordinances.

13. Camps should be conducted so as to spread the importance of handling BMW especially in rural areas.
14. The hospital management should ensure that funds are available for managing biomedical wastes. This is necessary to ensure because if we look at small hospitals, it becomes difficult to manage the treatment processes due to lack of funds so sufficient funds must be year marked for this purpose.[27,28,29]

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