OPEN ACCESS INTERNATIONAL JOURNAL OF SCIENCE & ENGINEERING

HOLISTIC APPROACH OF BIOMEDICAL WASTE MANAGEMENT SYSTEM

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Abstract: **In the last two decades, economic development has resulted in huge amount of environmental pollution and waste generation. One of the main issue in the process of protection of environment is the management of solid waste which comprises reasonable preparation of collection, transportation, dispensation and disposition of solid waste materials- be it hazardous or non- hazardous. Biomedical waste is one such concerning solid waste material. This paper highlights the series of risk and concerns to human health and nature, and aims at concluding a systemic, holistic and innovative approach to biomedical waste management. One of the approaches is plasma pyrolysis which not only wards off health risks but also eliminates environmental pollution. An attempt has also being made in reviewing the current biomedical waste management practice in various hospitals in India. The disposal of biomedical waste are inspected in terms of the rules and regulations, methods of segregation, packaging, labeling and treatment techniques.**

Keywords: *Biomedical waste, health risks, environmental risks, hospital, plasma gasification, biomedical waste management.*

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I INTRODUCTION

In the last two decades, economic development in the agricultural, medical and industrial segment has led to a more lavish, content and comfortable life. This rapid urbanization and startling increase in human population, solid waste disposal especially biomedical waste is one of the major concerns [1]. Healthcare is an essential aspect of human life and such care generates a large amount of solid waste namely biomedical waste [5]. These wastes are potentially infectious and hazardous as they are contaminated with disease causing pathogens [1,3,5]. The increase in medical and public health facilities and the growing use of disposables, as a precaution against infectious diseases has resulted in the enormous increase of the medical wastes generated in the hospitals. In India millions of tons of biomedical waste are generated every year. Moreover, this waste is mixed with other municipal waste and discarded in landfill where it can contribute to environmental and health risk [4]. Biomedical waste usually contains needles, specimens, cotton, human organs, vials etc. and effective removal of various types of wastes differently is the need of the hour [5, 3]. The aim of waste administration is to clear out the surrounding environment and find out suitable ways for its neutralization. Within this waste management comes hospital waste management which deals with health care waste management for ensuring appropriate hygiene and wellbeing to health care workers and communities [3]. There are four primary ways of hospital waste management: land filling, source reduction, recycling and incineration, but all these methods of waste management have its own drawbacks. Disposal of hospital waste in an environmentally friendly manner is thus a critical necessity. Though there is no such scheme of biomedical waste management that eradicates all the risk to environment and to humans, but one such environmentally acceptable practice is plasma gasification which has been discussed in the paper [4, 3].

II BIOMEDICAL WASTE

Biomedical waste is a waste containing potentially infectious material. It includes waste that is of medical or laboratory origin e.g. packaging, bandages, dressing, gloves etc. as well as research laboratory waste containing bio molecules or organisms that are constrained from release into the environment [6]. Health care centers, hospitals, maternity, nursing homes and research facilities produce huge amount of waste such as blood, body fluid, microbiological waste, antibiotics, radioactive substances, corrosive chemicals,

highly infectious waste, discarded medicines, disposables, sharps etc. [1,4]. In India, the amount of biomedical waste generated estimates to approximately 1-2kg per bed per day except the specialized care hospitals which produce large amount of waste. The World Health Organization estimates 85% of the biomedical waste to be non-hazardous while 10% to be infectious and 5% to be non-infectious but hazardous. The disposal of biomedical waste along with municipal solid waste in landfills can lead to higher degree of environmental pollution along with posing risk to public health [4].

III CLASSIFICATION AND COMPONENTS OF BIOMEDICAL WASTE

World Health Organization classifies biomedical waste into eight groups namely:

- General Waste
- Pathological Waste
- Chemical Waste
- Infectious Waste
- Sharps
- Pharmaceuticals
- Pressurized Containers
- Radioactive Waste

But, The Ministry of Environment Forest in India has classified Biomedical Waste into ten categories which are as follows [1]:

Table 1 Components And Category Of Biomedical Waste [1]

S.No.	Waste Category	Components
1.	Anatomical	Human cells, tissues, organs etc.
2.	Animal	Tissues, organs, body parts, fluid of animals.
3.	Microbiological and Biotechnological	Waste formed by lab cultures, specimens of organisms, human and animal cell culture, devices and toxins used in cultures.
4.	Sharps	Syringes, scalpels, needles, glass and blades.
5.	Unwanted Medicines and drugs	Out of date and contaminated medicines.
6.	Solid	Things infected with body fluids like cotton, dressing, plaster casts, lines and beddings.
7.	Solid	Not reusable items like tubing's, catheters, and intravenous sets.
8.	Liquid	Waste produced by lab and from washing, cleaning and disinfecting activities.
9.	Incineration	Waste from burning of waste.
10.	Chemical	Chemicals used in biological procedures or in disinfection.

IV SOURCES OF BIOMEDICAL WASTE

Before giving importance to the waste management techniques, it is important to realize the major sources of its generation. Inability to give proper attention to the sources of waste can prove to be a major drawback in its management. The sources can be classified into two categories: primary & secondary according to the quantities of waste generated [1].

Table 2 Sources Of Biomedical Waste [1]

Primary Sources		Secondary Sources
Hospital	Medical College	Clinic
Nursing Home	Immunization Centres	Ambulance Service
Dispensaries	Nursing Homes	Home Treatment
Maternity home	Animal Research Centres	Slaughter Houses
Dialysis Centre	Blood Bank	Funeral Service
Research Lab	Industries	Educational Institutes

V HEALTH AND ENVIRONMENTAL RISKS FROM BIOMEDICAL WASTE

Treatment of animals or human beings produces biomedical waste that includes all the materials which are disposed in health care center and aren't anticipated for some other utilization. The people who are at risk are [3]:

- Doctors
- Nurses
- Patients
- Visitors
- Workers (ancillary services)
- Service workers (waste treatment and disposal)

The infections that affect these groups the most are:

- Hepatitis B
- Hepatitis C
- Human Immunodeficiency

Table III represents the type of infections with the pathogen agent and the transmission path [3].

Along with biomedical waste management programs, implementation of immunization is also taken into serious consideration. The chemical and pharmaceutical wastes generate high risks to human life as they are carcinogenic, mutagenic, corrosive and toxic [3].

Lapsed chemicals and pharmaceutical items are the essential driver of poisoning by retention, inhalation and by ingestion. It also has an adverse effect on environment because it pollutes the water when removed by drainage system [3].

Table 3 Infections Caused By Biomedical Waste [1]

Type of Infection	Pathogens	Transmission Medium
Gastrointestinal	Entero-bacteria	Faeces or vomiting
Respiratory	Mycobacterium	Saliva or secretions by respiratory organs.
Eye	Herpes Virus	Secretions through eye.
Genital	Neisseria gonorrhoea Herpes Virus	Secretions through genitals.
Skin	Streptococcus	Purulent secretions
Anthrax	Bacillus Anthracis	Secretion by skin lesion
Meningitis	Neisseria Meningitides	LCR
AIDS	HIV	Through semen, blood or vaginal secretions.
Haemorrhagic Fever	Ebola Virus	Biological fluids.
Septicemia	Staphylococcus	Through blood, semen, vaginal secretions.
Hepatitis A	VHA	Through faeces.
Hepatitis B, C	VHB, VHC	Biological or body fluids.

Dioxin is a known carcinogen produced due to incineration of plastic waste containing chlorine. This dioxin links to the organic particles and gets deposited on land and water. In acts a cancer promoter and has negative effect on human health and environment [3].

VI STEPS IN BIOMEDICAL WASTE MANAGEMENT

There are several steps that need to be followed for effective waste management from gathering till disposal which are:

A. Waste Segregation

In any waste management segregation is an important factor. Various categories of waste are treated and disposed in specific colored containers till disposal. The color coding for different types of waste are as follows:

- Yellow Plastic Bag: Incineration or deep Burial.
- Red or Blue Bag/Bin: Autoclaving, microwaving or chemical treatment.
- White Puncture Proof Translucent Container: Needles, sharps, blades etc.
- Black Bag: Chemical Waste

The bags or bins utilized for brief stockpiling ought to have bio-hazard label on them with the exception of the black container or bag which ought to have cytotoxic mark on it. In this step, the waste that is segregated is managed by reusing, recycling and reducing the waste. The chemicals, medical equipment's can be reused to help save cost. Another aspect responsible for saving cost is the recycling of specific waste materials like shredded plastic. This step not only helps In cost saving and effective management but also reduces the spread of infections to health care professionals [2,3].

B. Waste Storage

The waste that is generated has to be stored at a place before its disposal and treatment. This storage is in accordance with the Biomedical Waste Rules, 1988. Before safe disposal, the waste is stored under refrigeration to prevent any problem. The storage areas are present near the waste treatment site and these sites should not have any drains present near them as it can contaminate the nearby water source [2,3].

C. Containers and their Labeling

The containers employed for storage and transportation should be properly labeled. Each container should be checked for containing the appropriate waste material according to the color of the container. These containers must be leak proof and must have the capability to withstand chemical and thermal treatment. The containers should be rigid and puncture so that the metal sharps can be well encapsulated. Each container should have clear identification of biohazard wastes along with proper labeling [2,3].

D. Handling and Transport

Transportation of unprocessed bio-waste is required from the site of production to the site of treatment. Untreated bio-hazard ought to be gathered and transported in an approach to keep away from any peril to human wellbeing or environment. The waste should also be handled by technical personnel that have the required training. This waste ought not to be blended with some other sort of waste material. Points that need to be considered for its transportation are as follows [2, 3]:

- The vehicle should have part lodges for the vehicle bearer individual and the containers.
- The cabin base should be verified for its leak proof quality.
- Vehicle should be labeled with biomedical waste symbol.
- The inner surface of the lodge ought to be smooth to keep any water stagnation.
- The waste lodges ought to be planned such that it can be cleaned with disinfectants effortlessly.

E. Treatment and Disposal

In the treatment of biomedical waste the basic principle that is involved is that mutilation and shredding should prevent unauthorized reuse. The treatment of the

waste should be preferred to be done near the point of generation. A range of treatments available for different categories of waste are as follows [1, 2, 3]:

Table 3 Method of Disposal and Treatment of Different Categories of Waste [1]

Waste Category	Process of Treatment and Disposal of Waste
Human Anatomical	Incineration and deep burial
Animal	Incineration and deep burial
Microbiological & Biotechnological	Autoclaving or microwaving or incineration
Sharps	Disinfecting chemicals or autoclaving or microwaving or mutilation shredding
Leftover Medicines and Cytotoxic drugs	Incineration or destruction/its dumping in landfills.
Solid	Incineration, autoclaving or microwaving
Solid	Disinfecting through chemicals or autoclaving or microwaving or shredding.
Liquid	Disinfecting through chemical treatment, then discharged.
Incineration	Disposed in landfill
Chemical	Treatment by chemicals and discharged into drains

VII TECHNOLOGIES ASSOCIATED WITH DISPOSAL AND TREATMENT OF BIOMEDICAL WASTE

A. Autoclaving

Autoclaving is a thermal process. In this procedure the waste comes in coordinate contact with the steam in controlled way for an adequate term. Horizontal system is preferred which is specially designed for treatment purpose. A temperature of 121°C is required for duration of 60 minutes to effectively inactivate the microorganisms and bacterial spores. It is used to sterilize reusable medical equipment's but can also be used for small quantity of waste and releases harmful gases [5].

B. Microwave Irradiation

The heating effect of electromagnet rays is used for inactivation of microbes. The frequency of theses rays lies between 300 – 300,000 MHz. A frequency of approximately 2450 MHz is appropriate for destruction of micro-organisms. It can be used to disinfect a variety of biomedical waste but cannot be used for cytotoxic, hazardous or radioactive waste [5].

C. Chemical Method

This method has been effectively used to kill microbes on floors, walls and medical equipments but now it is used for biomedical waste treatment also. Pathogens are killed or inactivated by chemicals. It disinfects rather than sterilizes. The chemicals commonly used for this method are Sodium Hypochlorite, Fenton Reagent and Hydrogen peroxide. It is most effective in treatment of liquid biomedical waste but has high operational cost [5].

D. Solar Disinfection

This method of disinfecting the biomedical waste uses the thermal effect of solar rays. A box of solar cooker is used to disinfect which causes s reduction of approximately 7 log in the amount of viable bacteria. It is a cost effective method but cannot be used for cytotoxic, hazardous or radioactive waste [5].

E. Incineration

Burning of biomedical waste material in the presence of oxygen in order to convert them into inert material is called incineration. In hospitals, most of the waste is incinerated but that creates a lot of problems to health care workers because of the harmful gases they emit.

These gases are harmful to the environment also as they cause air pollution. After burning, the toxic ashes disposed in the landfills can go into the ground water and contaminate it [4, 5].

F. Plasma Pyrolysis

Plasma Pyrolysis is the process of using plasma with limited supply of oxygen to convert organic matter into synthetic gas which is made up of hydrogen and carbon monoxide. A plasma torch is used which is powered with electric arc to convert organic matter into synthetic gas along with slag. The plasma torch contains inert gas such as argon or nitrogen and the electrodes are made up of copper or tungsten or zirconium. Strong electric current is passed between the two electrodes under high voltage which ionizes the inert plasma gas. The temperature ranges from 4000 to 25000°F. The waste gets heated, melted and then vaporized. This process creates the synthetic gas which can be used for harnessing energy and an inert slag which can be used for construction purposes. It is a holistic approach to biomedical waste management because it is not only eco-friendly but also harnesses energy [7, 2, 4].

VIII CONCLUSION

Biomedical waste is one of the most hazardous waste generated by humans and its management is a challenging part. No method of its management is fully successful which makes it more important for us to address this issue. This issue can only be addressed once we are well versed with the basic management techniques and technologies. All the present technologies like incineration, microwave irradiation, chemical method, autoclaving or solar disinfection, have its own limitation. But through this study we can conclude that the one of best and holistic approach to medical waste treatment is plasma pyrolysis because it is not only eco-friendly but also harnesses energy and produces and inert slag.

ACKNOWLEDGMENT

The authors are thankful to the Department of Biomedical Engineering for providing necessary support and guidance for completion of this paper. We are indebted to the Department of Civil Engineering for providing the opportunity and encouragement for carrying out the study.

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