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REVIEW ARTICLE

A Study on the need for Bio-Medical Waste Management-Available Treatment Techniques and Suggestions

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ABSTRACT

The failure to address the bio-medical wastes, has led the health domain into a place where a patient who has just undergone a treatment and treated successfully, to still be prone to many diseases which he hasn't faced at all. The patient can grow immunity to a disease that he was cured of. But, that very same patient, in no case can build a resistant power to resist diseases, if his surrounding is not infective free. The improper management of biomedical wastes have not only affected the patients inside the clinical establishments, but also the people who have no contact with the clinical establishments at all. In this scenario, proper sanitation practices must be adopted and biomedical wastes should be managed for a disease free and hygienic clinical surrounding. This review focuses on the need for biomedical waste management in clinical establishments, emphasizes the possible sources of bio-wastes, methods and technologies for combating and minimizing bio-hazards arising from bio-wastes and finally outlines the overall process of biomedical waste management.

Keywords: Biohazards, Sanitation, Bio-Medical Waste (BMW), Clinical establishments, Hygiene.

1. INTRODUCTION

In 1844, an Irish physician, Francis Rynd invented the hollow needle and used it as a subcutaneous vaccination, especially to inject a sedative to treat neuralgia. In 1853, Charles Pravaz and Alexander Wood developed a medical hypodermic syringe with a needle, enough to pierce the skin. It is to be noted that, a small drop of human blood spill is itself a biomedical waste that can lead to bio-medical hazards, when not treated properly. Another example is syringes that had been used for medical treatment for centuries. There are chances for generation of biomedical hazards from biomedical wastes that are disposed from clinical establishments. The term clinical establishments, according to the Clinical Establishment Act 2010 [1], denotes all the possible zones that includes a hospital, maternity home, nursing home, dispensary, clinic, sanatorium or an institution that offers services, facilities requiring diagnosis, treatment or care for illness, injury, deformity, abnormality or pregnancy etc., It also states that the generator is responsible for the disposal of the bio-medical wastes. The World Health Organization (WHO) has also put forward certain guidelines for proper bio-medical waste management.

The clinical establishments that include hospitals usually generate biomedical wastes in an enormous amount, which can transmit infectious diseases like HIV, Hepatitis B, Hepatitis C and Tetanus [2]. These diseases are not only transmitted within the hospital environment, but also to the outside environment, where they spread by mixing with air from the place they are dumped or burnt. Hence, hospitals are regarded as a major generator for these sorts of wastes. The focus of this study is solely the biomedical wastes

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related to humans, though the animal wastes also can cause bio-medical hazards.

2. MAGNITUDE OF THE PROBLEM

The issue of managing the biomedical waste is not only centralized in one area, it is in-fact spread throughout the geographical locations where, there are huge population rates, and in the places where high level health-cares are established.

2.1. Global scenario

The quantity of bio-medical waste produced depends on the hospital policies and care being provided. Studies were conducted in developed countries which showed great deviations between countries and specialities. The range was from 1-5Kg/bed/day. Peripheral data from some other developing counties also indicated a similar range with lower figures i.e. 1-2Kg/day/patient [3]. The country wise break up is shown below in table 1.

Adapted from [4]

Table 1.Amount and composition of hospital waste generated

Country	Quantity (kg/bed/day)
U. K	2.5
U.S.A	4.5
France	2.5
Spain	3.0
India	1.5

2.2. South-Asian countries

Health-care waste is recklessly disposed into the municipal solid waste landfill or open dumpsite in most Asian countries.

Figures 1 represent how the wastes are dumped with negligence. In countries like India, incineration is the main technology being used even though releasing dioxins is found to be a disadvantage. Regulatory policies are in the primary drafting stages and enforcement and implementation of policies are still being overviewed.

2.2.1. Legislative policies

Table 2 given below shows the summary of legislative policies of South Asian countries including India. Only the acts regarding bio-medical waste management is presented. This clearly shows that, most of the countries have taken very slow and delayed steps in framing rules for this fatal issue.

Adapted from [5]

Figure 1.Spoiled medicine dumped together with municipal solid waste in dumpsite (Nonthaburi, Thailand)

Adapted from [5]

Table 2.Legislative policies framed

Country	Legislation
Bangladesh	No proper legal framework to regulate healthcare waste in National Environment Act, 1995
Bhutan	Guidelines for Infection Control (Ministry of Health) for Healthcare waste management is addressed in Environmental Code of Practice for Hazardous Waste Management, 2001 Policy
India	Biomedical waste Regulations (1998) (1st Amendments: March 2000 & 2nd Amendments: June 2000)
Maldives	No separated rules related to healthcare management in Environmental Protection and Preservation Act 1993
Nepal	No policies and legislation dealing with hazardous waste
Pakistan	Hospital waste management rules, August 2005
Sri Lanka	No proper legal framework to regulate healthcare waste in National Environmental Act. A draft of National policy in HCWM exists in 2001.

2.2.2. Hospital wastes generated in South Asian Countries

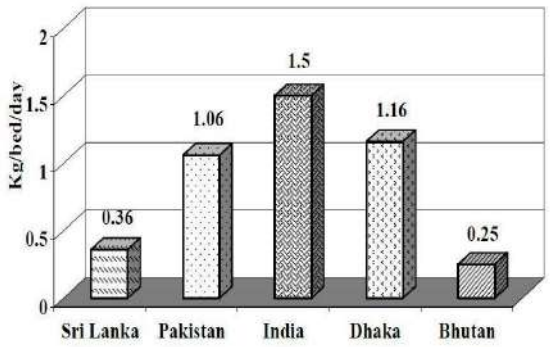
Table 3 gives the details of the generated waste in terms of Kg/bed/day and

also the wastes that are annually generated [6, 7]. Figure 2 represents the pictorial view of the average hospital wastes that are generated in some South Asian countries.

Adapted from [5]

Table 3.Hospital wastes generated in South Asian Countries

Country	Waste generation (Kg/bed/day)	Annual waste generation
Bangladesh	0.8-1.67	93,0755 tons (255 ton/day)(only in Dhaka)
Bhutan	0.27	73 tons
India	1.0-2.0	0.33 million tons
Maldives	NA	146 tons
Nepal	0.5	2,018 tons
Pakistan	1.63-3.69	0.25 million tons
Sri Lanka	0.36	6,600 tons (only from Colombo)



Adapted from [5]

Figure 2.Average bio-medical wastes generated in some South Asian Countries

2.2.3. Indian scenario

India doesn't stand out from the bio-medical waste contributing countries in the world, as it is the second highest populated country in the world. India, with its dense population, generates around 3 million tonnes of medical wastes every year and the amount is expected to grow 8% annually. Grounded on occupancy ratio of the hospitals, 700 gram per day waste is generated per bed in hospitals at Ahmedabad [8]. The pictorial representation on the information about the top 5 bio-medical waste producing states in India, is shown in figure 3 [9].

TOP 5 BIOMEDICAL WASTE GENERATING STATES

State	Biomedical waste generation and disposal (kg/day) Waste	Disposal
Karnataka	62,241	43,971
Uttar Pradesh	44,392	42,237
Maharashtra	40,197	40,197
Kerala	32,884	29,438
West Bengal	23,571	12,472
All India	4,05,702	2,91,983

Adapted from [34]

Figure 3.Top 5 bio-medical waste generating states in India

It is insisted that the bio-medical wastes should not be burnt or left as such, but should be processed using the available technologies. Figure 4 shows, some examples for the improper management of bio-medical wastes that are generated from clinical establishments [10].

These wastes must be treated with proper disposal [11]. The treatment methods for proper disposal of bio-medical wastes are expressed under the section 4.

Adapted from [10]

Figure 4.Highly contaminated syringes and blood spills

3. BIO-MEDICAL WASTE AND 'WHO'

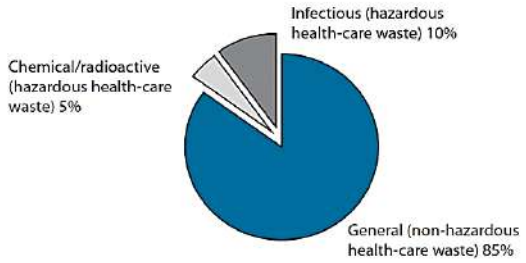
World Health Organization (WHO) defines healthcare waste as total waste generated by hospitals, health-care establishments, and research facilities by way

of diagnosis, treatment, immunization of human beings or animals, and other associated services [12].

According to estimation by WHO,

- 85% of hospital wastes are non-hazardous.
- 10% is infectious.
- 5% is non-infectious but still contains hazardous chemicals (methylchloride and formaldehyde).

Figure 5 shows the composition of health-care wastes.



Adapted from [12]

Figure 5.Typical waste composition in health-care facilities

The United Nations Conference on Environment and Development (UNCED) in 1992, led to the use of Agenda 21, which offered the following measures for trash handling. The instructions may be summarized as follows:

- Prevent and lower trash output.
- Reuse or recycle the garbage to the magnitude possible.
- Handle trash by safe and eco-friendly sound methods.
- Dispose of the finalized elements by garbage dump in confined and isolated sites.

3.1. WHO classification of bio-medical wastes

WHO classifies waste into the following categories

- **Infectious waste**

  Waste suspected to contain pathogens e.g. waste from isolation wards; laboratory cultures; materials, tissues (swabs) or equipments that have been in contact with infected excreta.

- **Pathological waste**

  Human tissues or fluids e.g. body parts; foetuses; blood and other body fluids.

- **Sharps waste**

  Sharp waste e.g. infusion sets; needles; knives; scalpels; blades; broken glass.

- **Pharmaceutical waste**

  Waste containing pharmaceuticals e.g. pharmaceuticals that are expired or no longer needed; items contaminated by or containing pharmaceuticals (bottles, boxes).

- **Genotoxic waste**

  Waste containing substances with genotoxic properties e.g. waste containing cytostatic drugs (often used in cancer therapy); genotoxic chemicals.

- **Chemical waste**

  Waste containing chemical substances e.g., film developer; laboratory reagents; solvents; disinfectants that are expired or are no longer needed.

- **Waste with high content of heavy metals**
  - Broken thermometers
  - Batteries
  - Blood-pressure gauges

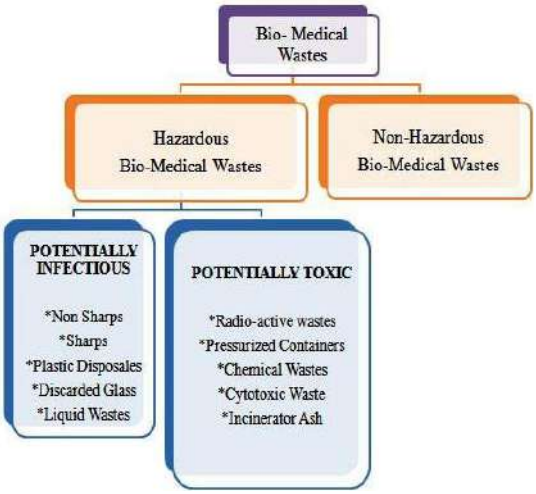
- **Pressurized containers**
  - Gas cylinders
  - Gas cartridges

- **Radioactive waste**

  Waste containing radioactive substances e.g. unused liquids from radiotherapy or laboratory research; contaminated glassware, packages, or absorbent paper; urine and excrete from patients, treated or tested with unsealed radio nuclides; sealed sources [14-19]. Figure 6 shows the general classification of hospital waste.

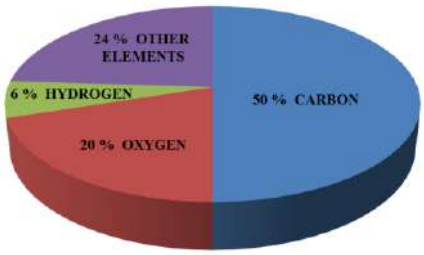
3.2. Chemical composition of bio-medical wastes

The chemical composition of the bio-medical wastes is shown in figure 7. The main ingredients include carbon at a high proportion of about 50%, oxygen of 20%, hydrogen of 6% and other chemical compounds of 24%.



Adapted from [14]

Figure 6.Hospital waste - a classification



Adapted from [17]

Figure 7.Chemical composition of bio-medical waste

4. STAGES IN HEALTH CARE WASTE MANAGEMENT

The stages in a proper health-care waste management system can be listed as follows,

- Waste generation
- Waste segregation
- Collection
- Storage
- Transportation
- Treatment and disposal

4.1. Waste generation

"Generator" means any person nominated on behalf of a hospital, nursing home, clinic, dispensary, laboratory, animal house, slaughter house, veterinary institutions including those established by or under, the control of Govt. which generates or handles any bio-medical waste [14].

Generators can be considered as separate entities if more than one BMW generator is located in the same building. The home generated wastes are not specifically regulated by BMW. The roles performed by the generators are shown clearly in figure 8.

Adapted from [17]

Figure 8.The roles to be performed by the generators

To ensure a clean and healthy environment we require, segregated collection, safe transportation and storage, environmentally sound treatment and disposal.

4.2. Waste segregation

It should be done at the source of generation of bio-medical wastes like all patient care areas; diagnostic services, operation theatres, labour rooms and treatment rooms. Figure 9 shows the bins that are used for segregating the BMW in hospitals.

Adapted from [12]

Figure 9.Hospital that has bins for segregating wastes

4.3. Collection of bio-medical waste

The bio-medical wastes that are segregated depending upon their categories are to be kept in special containers. The different techniques that are used for collection of the bio-medical wastes are listed below.

4.3.1. Colour coding system

The main objective of a colour coding system is to ensure the non-equivocal and immediate identification of hazards which is associated with the treated or handled HCW type. In such a sense, simplicity of the colour coding system should be maintained which enables its application through out the country. The colour codes are given for each type of wastes that are segregated. This is depicted in figure 10.

BIO-MEDICAL WASTES

COLOUR CODING	TYPE OF CONTAINER	WASTE CATEGORY	TREATMENT OPTIONS (As per Schedule 1)
Yellow	Plastic Bag	1, 2, 3 and 6	Incineration / deep burial
Red	Disinfected Container / Plastic Bag	3, 6, and 7	Autoclaving / Microwaving / Chemical Treatment
Blue / White Translucent	Plastic Bag / Puncture Proof Container	4 and 7	Autoclaving / Microwaving / Chemical treatment and Destruction /Shredding
Black	Plastic Bag	5, 9 and 10 (Solid)	Disposal in secured landfill

Adapted from [27]

Figure 10.Colour coding system – schedule 2

4.4. Storage

There should be special rooms within the hospitals that can store the bio-medical wastes. Unless a refrigerated storage room is available, storage times for health-care waste (i.e. the delay between production and treatment) should not exceed the following conditions given below.

During temperature climate,

- 72 hours in winter
- 48 hours in summer

During warm climate,

- 48 hours during the cool season
- 24 hours during the hot season

Untreated wastes should not be kept beyond 48 hours. If there is a need to keep these wastes for such a long period, then the authorized person is held responsible to get permission from the prescribed authority, and has to take measures that guarantee no adverse effects on health and environment.

4.4.1. Storage recommendations for risky wastes

- Cytotoxic waste should be stored separately from other health-care waste in a designated secured location.
- Radioactive waste should be stored in containers that prevent dispersion, behind lead shielding. Waste that is to be stored during radioactive decay should be labelled with the type of radionuclide, the date, and details of required storage conditions.

4.4.2. Recommendations for storage facilities for health-care waste

- There should be a water supply for cleaning purposes and easy access to the authorized persons should be enabled.
- It should be possible to lock the store to prevent access by unauthorized persons.
- Easy access for waste-collection vehicles is essential and protection from solar radiation is mandatory.
- There should be good lighting and at least passive ventilation.
- A supply of cleaning equipment, protective clothing, and waste bags or containers should be located conveniently close to the storage area.

4.5. Transporting

By definition, it means "movement of BMW from the point of generation or collection to the final disposal" [20-25].

- **On-site transport**

  Health-care waste should be transported within the hospital or other facility by means of wheeled trolleys, containers, or carts that are not used for any other purposes

  Vehicles used should be cleaned and disinfected daily with an appropriate disinfectant. A vehicle used for the onsite transportation of health-care waste is shown in figure 11 below.

Adapted from [12]

Figure 11.Bio-medical waste trolleys used in Thailand

- **Off-site transport**

  When situations arise, that the hospital wastes must be treated outside the hospital for final treatment, and disposal in a shared facility, the hospitals must abide by certain guidelines. Large hospitals with their own treatment facility, has no need to transport their wastes. But, small health-centres who do not have any treatment facilities to make the bio-medical wastes harmless, must transport their wastes to treatment sites. Hence road transport is adopted by such small health-cares. The hazardous bio-medical wastes that are transported to longer distances must have labels pasted on them.

- **Timing and documentation system**

  The transport timing should not clash with peak working hours. There should be proper documentation system which should record, the type of bio-medical waste, taken by whom, for which type of disposal on a specific date/shift etc.,. This is to ensure that all such wastes are actually disposed of, as per guidelines.

4.6. Bio-medical waste treatments

The techniques involved in treating the bio-medical wastes are,

- Incineration
- Non-Incineration
  - Autoclave treatment
  - Hydroclave treatment
  - Microwave treatment
- Chemical disinfecting
- Plasma pyrolysis
- Sanitary and secured land filling

4.6.1. Incineration

This is a high temperature thermal procedure that involves ignition of the waste within a restricted state for converting them into inert material and gases. Figure 12 given below, shows an incineration process under operation. Incinerators can be oil fired or electrically powered or a combination of both. Generally, three types of incinerators are used to treat bio-medical wastes. They are,

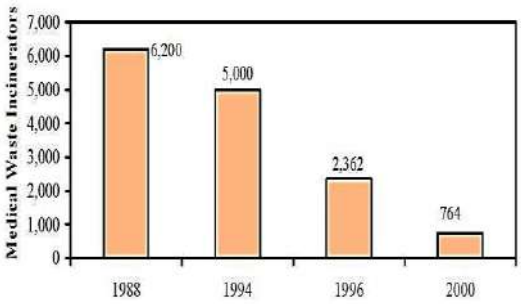
- Multiple hearth type
- Rotary kiln
- Controlled air types

All these types can contain primary and secondary ignition chambers to make sure that there is a best possible ignition. These are refractory lined**.**

The requirement for surplus airflow restricts the temperature that is feasible. Due to inadequate temperature generated in the process chamber, incinerators create extremely toxic products like furans and dioxins. Dioxins and furans may also be found in the bottom ash (TEQ level range from 106ng/kg to 466ng/kg with a mean value of 258ng/kg in municipal waste incinerators in India and fly ash has higher contamination levels 13000ngTEQ/kg).This can create air pollution or even the toxic pollutants can stay behind in the bottom ash, ultimately finding their way into the landfills [32].

Adapted from [31]

Figure 12.Incineration in operation



Adapted from [5]

Figure 13.Usage of medical waste incinerators in USA

Thus the incineration ash is potentially hazardous. The ash remains after incineration contains heavy metals that may leach out. This is the reason behind the fall in the usage of medical wastes incinerators in USA. This is shown graphically in figure 13.

4.6.2. Non-incineration

Non-incineration treatment involves four vital processes. They are,

- Thermal process
- Chemical process
- Irradiative process
- Biological process

The greater part of non-incineration technologies make the most of the thermal and chemical processes. The major principle of the treatment technology is to decontaminate wastes by destroying pathogens. Facilities ought to make sure that the technology possibly will meet up the condition criterion for disinfection.

There are two types of non-incineration technologies to treat bio-medical wastes. They are,

- Autoclave treatment/ Autocalve
- Hydroclave treatment/ Hydroclave.

4.6.2.1. Autoclaving

The autoclave technology, functions based on the theory of the typical pressure cooker. The process engages using steam at elevated temperatures. The steam created at elevated temperature breaks through the waste materials and kills all the microorganisms. These are also of three types. They are,

- **Gravity type autoclave system**

  The air is emptied with the help of the gravity alone. The system operates with the temperature of 121°C and steam pressure of 15psi. The system, with the above condition, operates for 60-90 minutes.

- **Pre vacuum autoclave system**

  Vacuum pumps are made use to empty the air from these systems. This reduces the time cycle to 30-60 minutes. It works at about 132° C.

- **Retort type autoclaves**

  They are designed at a much higher steam temperature and pressure.

Autoclave treatment has been recommended for the following wastes like,

- Microbiological wastes
- Biotechnological wastes
- Waste sharps
- Soiled wastes
- Solid wastes

This technology offers certain categories that were pointed out in the rules of bio-medical waste to be innocuous and unrecognizable so that the treated remains can be land filled.

4.6.2.2. Hydroclave treatment

Hydroclave is a dual walled container in which the steam is injected into the outer jacket to heat the inner chamber that is holding the waste. The humidity present in the waste evaporates as steam and builds up the requisite steam pressure of about 35psi to 36psi. Sturdy paddles gradually rotated by a strong shaft inside the chamber tumbles the waste always against the hot wall thus mixing as well as fragmenting the same. Due to the lack of adequate moisture, added steam is injected. The system functions at 132°C and 36psi steam pressure and a sterilization time of about 20 minutes.

The complete period for one cycle is about 50 minutes, which includes start-up, heat-up, sterilization, venting, depressurization and dehydration. The treated matters can be shredded prior to disposal. The estimated volume and weight reductions are up to 85% and 70% respectively. The hydroclave can treat the same waste as the autoclave does and the waste sharps are also fragmented. This technology has assured benefits, such as, absence of harmful air discharges, nonexistence of liquid discharges, non-requirement of chemicals, reduced volume and weight of waste etc.,

4.6.2.3. Microwave irradiation

Microwave treatment is also a wet thermal, non-incineration, disinfection technology but it is not like the other thermal treatment systems, which heat the waste externally. Microwave heats the targeted material from inside out, exhibiting an elevated level of disinfection.

Microwave technology has certain benefits, such as,

- Absence of harmful air emissions
- No requirement of chemicals
- Reduced volume of waste

Though, the investment costs are high at present, according to legislation, the microbiological and biotechnological waste, the soiled and solid waste is permitted to be micro-waved.

4.6.3. Chemical methods

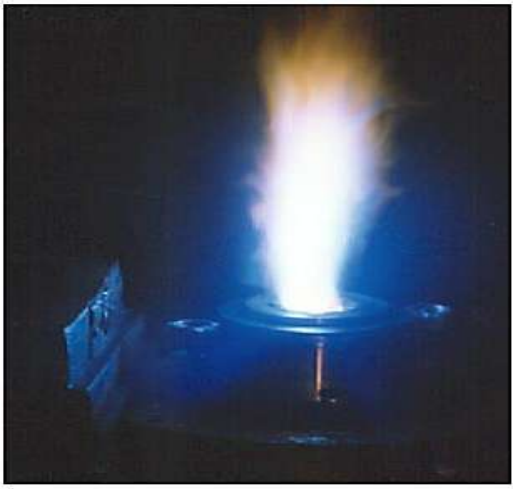
Chemical disinfecting is a treatment suggested for waste sharps, solid and liquid waste and also for chemical wastes. Chemical treatment involves the use of at least 1 per cent hypochlorite solution with a minimum contact

period of 30 minutes or other equivalent chemical reagents, such as, phenolic compounds, iodine, hexachlorophene, iodine-alcohol or formaldehyde alcohol combination.

The comparison of various treatment technologies is shown in table A1.

4.6.4. Plasma pyrolysis

Plasma pyrolysis is an advanced technology for safer disposal of bio-medical wastes [26-30]. It is an environment-friendly technology, which converts organic waste into commercially useful byproducts. Figure 14 shows the plasma torch producing high temperature plasma. The intense heat created by the plasma causes it to dispose all types of waste including municipal solid waste, biomedical waste and hazardous waste in a safe and reliable manner. Medical waste is pyrolysed into CO, H_2, and hydrocarbons when it comes in contact with the plasma-arc. These gases are burned and produce a high temperature of around 1200°C.



Adapted from [30]

Figure 14.Plasma torch producing high temperature plasma

The chemical reactions that occur in thermal cracking, by plasma, involving partial oxidation in the presence of water vapour is exhibited in the below given equations (4.1, 4.2 and 4.3). This process corresponds to the molecular dissociation by plasma.

$$C + H_2O \Rightarrow CO + H_2 \quad (4.1)$$

$$C + 2H_2O \Rightarrow CO_2 + 2H_2 \quad (4.2)$$

$$C + CO_2 \Rightarrow 2CO \quad (4.3)$$

Plasma pyrolysis combines he pyrolysis process and the thermo-chemical properties of plasma. Plasma pyrolysis uses extremely high temperatures of plasma-arc in an oxygen starved environment to completely decompose waste material into simple molecules. Hot plasmas are particularly appropriate for treatment of solid waste and can also be employed for destruction of toxic molecules by thermal decomposition.

Gas chromatography results of the plasma-pyrolysed, simulated medical waste (given in table 4) expose that typical gaseous products formed are rich in hydrogen and carbon monoxide, with some lower hydrocarbons.

Adapted from [30]

Table 4.Gases after pyrolysis

GAS	QUANTITY (%)
N_2	45.0351
H_2	22.6305
CO	26.6525
CH_4	1.5073
CO_2	4.20215
$C_2 – C_5$ (hydrocarbons: C_2H_6, C_3H_8, NC_4, IC_5, NC_5)	0.4511

4.7. Disposal of bio-medical waste

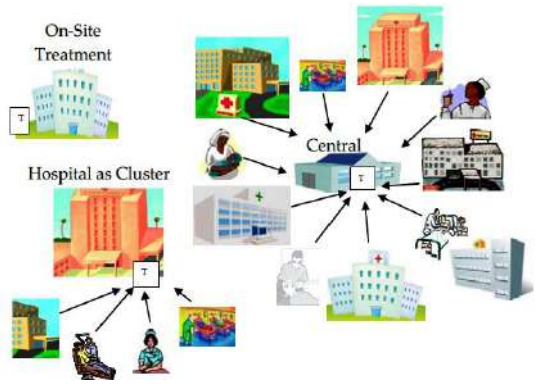
After treatment of the bio-medical waste, it becomes non-infectious or non-hazardous and depending upon the quantity of the solid waste generated the following disposal options are available

- Site as prescribed by competent authority.
- Disposal of solid waste
  - Landfill
  - Use of pills
  - composting
  - Bio-gas
- Disposal of liquid waste
  - Discharge into sewers
  - Waste stabilizing pond
  - Soakage pits

5. UNDP GEF PROJECT ON HCW

There are multi-various examples of safe and sustainable management of HCW [31]. One current initiative is the UNDP/GEF

global medical waste management project which is creating model hospitals which are mercury-free and have non-incineration medical waste management technologies. Figure 15 shows the UNDP GEF project on HCW. This is carried out in collaboration with seven countries, with WHO and HCWH as principle cooperating agencies.



Adapted from [31]

Figure 15.UNDP GEF project on HCW

6. RECOMMENDATIONS/ SUGGESTIONS

For the use of incinerator, training should be given to the staff members.

- Funds should be allocated specifically for each and every bio-medical waste management process being carried out.
- Hospitals should be provided with specially designed dustbins for keeping the bio-medical waste.
- Municipality and corporation wastes should not be mixed with bio-medical wastes.
- Private hospitals should also be allowed to use incinerators.
- Special vehicle i.e. bio-medical waste vehicles should be initiated to collect waste from private hospitals and private medical clinics for carrying it up to the main incinerator.
- There should be biomedical waste label on waste carry bags and waste carry trolleys and also posters should be put on the wall adjacent to the bins (waste) giving details about the type of waste that have to be disposed in the baggage as per biomedical waste management rule. Carry bags also have the bio-hazard symbols on them.

7. CONCLUSION

Necessary actions for waste management must be taken by civic bodies in supervising the clinical establishments. The government must show the same level of seriousness that is given to the nuclear power plants. Proper funds should be given to at least government hospitals for managing bio-medical wastes. Using safe and sustainable procedures recommended by bodies like UNDP/GEF is also a highly recommendable one. The clinical establishments should also work in full co-operation with the government in implementing the regulations.

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APPENDIX

Adapted from [4]

Table A1.Comparison of treatment technologies of bio-wastes

Treatment Systems	**Autoclave**	**Hydroclave**	**Microwave**	**Incinerator**	**Chemical**
Description	Steam sterilisation (Direct heating)	Steam sterilization, (indirect heating) simultaneous shredding and dehydration	Microwave heating of pre shredded waste	High temperature waste incineration	Mixing pre ground waste with chemicals, such as chlorine
Sterilization efficacy	Medium	Medium	Medium	High (total destruction of microorganisms)	Dependent on chlorine strength and dispersment through the waste
Capital cost	Low	Low	High	High	Moderate
Operating cost	Low	Low	High	High	Low
Operator maintenance skills	Low skill level required	Low skill level required	Automated, but highly complex and high level maintenance skill required	High level operator and maintenance skills required	High level required for chemical control and grinder
Air emissions	Odorous but non-toxic	Somewhat odorous but non-toxic	Somewhat odorous but nontoxic	Can be highly toxic	Some chlorine emissions
Water emissions	Odorous, may contain live microorganisms	Odorous but sterile	Negligible	None	None
Treated waste characteristics	Wet waste, all material recognizable	Dehydrated, shredded waste, unrecognizable material	Shredded but wet waste	Mostly ash, may contain toxic substances	Shredded wet waste, containing chemicals used as disinfectants

Adapted from [33]

Table A2.Recommendable treatment procedures

Treatment Type	Type of clinical Wastes					
	Infectious	Sharps	Pathological	Pharmaceutical	Genotoxic	Radioactive
Incineration	Yes	Yes	Yes	Yes	Yes	No
Autoclaving	Yes	Yes	No	No	No	No
Microwaving	Yes	Yes	No	No	No	No
Plasma pyrolysis	Yes	Yes	Yes	Yes	Yes	Yes
Landfilling	Yes	Yes	No	No	No	No