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Safe Disposal of Hospital Waste - A Review

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Abstract: ***The issue of improper Bio-Medical waste management is one of the serious ones all over the world. It was first discussed in a meeting by The World Health Organization Regional office for Europe at Bergen, Norway in 1983. The Environment Protection Agency (EPA) of USA first brought the issue into limelight while investigating the matter of "beach wash-ups" during summer 1998. That's why USA is considered to be the pioneer in the field of Waste Management. But when the issue concerns India, it becomes a more serious one. The issue has from time to time drawn the attention of the Hon'ble Supreme Court of India and Apex Court and the Government of India. Several non-Government organizations also have conducted so many survey works. They have issued several instructions regarding the management of Bio-Medical Waste. But all instructions, rules or laws have not always proved to be effective in India. This study explores [i] the rules for management and handling of biomedical wastes; [ii] the definition, categories of biomedical wastes, suggested storage containers including colour-coding and treatment options, [iii] the effects of biomedical waste in the environment such as air, land, radioactive pollution and [iv] disposal of wastes, regulation and recommendations [v] the reasons why the previous instructions have not succeeded fully in India.***

Keywords: Hospital solid waste; health hazard; disposal methods

1. Introduction

1.1 What is Hospital waste?

Biomedical waste may be solid or liquid. Examples of infectious waste include discarded blood, sharps, unwanted microbiological cultures and stocks, identifiable body parts (including those as a result of amputation), other human or animal tissue, used bandages and dressings, discarded gloves, other medical supplies that may have been in contact with blood and body fluids, and laboratory waste that exhibits the characteristics described above. Waste sharps include potentially contaminated used (and unused discarded) needles, scalpels, lancets and other devices capable of penetrating skin.

1.2 Classification of Bio-Medical Waste

The World Health Organization (WHO) has classified medical waste into eight categories such as General Waste, Pathological, Radioactive, Chemical, Infectious to potentially infectious waste, Sharps, Pharmaceuticals & Pressurized containers.

1.3 Generation of Hospital waste

Biomedical waste is generated from biological and medical sources and activities, such as the diagnosis, prevention, or treatment of diseases. Common generators (or producers) of biomedical waste include hospitals, health clinics, nursing homes, medical research laboratories, offices of physicians, dentists, and veterinarians, home health care, and funeral homes. In healthcare facilities (i.e., hospitals, clinics, doctors offices, veterinary hospitals and clinical laboratories), waste with these characteristics may alternatively be called medical or clinical waste.

WHO stated that 85% of hospital wastes are actually non-hazardous, around 10% are infectious and around 5% are non-infectious but hazardous wastes. In USA, about 15% of hospital waste is regulated as infectious waste. In India this could range from 15% to 35% depending on the total amount of waste generated (Glenn & Garwal, 1999; Anonymous, 1998; Chitnis et al., 2005).

1.4 Sources of biomedical waste

Biomedical waste has different sources. According to the intensity the pollution it can be divide into Major and Minor sources. Major sources are those sources where lump sum wastes are produce and it is basically regular manner. Minor sources are those sources where wastes are produce mainly regular or periodical manner.

1.4.1. Major Sources

Major Sources of solid waste are like Govt. hospitals/private hospitals/nursing homes/dispensaries, Primary health centers, Medical colleges and research centers/ paramedic services, Veterinary colleges and animal research centers, Blood banks/mortuaries/autopsy centers, Biotechnology institutions, Production units etc.

1.4.2 Minor Sources

Beside it, the Minor Sources are Physicians/ dentists' clinics, Animal houses/slaughter houses, Blood donation camps, Vaccination centers, Acupuncturists/psychiatric clinics/ cosmetic piercing, Funeral services, Institutions for disabled persons etc.

2. Amount and Composition of Hospital Waste Generated

The amount, hazardous & non-hazardous substances and composition of hospital waste are shown in Figure 1, Figure 2 & Figure 3 respectively.

2.1 Amount

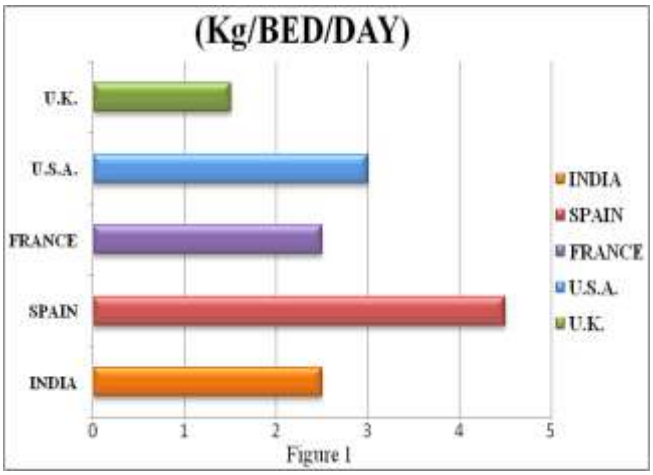


Figure 1

2.2 Hazardous/non-hazardous

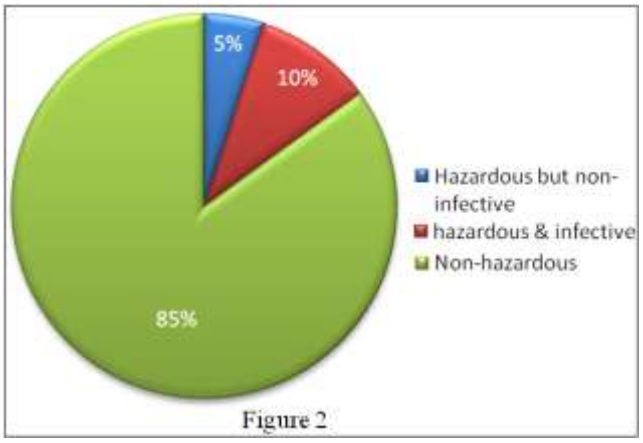


Figure 2

2.3 Composition

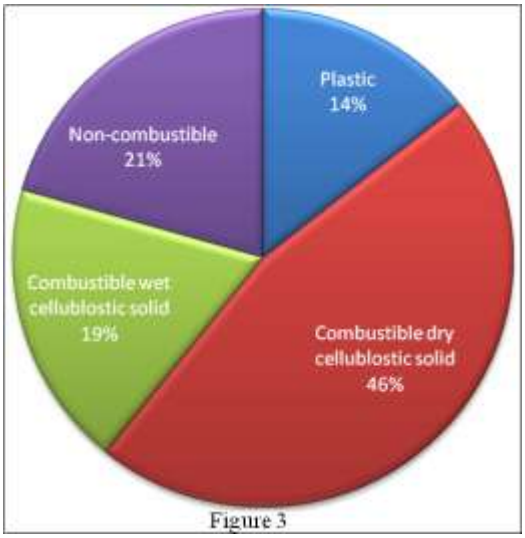


Figure 3

3. Ultimate & proximate analysis of hospital waste

Hospital waste causes dangerous infectious effect human health with its on growing capacity. Proper management of hospital waste (HW) is dependent on the expert persons suitable for handling adequate equipment which includes proper design, construction, controls and instrumentation as well as cost of operation and maintenance. On necessity of minimization and disposal of HW, various analysing methods for HW are available with their own efficacy. In which some are very usual but cause of various hazardous effect, some other better in efficiency not in financial background. With very low maintenance cost and no need of expertise incineration very popular in practice of hospital waste treatment and results good efficacy of disinfection. Fulfil the waste volume and weight in drastic way. But this method also has some limitations like it can only destroy the microorganisms, many chemicals and pharmaceuticals still in residue and also it emits of toxic pollutants. On behalf that autoclaving is efficient wet thermal process which disinfects microbial cultures or sharps type infectious wastes with minimum volume. Though this treatment allows limited quantity of waste and relatively higher operational cost, but it is recommended to the all resourceful general hospitals for its efficiency.

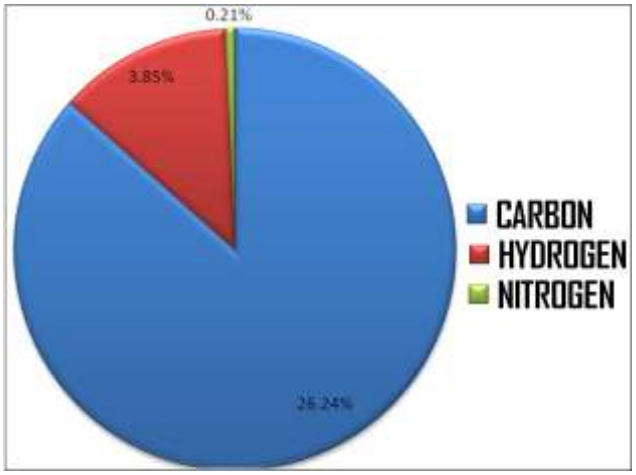
Relatively microwave is more environmentally applicable with its efficiency and drastic reduction in waste volume. It is almost 90% efficient for reduction of viable spores. But it is not recommended to the developing countries with high maintenance and potential operation. This process becomes popular in various developed countries. But none of these processes can completely destruct the chemical and pharmaceutical part of HW. Rotary kiln, Chemical disinfection and pyrolysis have great efficiency in disinfection of HW. These processes are applicable for all type of infectious waste including chemical and pharmaceutical waste. But these methods need highly financial support for installation, operation and regular maintenance. Pyrolysis and chemical waste are relatively more expensive, though these have high efficacy and it is not popular to world. A chemical in waste is very much workable technique with a high quality of chemical which generating. As similarly plasma arc pyrolysis is a technique of pyrolysis which minimizes the volume and disinfection hazardous waste. Pyrolysis is at the end of the method to generate fuel oil from waste.

Fuel oil evolved by any other processes integrally it is called Refuse derived fuel (RDF). Now a day, RDF method is more liked concerning its production of fuel oil and volume, toxicity minimization of solid waste. Advance and most recent technologies are efficient as well as high financial support for operation, maintenance and also needs very well trained expertise. Use of modern technologies in hospital waste management is exerting minimal effect on environment and human health.

Ultimate

and proximate methods of HWM

Ultimate methods	Proximate methods
Incineration is capable in reduction of waste volume upto 90% with low maintenance cost operated by untrained employees. For all types of waste this method is suitable but not so efficient in removing infectious waste. As example, a plant at Timarpur, Delhi, India is consuming 300 tonnes of HW per day.	Rotary kiln operating at high temperature (1200-1600), capable of causing decomposition of genotoxic substances and heat-resistant chemicals. Where available capacities range from 0.5 to 3 tonnes/hour. Equipment and operation costs are high, as is energy consumption. Wastes and incineration by-products are highly corrosive and Well trained personnel are required.
Autoclaving also very efficient reducing volume of HW specially the microorganism removed by 99%. But it relatively higher investment cost. As example in the European market, the cost of this type of wet thermal equipment with the capacity of 50 tonnes of waste per year is about US$ 100000.	Depending on some factors Chemical disinfection is very efficient method for HW treatment. Chemical disinfectants are main element of this process. Therefore, depending on the price of chemical disinfectants this method needs capital investment costs are in the range US$ 50000–100000 and operating costs, which are generally in the range US$ 100–120 per tonne the price of chemical disinfectants may vary from country to country. Where relatively cheap chemical disinfectants are easily available on the local market, chemical disinfection is an economically attractive treatment option. However, the process is not very popular in developing countries at present, with limited choice of equipment.
	Pyrolysis is a very much waste treatment and energy recovery method of HW. It is capable of disinfection of Infectious waste (including sharps) and pathological waste and Pharmaceutical and chemical residues. The available capacities of this method range from 200 kg/day to10 tonnes/day. Well trained personnel are only capable of handling these equipment which is relatively expensive to purchase, and expensive to operate and maintain. As in Europe, operating and maintenance costs of this method for a small-scale hospital may reach about US$ 380 per tonne of waste incinerated.
These methods are easily accessible with low installation value and limited area.	High installation value made these methods is accessible only for developed countries.
For operation and maintenance there is no need of expertise.	It needs an expert to operate and maintain the corresponding equipment.
On reduction of volume of waste these are very efficient. Incineration reduced the volume up to 90% of its total volume.	
Due to its easy accessibility and low cost, these methods are much popular.	



4. Present Scenario of Hospital Wastes

In India, hospital wastes generate around 3 million tonnes every year and the amount is expected to grow at 8.00 per cent annually. Health care wastes if not handled and disposed indiscriminately may cause adverse effects on human health and environment. According to the available information from the State Pollution Control Boards (2007-08) 52,001 (53.25 %), health care establishments are in operation without obtaining authorization from their respective SPCB/PCC. Approximately 288.20 tons per day (56.87%) out of 506.74 tons per day wastes generated is being treated either through Common Bio Medical Waste Treatment Facilities (159 in number) or captive treatment facilities. There are 602 bio medical waste incinerators (which include both common and captive incinerators), 2218 autoclaves, 192 microwaves, 151 hydroclave and 8,038 shredders in the country. About 424 (70.4%) out of 602 incinerators are provided with air pollution control devices and 178 (29.6 %) incinerators are in operation without air pollution control devices.

4.1 A Survey of waste generated in the hospitals of Murshidabad district, West Bengal, INDIA:

From a small survey of some hospitals at Murshidabad District in West Bengal (INDIA), the following data are collected.

S. No.	Name of the Hospitals	No of Beds	Waste generated/ bed/day	Total Waste generated/ year
1	Kandi Sub- divisional Hospital	250	550 g	50187.5kg
2	Bharatpur-I B.P.H.C.	55	300g	6022.5kg
3	Bharatpur-II B.P.H.C.	55	350g	7026.25kg
4	Burwan Rural Hospital	30	400g	4380kg
5	Khargram Rural Hospital	55	400g	8030kg
6	Gokarna B.P.H.C.	30	200g	2190kg
7	Berhampore Medical College Hospital	950	>1kg	346750 kg

8	Gitaram Hospital	100	350g	12775kg
9	Rabindranath Tagore Diagnostic Centre	80	300g	8760kg
10	Monmohini Hospital	100	310g	11315kg
11	Glocal Hospital Berhampore	110	450g	18067.5kg

5. Diseases come if not properly disposed

5.1 Health hazards

According to the WHO, the global life expectancy is increasing year after year. However, deaths due to infectious disease are increasing. A study conducted by the WHO in 1996, reveals that more than 50,000 people die everyday from infectious diseases. One of major causes for the increase in infectious diseases is improper waste management. List of infections and diseases documented to have spread through bio-medical waste. Tuberculosis, pneumonia, diarrhoeal diseases, tetanus, whooping cough etc., are other common diseases spread due to improper waste management (Chitins et al, 2002; Chitins et al, 2003; Tudor et al, 2005; Marinkovic et al, 2005).

5.2 Occupational health hazards

Occupational health concerns exist for janitorial and laundry workers, nurses, emergency medical personnel, and refuse workers. Injuries from sharps and exposure to harmful chemical waste and radioactive waste also cause health hazards to employees in institutions generating bio-medical waste. Proper management of waste can solve the problem of occupational hazards to a large extent (Patil & Shekar, 2001).

5.3 Hazards to the general public

“Generator” means any person nominated on behalf of a hospital, nursing home, clinic, dispensary, laboratory, animal house, and slaughter house, veterinary institutions including those established by or under, the control of Govt. Which generates or cause to be generated, handles or cause to be handled any Bio Medical Waste or where no such person is nominated the person in charge thereof? Thus, all the Hospitals, nursing homes, veterinary hospitals, clinics, dispensaries, diagnostic laboratories, ’ pathological laboratories, blood banks, mortuary and any other health care establishments are the potential generators of Bio-Medical Waste.

The general public’s health can also be adversely affected by bio- medical waste. Improper practices such as dumping of bio-medical waste in municipal dustbins, open spaces, water bodies etc., leads to the spread of diseases. Emissions from incinerators and open burning also lead to exposure to harmful gases which can cause cancer and respiratory diseases (Manohar et al, 1998; Da silva et al, 2005).

Plastic waste can choke animals, which scavenge on openly dumped waste. Injuries from sharps are common feature-affecting animals. Harmful chemicals such as dioxins and furans can cause serious health hazards to animals and birds. Certain heavy metals can affect the reproductive health of the animals (Code & Christic, 1999).

6. Methods of disposal in various countries

There are mainly five technology options available for the treatment of Bio-Medical Waste or still under research can be grouped as Chemical processes, Thermal processes, Mechanical processes, Irradiation processes & Biological processes.

6.1 Chemical processes

These processes use chemical that act as disinfectants. Sodium hypochlorite, dissolved chlorine dioxide, per acetic acid, hydrogen peroxide, dry inorganic chemical and ozone are examples of such chemical. Most chemical processes are water-intensive and require neutralising agents.

6.2 Thermal processes

These processes utilise heat to disinfect. Depending on the temperature they operate it is been grouped into two categories, which are Low-heat systems and High-heat systems Low-heat systems (operates between 93-177°C) use steam, hot water, or electromagnetic radiation to heat and decontaminate the waste.

Autoclave & Microwave are low heat systems.

Autoclaving is a low heat thermal process and it uses steam for disinfection of waste. Autoclaves are of two types depending on the method they use for removal of air pockets are gravity flow autoclave and vacuum autoclave.

6.3 Mechanical processes

These processes are used to change the physical form or characteristics of the waste either to facilitate waste handling or to process the waste in conjunction with other treatment steps. The two primary mechanical processes are

- Compaction - used to reduce the volume of the waste
- Shredding - used to destroy plastic and paper waste to prevent their reuse. Only the disinfected waste can be used in a shredder.

6.4 Irradiation processes

Exposes wastes to ultraviolet or ionizing radiation in an enclosed chamber. These systems require post shredding to render the waste unrecognizable.

6.5 Biological processes

Biological enzymes are used for treating medical waste. It is claimed that biological reactions will not only decontaminate the waste but also cause the destruction of all the organic constituents so that only plastics, glass, and other inert will remain in the residues.

7. Decomposition

7.1 Electric arc plasma

Plasma arc recycling doesn't involve combustion. Instead of

simply burning the waste (at a few hundred degrees), the waste is heated to much higher temperatures (thousands of degrees) so it melts and then vaporizes. This is done by an electrical device known as a plasma arc, which is a kind of super-hot "torch" made by passing gas through an electrical spark.

7.2 What is plasma?

Plasma is the fourth state of matter. Many places teach that there are three states of matter; solid, liquid and gas, but there are actually four. The fourth is plasma. To put it very simply, a plasma is an ionized gas, a gas into which sufficient energy is provided to free electrons from atoms or molecules and to allow both species, ions and electrons, to coexist. The funny thing about that is, that as far as we know, plasmas are the most common state of matter in the universe. They are even common here on earth. Plasma is a gas that has been energized to the point that some of the electrons break free from, but travel with, their nucleus. Gases can become plasmas in several ways, but all include pumping the gas with energy. A spark in a gas will create plasma. A hot gas passing through a big spark will turn the gas stream into a plasma that can be useful. Plasma torches like that are used in industry to cut metals. The biggest chunk of plasma you will see is that dear friend to all of us, the sun. The sun's enormous heat rips electrons off the hydrogen and helium molecules that make up the sun. Essentially, the sun, like most stars, is a great big ball of plasma.

7.3 How plasma can destroy pathogens?

Microorganisms that cause pathology in humans and animals enter the body at different sites and produce disease by a variety of mechanisms. Many different infectious agents can cause pathology, and those that do are referred to as pathogenic microorganisms or pathogens.

Plasma treatment can effectively inactivate a wide range of micro-organisms. They attack viruses and other pathogens. They also make antibodies which help to destroy bacteria.

7.4 Advantages of electric arc plasma

Plasma method utilizes efficiently all four types of hazardous, toxic or lethal waste because of high temperature, capable of disassociating molecular bonds.

Plasma waste utilization method takes place in a close system, without releasing ashes, waste remnants, dusts and toxic gases into environment. Regained metals return to metallurgic industry and created slag is used as an additive to road construction materials. Non-toxic gases, which are created, are stored in special containers (gas cylinders) and used as fuel and energy creators.

The volumetric waste reduction for most solid wastes is approximately 300 to 1. Conventional incineration ratio is in the range of 5 to 1 since large quantities of ash are produced.

Plasma technology allows converting large quantities of municipal waste in the range of 10 to 500 tons a day.

This method of waste reduction is the only method available to reduce electronic waste, which does not undergo biodegradation.

The costs of using plasma technology are significantly reduced from $40/ton to **ZERO** as a result of creation of ecologic by-products. The costs of using conventional incineration are in the range of $100/ton.

Contaminates in slag and gases created during plasma utilization with elements such as mercury, cadmium, sulphur, SO_2, HCL, dioxins, selenium, chromium, lead, barium, arsenic, radioactive elements are strictly controlled by usage of special water or dry scrubbers and filters. Using this method elements are considerably minimized below environmental standards. The remainder of the pollutants sink into glassy slag and can be treated further in close system, which is a major distinction to conventional incineration.

The ashes that are formed as a result of conventional incineration can be burned down to further using plasma technology to make them harmless.

Contemporary plasma converters are computer controlled, safe, quiet and can be stationary or mobile.

Plasma waste utilization will improve public health and safely achieve “total and irreversible destruction of hazardous and toxic compounds”, “lethal viruses, bacteria and prions that are so dangerous to our health.” (Startech Environmental Corp.)

8. Conclusions

In India, the effects of improper Bio-medical Waste Management have been identified by both Government and Non-government organizations. The improper Biomedical Waste management causes so many diseases to take an epidemic form. It has a long term negative effect on health as well as on environment. Therefore, several hazards and toxic materials containing should be disposed off with proper care. Previously the issue was more serious because in the past medical waste was often mixed with household waste and disposed of in municipal solid waste landfills. But in recent years, increased public concerns have resulted in systematic management of biomedical wastes. But in India, the management is not so easy. Increasing population of India, inadequate planning, lack of infrastructure, lack of general awareness, costly management systems, epidemic form of diseases have led to failure in this regard. Therefore, along with solving other problems, low cost management system should be imposed. Electric arc plasma process is also to be carried on.

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