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A Study about Knowledge, Attitude, Practices and Technologies of Biomedical Waste Management Techniques

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Abstract:*Biomedical waste poses a big threat to both human beings and also to the environment. Today, about one fourth of the total biomedical waste is found hazardous. The safe and appropriate disposal of the healthcare related waste, are of big concern for mass wellbeing. This paper, gives a review about the awareness of people about biomedical waste management, their attitude towards it and, various practices in biomedical waste management. Various techniquesare discussed in the paper along with a new hybridized technique which seems to be very efficient and reliable in biomedical waste treatment process. The objective of this technique is to eliminate the risk of getting infected during the waste treatment and also to bring down the stress in the biomedical waste management procedures.In this technique, disinfecting is done using ultraviolet rays and ultrasonic waves.*

Keywords:*Biomedical Waste Management, Healthcare, Segregation, Waste treatment, Disposal*

I. Introduction to Biomedical Waste

Biomedical waste is a term used for the waste that is generated during the treatment, and the diagnosis of human beings or animals, and may also be generated in some research activities, or in testing of the biological components etc. In other words, biomedical waste can be defined as the health care waste, including the waste of the healthcare establishment, or research amenities, or in laboratories. Biomedical waste can be classified into two types. First is the biological waste and, second form is the non-biological waste. An another classification is infectious and non infectious waste [1][4]. Healthcare activities produce the biomedical waste having great possibility of being infectious than any other type of waste. This type of biomedical waste can create great hazards to the health of all living beings. So, this becomes very essential to handle this biomedical waste.

Biomedical Waste Problem:

These days, the proper disposal and collection of the biomedical waste has become a significant concern for both the medical personnel and the general community [9]. There can be many hazards if we are unaware of handling this, but among all HIV/AIDS, Hepatitis B and Hepatitis C are having very strong substantiation of transmission through the healthcare waste [3][9]. So, it can be said that although the advancement of medical science is a need of mankind but, its waste can be hazardous, or even lethal. Effective management of the biomedical waste is also a social responsibility along with a legal necessity.

If the biomedical waste gets mixed with the municipal waste it becomes even more dangerous. As, it may lead to a number of diseases which easily passes to human beings through various means, like birds, insects, rats or other animals. There are very few biomedical waste treatment plants in India. Most of the healthcare systems were follow the indiscriminate disposal of waste, which may lead to adversative effect on living beings and also on environment.

II. Biomedical Waste Management

Biomedical waste treatment and its disposal both have to be done very carefully, as this can cause various types of infections during its handling also.

From 1994-1995, the government of India, ordered the medical personnel not to put the biomedical waste in municipal bins. But order them to burn it [10].

In 1998, government framed Biomedical Waste (Management and Handling Rules). According to the rule, the biomedical waste must be treated and disposed according to the options given under Schedule I, and in compliance with the standards given in Schedule V of the rule [1].

Any standard method of biomedical waste treatment comprise of segregation, followed by storage in colour coded containers, systematic collection of waste, transport it to the treatment site, treatment according to waste type. Segregation is done on the type of waste. Good segregation is the key to successful biomedical waste management. Incineration, deep burial, microwave, autoclave, chemical treatment etc. are various waste treatment options as per the Schedule I, of the rules. Disinfection is done to reduce the number of micro-organisms on the biomedical waste. While, sterilization is the removal of all the micro-organisms, including spores also. Sterilization is done by dry heat,or by various types of moist heat [14],[19]

Schedule I: Schedule I is given under Biomedical Waste (Handling and Management) Rules in 1998 [14].It describes various categories of waste along with the disposal and treatment method which should be used for that Category waste, as given below.

Category	Source of Waste	Treatment and Disposal Method
1	Human Anatomical Waste	Incineration/Deep Burial
2	Animal Waste (Tissues, Organs and Body Parts)	Incineration/Deep Burial
3	Biotechnology and Microbiological Waste (Wastes from laboratory cultures, Stocksor specimens of micro-organisms live or attenuated vaccines, Human and animalcell culture, Biological, Toxins, Dishes and devices used for transfer of cultures)	Microwaving/Incineration/Local Autoclaving
4	Waste Sharps (Needles, Syringes, Scalpels, Blades, Glass, etc.)	ChemicalTreatment/Microwaving/Shredding/Autoclaving
5	Discarded Medicines and Cytotoxic drugs	Incineration /Destruction
6	Soiled Waste (Contaminated with blood and body fluids such as cotton, Dressings, Soiled plaster casts, Lines, Beddings)	Incineration/Autoclaving/ Microwaving
7	Solid Waste	Chemical Treatment/Autoclaving/ Microwaving/Shredding
8	Liquid Waste	Chemical Treatment/Discharge intodrains
9	Incineration Ash	Disposal in landfill
10	Chemical Waste	Chemical treatment/Discharge into drains

III. Knowledge, Attitude, and Practices on Biomedical Waste

S. Thirumala [1], in Sept. 2013 conducted a survey about biomedical waste in Hospitals of Davanagere city. He has observed lack of awareness,and improper waste management systems. Although, the conditions were found better in Bapuji Hospital, Davanagere about biological waste management. He concluded that cost saving and well-organised waste management systems are necessary.

Alok Sharma and others [2], prepared a 144 questionnaires and, the result of the survey was surprising. 36% of the nurses were found having very poor knowledge, and only 15% of Class VI had an excellent knowledge about biomedical waste management practices. They concluded that people have poor knowledge and very less awareness of hazards generated by biomedical waste, its legislation and treatment.

Rajesh K Chudasama [3], performed a study on biomedical waste management at tertiary care hospital, in Rajkot. Based on his study, it was concluded that, the importance of training about biomedical waste management cannot be overemphasized, lack of good knowledge about waste on this topic has great impacts on practices of proper waste management.

A survey conducted on biomedical waste management in Varanasi city, India by Vijai Krishna, Nitika Naik, and Sadhana Chaurasia shows that 49% of the hospitals, pathological laboratories, and nursing homes are not involved in biomedical waste treatment, although, remaining 51% are actively co-operating with Centre for Pollution Control (C.P.C) for biomedical waste management [4]. It was observed that, C.P.C is doing good in biological waste disposal, and also in keeping the environment healthy.

The result of the study about the knowledge, attitude and practices done by Sanjeev R and others, among dental healthcare personnel in Kothamangalam, is that, the mean attitude, knowledge and practice scores are 4.69 ± 1.97, 4.35 ± 1.63, 4.43 ± 0.78 respectively [5]. This study reveals that knowledge and practice among the personnel is low, although attitude score is high about the biomedical waste management.

A study of biomedical waste management practices at King George's Medical University, Lucknow city, Uttar Pradesh, India gives the status of the biomedical waste management [6]. The King George's Medical University uses high-density polyethene bags inside the colour coded bins. Infectious and non-infectious wastes are collected separately. Waste collection is done by seven teams, each with four members. They collect the waste 3-4 times a day. 3 types of trolley are used for transportation of waste. The central site where collection and treatment is done is ventilated along with fire protection facilities.

The research is done by Anjali Acharya, and team about the impact of biomedical waste on environment of city Pune, India [7]. The conclusion drawn from this is that there can be direct and indirect health consequences of living beings and also to the environment. Indirect hazards are due to toxic emissions from the inadequate burning of the waste. Whereas direct hazards can happen when disposable materials are re-used.

A case study of Gandhinagar Hospital, Jammu, reveals that the average solid waste generation per day per bed is 632.04 g [8]. The waste management system of the hospital includes collection of waste by sweepers and disposing it into the community dustbins. Thus, it can be concluded that the biomedical waste from the hospital are not disposed in a well manner. This type of disposal can cause serious threat to the living beings in that area.

Biomedical waste management practices, in Mandya City shows that due to urbanisation, the rate of biomedical waste generation has increased rapidly [15]. In some hospitals in the city there is lack of colour coded bins. And in most of the hospitals closed bins are not available.There is no accountability of waste generation. Cleanliness has not been maintained at the places where the waste bins are placed and there is splash of blood on the wall also, medicine spillages on the ground. Waste handlers use surgical gloves while handling the waste which doesn't protect the palm from sharps andsyringes.

Case study of various hospitals in Eluru, Andhra Pradesh, is done, and it is observed that in many hospitals of the city thebest biomedical waste management practices are not following meticulously by the doctors, staff and, nurses [16].

Many studies are available on the improper disposal of biomedical waste. The study toinvestigate and followed the disposal of clinical waste within dental surgeries in Bangkok and found that mostwastes were disposed of into the domestic rubbish stream.

IV. Biomedical Waste Management Techniques

The proper waste management procedure comprises of the following steps [11],[14].

1. Waste Survey
2. Waste Segregation
3. Waste Storage
4. Waste Transportation
5. Waste Treatment and
6. Waste Disposal

1. Waste Survey

The very first step in biomedical waste management is to identify the various areas where this waste is generated [11]. The area which are the major source of biomedical waste are healthcare institutes, hospitals, clinics, research institutes, blood banks, veterinary institutes, and animal houses.

2. Waste Segregation

Waste segregation is the key to successful biomedical waste treatment process. Generally, colour coding and labelling is used for the waste containers. So that there can be an easy identification of waste type of each container [11][12]. According to the biomedical waste rules, 1998 in India, there are ten categories of biomedical waste, described as:

1. Human Anatomical Waste 2. Animal Waste 3. Microbiology and Biotechnology Waste 4. Waste Sharps 5. Discarded Medicines and Cyto-toxic Drugs 6. Soiled Waste 7. Solid Waste 8. Liquid Waste 9. Incineration Ash 10. Chemical Waste

Yellow colour code is used for categories 1, 2, 3, and 6.
Red colour code is for the categories 3, 6, and 7.
Blue/White transparent bags are used for categories 4, and 7.
Black colour code is used for categories 5, 9, and 10.
Category 8 do not require any container/bag.

3. Waste Storage

Storage of biomedical waste is necessary at two places:

1. The place where waste is generated,
2. Common storage area for total waste of an organisation

While storing each waste must be put into the appropriate coloured bags. When the bag or the container is sealed for transportation/treatment appropriate label should be provided on it [12]. Label must contain 'biohazard' symbol, name of department/ward where waste is generated. It should also contain details of both sender and receiver over it along with the details of person who can be contacted in case of emergency.

4. Waste Transportation

Wheeled trolleys, carts, or containers can be used for transportation of biomedical waste. These must not be used for any other purpose [12]. The corridors used to take waste should not cross the paths used by the visitors and patients. The waste should be taken to the common storage area for the further treatment. Suitable system should be used for securing the load during the transport.

5. Waste Treatment

The biomedical waste treatment and disposal should be done in accordance to the Biomedical Waste (Management and Handling) Rules, 1998. Different categories of waste should be treated in different ways according to Schedule I of the rules [11]. There is not a single technology to handle all types of biomedical waste.

6. Waste Disposal

Several techniques are used for waste disposal, different for different types of biomedical waste. The techniques for waste treatment and disposal are discussed below.

A. Thermal Treatment Techniques

i) Incineration

It is a high temperature, dry oxidation technique. This process involves the combustion of waste under controlled conditions [13],[14]. In this, waste is converted into inert gases and material. This treatment is done at 800-1100°C temperature. Generally, rotary kiln having multiple hearths or controlled air types incinerators are used for heating up.

According to rules, this method has been recommended for cyto-toxic drugs, human anatomical waste, discarded medicines, animal waste, and soiled waste. This is one of the advantages of this technique that it can be used for a variety of biomedical waste.

Disadvantage of this technique is the production of ash and combustion by-products during treatment.
Limitation: This is a very high cost technique.

ii) Autoclaves Treatment

This is a low heat process involving steam sterilisation under some pressure. To disinfect the waste material, steam is brought in direct contact with biomedical waste for a sufficient duration of time. Gravity type, Retort type, and Pre-Vacuum type autoclaves are used for it. The temperature of this treatment process varies from 120-140°C.

This treatment is recommended for biotechnology waste, microbiology waste, soiled and solid wastes.This method is used for centuries for sterilizing the medical instruments [13],[14].
Limitation: A limitation of this treatment technique is that,it cannot be used for large anatomical waste as it is difficult to determine the time and temperature needed before treatment.

iii) Plasma Pyrolysis Technology

This is an, another thermal disintegration method for carbonaceous materials in an oxygen starved environment. It works on the principle of converting electrical energy into heat energy [13],[14]. In this method primary chamber pyrolysis takes place at 1100°C and the secondary chamber combustion takes place at 950 to 1000°C.

Advantage of this method is that lesser number of POPs (Persistent Organic Pollutants) are formed, also it is a compact smoke free technology and consumes less space.
But, has a disadvantage of its high cost and high requirement of technical persons.

iv) Gasification Technique

This process operates with the substoichiometric air level. In this, waste is heated at 500-1600deg. C with $O_2$and H_2O as gasification agent at 1-45 bar pressure, depending upon the type of waste [17],[18].
This technique has same disadvantages as incineration technique.

B. Integrated Steam Based Treatment Techniques

v) Hydroclave Treatment

It is also a steam sterilisation process similar to autoclave treatment process. In this method a doubled wall container is used [13],[14]. Steam is injected into outer jacket so as to heat inner chamber of container. Waste material is contained in the inner chamber. The total process includes start-up, heating, sterilising, venting, depressurisation, and dehydration. The weight and volume of waste is reduced upto 85% and 70% respectively.This treatment is used for waste sharps.

vi) Microwave Treatment

This treatment process is a wet thermal disinfection technology, in this the waste is heated from inside out [12],[14]. It provides a high level of disinfection. The waste is shredded and allowed to enter the microwave generators.
This method has some benefits like, absence of harmful emissions, non-requirement of chemicals, absence of liquid discharge, and more. The main disadvantage of the process is its high cost.

C. Chemical Based Treatment

vii) Chemical Disinfection

Chemical treatment is performed by using 1% hypochlorite solution with a minimum contact period of 30 minutes. This treatment is used for the infectious waste only.

Limitation: This technique does disinfecting rather than sterilizing [13],[14]. Also, the chemical treatment of solid infectious waste is problematic as this can generate toxic liquid waste.
The waste treated by this method requires specialized disposal after treatment.

viii) Sanitary Landfill

Sanitary land filling method can used in place of incineration for the human anatomical waste. It can also be used for autoclave/microwaved/hydroclaved waste.

V. Advanced Technologies

ix) O_3Technique

Ozone is a strong oxidising agent as it breaks very easily to form more stable O_2. In this technique mixers and shedders are required so as to expose the biomedical waste to the bactericidal agent [13],[14]. Ozone is used for air purification and water treatment.

A disadvantage of this method is that if ozone concentration goes more than 0.1 ppm, it can cause irritation in eyes and some problems in respiratory system.
So, regular tests are needed to ensure that microbial inactivation standards are met.

x) Promession

It includes a mechanical process and, removal of heat to destroy anatomical waste [13],[14]. This technique involves cryogenic freeze-drying of waste using liquid nitrogen and mechanical vibration to disintegrate waste into powder before its burial.

xi) Proposed Hybrid Technology

The new hybrid biomedical waste management technology proposed in this paper, focuses on the development of an integrated treatment systemand disinfection of the biomedical waste using ultraviolet rays and ultrasonic waves, the objective of the technology is to reduce the risk of infection and to minimizethe stress of the biomedical waste treatment procedures.

There are some more emerging technologies such as gas phase chemical reduction, super critical water oxidation, vitrification, sodium reduction, biodegradation and more. These all techniques are under considerations and are not implemented practically till now. They can be supposed to the upcoming waste management techniques having better performances [17],[18].

VI. Conclusion

Every concerned health personnel should have proper knowledge, practice, and capacity to work on the problem of biomedical waste collection, proper handling techniques, and its management.But in the real scenario, as concluded from the case studies discussed in paper, people concerned with this do not have appropriate knowledge about the treatment of waste. The practices done for biomedical waste management are poor in most of the organisations.Unawareness of people about the lethal hazards of biomedical waste can be a reason for this behaviour. In all the case studies discussed, it is noted that only a few institutions follow the guidelines given in Biomedical Waste (Handling and Management) Rules during waste management. Some hospitals even do not have coloured bins, and trolleys to store and transport biomedical waste.

It can be revealed from the study that at some places although theattitude about waste management is high, the knowledge and practice is comparatively low.

Biomedical waste management should be done very carefully according to the given technologies, otherwise it may lead to deadly diseases.It is very important to perform biomedical waste management in an appropriate manner so as order to protect our environment and health of community. We must sensitize ourselves to this important issue not only in the interest of health managers but also in the interest of community.

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