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BIOMEDICAL WASTE MANAGEMENT IN A TERTIARY CARE HOSPITAL. A SCIENTIFIC REVIEW.

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Abstract

The interaction of the micro- (internal) and macro- (surrounding) environments of human beings determines the status of the health of an individual or of the community at large. On a daily basis, the generation and disposal of biomedical waste have become an emerging problem world over. These are being produced during the processes of sampling, testing, diagnosis, therapy, immunization, and surgery on humans, animals, and in research experiments. Several categories of biomedical waste have been discussed, and steps involved in the management of biowaste include segregation, storage in containers, labeling, handling, transport, treatment, disposal, and waste minimization. Potential implications of biomedical wastes include transmission of diseases like Hepatitis B, C, E, dengue, and HIV through improperly contained contaminated sharps; proliferation and mutation of pathogenic microbial populations in municipal waste through dumping of untreated biomedical waste; and physical injury and health hazards. Certain other implications include degradation of the environment esthetically by careless disposals, having a negative effect on public health; increased risk of nosocomial infections; change of microbial ecology and spread of antibiotic resistance; and increased density of the vector population, resulting in the spread of diseases in public. Sensitization and public awareness are important to protect the environment and public health globally.

Keywords- Biomedical waste, hospital environment, health, infection

Introduction

The status of the health of an individual or community is determined by the interplay and integration of the micro (internal) environment of human beings and the macro (external or surrounding) environment. Imbalance in these two may have serious repercussions on the national well-being. Therefore, a balance has to be maintained in order to increase living standards and promote a healthy society (Neema and Gareshprasad, 2002; Murthy et al., 2011).

There has been an insignificant amount of waste generated by the human population throughout the history of mankind due to lower societal levels of exploitation of natural resources. Mainly, ashes as biodegradable wastes were commonly produced during the pre-modern era and had been released back into the local ground with minimal environmental impact. Certain civilizations are, however, more prolific in their output of waste than others, for which management of waste has become a pre-requisite (http://www.siemens.com). Physical as well as social factors in and around the surroundings of man's environment include land, water, atmosphere, climate, sound, odor, and taste, along with certain biological factors, viz., animals, plants, etc. These factors play a significant role in regulations' formulation for appropriate management of biological wastes (Hegde et al., 2007; Centre for Environment Education and Technology, 2008).

Medical wastes in hospitals are otherwise known as clinical wastes. Normally, waste products is the term applied to those wastes that are produced in healthcare premises (hospitals and clinics; offices of doctors and veterinary hospitals) (National Research Council Recommendations Concerning Chemical Hygiene in Laboratories, 2013). So far, management of waste in the medical profession has not been considered an issue. In the 1980s, concerns have been raised regarding exposure to human immunodeficiency virus (HIV) and hepatitis B virus (HBV). The disposal of biomedical waste has thus become a major emerging problem worldwide. There is an urgent need for planning and the implementation of procedures and practices that are updated at various levels of the plan concerning the management of biomedical waste, associating it with the health of the environment (Patnaik, 2007; Gautam et al., 2010).

Biomedical waste (BMW) is the waste produced during the processes of sampling, testing, diagnosis, therapy, immunization, and surgery on humans, animals, and in research experiments. This includes categories mentioned in Schedule I of the BMW (Management and Handling) (Second Amendment) Rules, 2000, as amended by the Ministry of Environment and Forests Notification. The Common Biomedical Waste Treatment Facility (CBWTF) is a set-up that necessitates biomedical waste treatment generated from numerous healthcare units, reducing the adverse effects. It must be managed properly to protect the public, particularly the healthcare and sanitation workers who are exposed to biomedical waste on a regular basis, leading to occupational hazards (http://www.initial.co.uk/medical-services/regulations/index.html). Wastes that are treated may be dispatched to landfills or recycled.

Recently, as a major concern, biomedical waste management has emerged as an issue for both hospitals and nursing home authorities, as well as for the environment. From health care units, the biomedical waste that is generated depends upon several factors, viz., methods of waste management, various types of units of health care, health care unit occupancy, health care unit specialization, reusable items and their ratio in use, infrastructure and resources, and their availability (Mandal and Dutta, 2009). As a humanitarian topic, biomedical waste and its proper management have become global issues. Worldwide hazards of biomedical wastes and their poor management have raised concern, especially on the ground of their far-reaching effects on humans as well as health and the environment. During the care of patients, several hospital wastes are generated that have several harmful as well as adverse effects on the environment. To the workers associated with health care too, hospital wastes possess a potential health hazard. An increasing issue of concern to hospitals as well as other health care workers is the disposal of waste (Sharma and Chauhan, 2008).

The objectives of biomedical waste management involve mainly the prevention of disease transmission from one patient to another, health workers from patients, and vice versa, and the prevention of injury to the workers in health care units as well as workers involved in support services. This helps in turn prevent exposure to the deleterious effects of cytotoxic as well as genotoxic and chemical wastes in general that are generated in hospitals. Management of waste can be a relatively effective as well as efficient practice that is related to compliance when design is done properly (Pasupathi et al., 2011).

For the implementation of the industrial program for medical wastes, a pilot project has been launched to improve the separation of hazardous as well as non-hazardous wastes that can reduce the amount of waste that is hazardous in this sector. Special types of containers (for medical wastes that are hazardous in nature) have been used by various employees of the hospitals to dispose of various types of waste that are harmless in nature. The generation of medical wastes that are hazardous in nature can be significantly reduced by the provision of on-site information and the appointment of a training officer who acts as in charge of continuing education for personnel in hospitals (www.bundesabfallwirtschaftsplan.at/dms/BAWP_2006_englis.pdf).

As per the report of the World Health Organization (WHO), among the non-hazardous materials, 85% are hospital wastes; wastes that are not of hospital origin (the rest, 15%) are divided into two categories: infectious (10%) and non-infectious but hazardous wastes (5%).

As far as the management of biomedical waste is concerned, its proper management has become a humanitarian topic worldwide. Hazardous and poor waste management (biomedical) has become a matter of concern, particularly in light of its far-reaching effects on human and animal health and the environment (Sharma and Chauhan, 2008; Mathur et al., 2012).

Aim- The present review discusses, in brief, biomedical wastes and their management.

Definition of Biomedical Waste

BMW is defined as "any waste generated during the process of diagnosis and treatment or immunization of human beings or animals or in research activities contributing to the biological production or testing" (Bekir Onursal, 2003).

Classification of Biological Waste Non–Hazardous Wastes

Non-hazardous waste accounts for approximately 85% of total waste generated in most health-care facilities. This includes waste constituting remnants of food and peels of fruit; wash water; paper cartons; packaging materials, etc. (Hegde et al., 2007)

Hazardous Wastes Potentially infectious wastes

In the scientific documents as well as in the regulations and guidance, various terms for infectious wastes have been used over the years. These include: infectious as well as infective; medical and biomedical; hazardous and red bag; contaminated; infectious medical wastes; along with regulated wastes in the medical profession. Basically, all these terms indicate similar types of waste, even though the terms involved in regulation are usually defined in a more specific manner (Block, 2001).

Constraints Associated with BMW Management

Due to the adaptation of improper and indiscriminate methods of waste disposal by some health care centers, biowaste regulation is not up to par. There has been an admixing of waste from hospitals with waste in general, which has made streams dangerous. The consequence of this improper admixing ultimately resulted in an incorrect waste disposal method. This, in turn, pollutes the environment, produces unpleasant odors, and promotes the growth of insects, rodents, and worms. It ultimately favors the transmission of diseases like typhoid, cholera, hepatitis, and AIDS via injuries from contaminated sharps (CEET, 2008). This facilitates the easy incoming movement of flies, insects, and rodents, as well as cats and dogs that widely spread diseases like plague and rabies. It is thereby necessary to undertake waste management appropriately for maintaining a good standard environment and lessening health hazards.

Steps in Waste Management

For effective management of biomedical wastes, several steps are necessary to be followed, from the gathering of such wastes until disposal, which are briefed as below.

Waste Segregation

Segregation is a very important factor in waste management system. Depending upon the treatment and disposal option for various categories of wastes, specific colored containers are required to segregate and store these at temporary central storage place till disposal within 48 hours. The waste going for incineration or deep burial should be collected in yellow plastic bag or bin. The waste which is planned for autoclaving or microwaving or chemical treatment and finally to secured landfill or for recycling, should be collected in red or blue bin or bag. The waste sharps such as needles, blades *etc.,* that are used for disinfection, destruction, or shredding must be collected in a white, puncture-proof, translucent container, which will be encapsulated or recycled as a final disposal. The chemical waste (solid), out-dated medicines, and cytotoxic drugs that go for disposal in secured land fill should be collected in a black bin or bag with a cytotoxic label. All the bins and bags should have biohazard labels, except for the black-colored bin or bag on which cytotoxic labels need to be inserted (Ndiaye et al., 2003; Friends of the Earth, 2008).

This step also includes the management of waste of various kinds in several containers at the point of generation (reuse, recycle, and reduction). Reusing chemicals, medical equipment, *etc.*

translates into cost savings. Recycling of specific materials like disinfected and shredded plastic helps a secondary industry reduce waste generation and decrease the cost of waste disposal. The spread of infection is contained through segregation, thereby reducing the chances of health care workers' infections. Laceration or puncture injuries causing waste need to be disposed of as "sharps," and they must be separated from the rest of the waste. Intermixing of sharp metals as well as glasses that are broken is permitted, but not with waste that is non-sharp. Commingling of glass or plastic wastes with inflammable wastes, biological wastes with chemical wastes, or certain laboratory trash must be avoided (Sita, 2004).

Waste Storage

The wastes must be stored like what is required as per the Biomedical Waste (Management and Handling) Rules, 1988. Between waste generation points and waste treatment and disposal sites, events of storage of waste occur. There may be temporary withholding of biological wastes under refrigerated conditions before safe disposal without causing problems aesthetically. Near the waste treatment sites, storage areas are present. There must not be floor drains for containing spills, which should be recessed for holding liquid.

Imperviousness to liquids is required for floors and walls, with easy follow-up on cleaning procedures. Regular disinfection is also mandatory. There is a requirement for refrigeration for storing putrifiables and other wastes for a prolonged period of time. There must be a post in the storage area showing 'EXPLICIT' signs (Da Silva et al., 2005; www.purdue.edu).

Containers and their labeling

Non-leaky containers must be used along with proper labeling and maintenance of their integrity, provided treatment is done chemically and thermally. Containment for biohazardous material must be sealed. The use of containers that are leak-proof and have the capability of withstanding thermal as well as chemical treatment must be employed for chemicals. Rigid containers that are resistant to puncture and can be encapsulated well must be used for metal sharps for proper disposal, and they must be able to withstand 40 psi pressure without getting ruptured. Plastic bags of heavy-duty standard or other such containers must be used for non-hazardous materials, along with a symbol of biohazard. Biohazard bags of red or orange color must not be used for materials that are non-hazardous. Rigid as well as puncture-proof containers must be used for pasteur pipettes as well as glassware that is broken (plastic, heavy cardboard, or metal), and sealing should be done in "Biohazard bags" that are made up of heavy-duty plastic and are autoclavable. No labeling is required unless there is any chance of recycling the waste, and in such instances, the container must be labeled 'Do Not Recycle'. Wastebaskets must not be used for syringes that are loose or any other kind of sharps (Khan et al., 2001; Gayathri and Kamala, 2005; www.envirovigil-bmwm.com; www.epa.gov). Each bag or container must have a label that is backed by adhesive with generator information that is placed into the bags that contain medical waste. Building services should provide special labels with space for recording dates along with contact information, and such labels must be applied to all the containers placed inside the medical waste boxes (www.web.princeton.edu). Clear identification of every container of biohazardous waste that is untreated, along with their proper labeling with the symbol biohazard,must be done.

Handling and transport

Biomedical wastes must be collected and transported in a way that avoids any possible peril to the health of humans and the environment. Biohazardous waste that remains untreated must be handled or transported by only technical personnel who have undergone proper training. Soon after the generation of the waste, segregation into containers or bags that are specifically color-coded must be followed. Reducing the risk of needle-prick injury and infection is required while handling these wastes. No other forms of waste should be mixed with biomedical waste. Transportation of untreated waste from the facility of generation to another treatment site and disposal is required if medical waste remains untreated on site (Kautto and Melanen, 2004; Marinkovic et al., 2005).

The following points need to be considered for the transportation of BMWs:

1. Split cabins should be provided for the vehicle carrier and the containers of biomedical waste.
2. Verification of the waste cabin base for leak proof
3. The design of the waste cabin must be done in such a way that it can be easily cleaned with disinfectants and facilitates preserving containers of waste in
4. Minimize water stagnation; the inner surface of the cabin should be smooth.
5. There should be provision for sufficient rear openings and/or sides for easy loading or unloading of waste.
6. Labeling a vehicle with the BMW symbol

Treatment and disposal methods

The basic principle involved in the treatment of biological wastes is that mutilation or shredding must be able to prevent unauthorized reuse. In its simplest form, a 1 percent solution of hypochlorite is used for chemical treatment. On the other hand, the incineration procedure does not involve any pre-treatment. The procedure of deep burial is required in towns only where the population of humans is less than 5 lakhs (www.hercenter.org; www.mppcb.nic.in). Treatment of wastes, moreover, should be done as close to the point of origin as possible (http://www.chemsoc.org/ networks/gcn/industry.htm). Keeping all these points in mind, the treatment and disposal methods for various kinds of waste must be carried out cautiously and appropriately.

1. Animal carcasses and body parts: incineration, biodigestion, or
2. Animal waste; solid (bedding, manure, *etc.*)
1. Animal waste (biohazardous): thermal or chemical treatment for incineration and disinfection.
2. Animal waste (non-hazardous): using as compost or
3. Chemical waste: It should be treated by using a 1% sodium hypochlorite solution or any other equivalent chemical agent, thereby ensuring proper After treating for liquids and securing landfills for solids, discharging into drains is required (Saurabh and Ram, 2006).
4. Genetic material: National Institute of Health (NIH) guidelines must be followed for disposing of materials that contain recombinant DNA or organisms that are genetically
5. Human pathological waste
1. Dead body, recognizable body parts: cremation or burial for disposing
2. Other solids—incineration or disinfection for
3. Body fluids: disinfection by thermal or chemical treatment for discharging into the drain system
6. Metal sharps: To prevent laboratory as well as custodial and landfill workers' injuries, metal sharps are needed to be discarded along with encapsulation. Needles, blades, etc. possess the threat of biohazard even after sterilization or capping and in the original container. If there is a requirement for autoclaving, an autoclave indicator tape strip must be placed in the container before the process of rinsing gas chromatography. Needless must be used for removing hazardous chemicals, along with their disposal with glassware that is broken (non-contaminated) (Patil and Pokhrel, 2004).
7. Microbiological waste: treatment thermally or chemically is required for discharging into the sewer system.
8. Non–hazardous biological
1. Autoclaving or treating all microbial products chemically is necessary for good laboratory practice, even if the materials are non-hazardous.
2. Solid-trash dumpster placement of the
3. Liquid: Discharging into the sewer
9. Plastic waste, pasteur pipets; glassware (broken): Disinfection by treating thermally or chemically, encapsulation, and trash dumpster placement if there is contamination with biohazardous If these are not contaminated, place them in a trash dumpster. Glassware and plastics should not be incinerated (Ravikant et al., 2002).
10. Radioactive waste: Freezer temperatures are required for withholding animal carcasses that are radioactive for decaying for their half-lives (ten). A health physics program for radiation safety must be implemented especially for metal sharps that have radioactive materials' contamination. Packaging and shipping of carcasses containing long-lived radionuclides are mandatory by federal as well as state authorities and are needed to be sent to a repository site where nuclear materials are approved.

The radiation safety requirement generally while disposing of wastes that are radioactive in nature is that the degree of exposure to radiation of the waste treatment plan at large or personnel should not exceed the following values: an effective dose of 0.01 mSv a year. The preparation of the waste treatment plan is required to be done by a responsible party who can discharge radioactive material into the sewer system or environment (www.ec.europa.eu).

For generators that dispose of medical waste, the methods of disposal that are followed include truck service on site and mail-back disposal. Treatment on site uses equipment that is very expensive, and only large hospitals carry out such activities. Medical waste is hired by truck services, which have trained employees to collect medical waste in special containers. Treatment is carried out in an area that is planned to hold a huge concentration of medical waste. Similar is the mail-back disposal of medical wastes, except that shipping of the wastes is done through postal services instead of private haulers (Guidance on Closed Containers, 2013).

Waste Minimization

Preventing waste material (also known as waste reduction) is a significant method of waste management. Manufacturing processes in industries can be used more efficiently, and materials that are of better quality will result in a reduction in waste production. The techniques involving minimization of waste materials and their application techniques have led to innovative as well as commercially successful replacement products' development. Minimization of waste has been proven beneficial to industries and helps in creating value along with increasing work quality (Royal Commission of Environmental Pollution, 2007). The methods of avoidance include reusing second-hand products, repairing broken items instead of buying new designer products, and refilling and reusing them. Consumers get encouraged by that way to avoid disposable products' use by removing any remains of food or liquid from cans, using less material for packaging, and designing for achieving the same purpose (Kvist et al., 2004; Rao and Prabhakar, 2013; www.ene.gov.en).

Technologies Associated with the Treatment and Disposal of Biomedical Wastes

Incineration

This is considered a thermal process requiring high temperatures under controlled waste combustion conditions in order to convert them into materials that are inert in nature along with gases. For hospital waste, three different kinds of incinerators are in vogue: multiple hearth types, rotary kilns, and air types (controlled). Both primary and secondary combustion chambers are provided in all three types, ensuring combustion at optimal levels. These are interestingly refractory-lined (Gravers, 1998). Most of the waste in medical hospitals is incinerated, but the solid as well as medical wastes that are regulated are burned in reality, thereby creating problems for the health care workers. Incinerators (medical wastes) are used to emit air pollutants that are toxic in nature as well as residues of toxic ashes that are the major source of dioxins in the environment. In landfills, the toxic ashes that are sent for disposal have the potential to leach into the groundwater. To avoid the production of dioxin, plastic bags that are non-chlorinated are required to be introduced into the incinerator. Incineration of red bags must be avoided as cadmium is present in the red color, causing toxic emissions. If a red bag is filled with items that contain mercury, the wastes that are infectious will be contaminated by mercury (Singh et al., 1996).

Non–Incineration

Four basic processes are included in non-incineration treatment: thermal, chemical, irradiative, and biological. Thermal as well as chemical processes are employed in the majority of the non-incineration technologies. Decontamination of wastes by the destruction of pathogens is the most important purpose of this treatment technology. In order to meet the state criteria, disinfection facilities should be provided (Thornton et al., 1996).

Plasma Pyrolysis

Direct use of waste products as combustion fuel or their indirect processing into another kind of fuel helps in harnessing the energy contents. In this context, pyrolysis has been found to be a related form of thermal treatment wherein high temperatures are used for treating waste materials with a limited supply of oxygen (www.ec.europa.eu). A state-of-the–art is plasma pyrolysis technology that ensures the safe disposal of medical wastes. It is an environment-friendly technology that converts organic wastes into byproducts that are commercially useful. Disposal of various types of waste, including solid waste from municipalities, biomedical waste, and hazardous waste, safely and authentically is enabled by plasma-generated intense heat. Pyrolysis of medical wastes into carbon monoxide, hydrogen, and hydrocarbons is possible when they come into close contact with the plasma arc. Such gases generate high temperatures (1200 °C) when burned (Surjit et al., 2007; www.envfor.nic.in). Wastes that are temporarily held in small quantities are referred to as accumulation, while waste storage is characterized by a holding period for a longer period and a large quantity of waste. The location of the treatment of wastes needs to be in close proximity to storage areas. Storage also includes any off-site holding of waste. Floor drains should be avoided in order to contain spills and must be recessed. The impervious nature of floors and drains is mandatory because they help to easily contain liquid, and cleaning also becomes easier. For prolonged storage, refrigeration is necessary in the case of putrifiables as well as other wastes. ‘EXPLICIT’ signs must be posted in the storage area (Hegde et al., 2007).

Potential Implications of Biomedical Wastes

- The greatest infectious risk due to biomedical wastes is associated withthe improper containment of sharps, resulting in hepatitis B, C, and HIV transmission.
- The dumping of untreated biomedical waste in municipal bins may increase the chance of survival, along with the proliferation and mutation of pathogenic microbial populations in such wastes. This causes epidemics as well as an increased incidence and prevalence of communicable diseases in the
- Pathogen-associated health risks may lead to aerosolization during the processes of compacting, grinding, or shredding, which is seen in association with certain management of waste in the medical profession or with practices of
- There is also an association between the temperatures of incinerators and steam sterilizers that are highly operating and the poisonous gases that are emitted into the atmosphere post-treatment of waste.
- There is confinement of the public impact on degradation esthetically in the environment that prevents disposal as well as the environmental impact of incinerators that are operated improperly or other equipment that is used for treating biomedical waste.

- Poor management of waste leads to an enhanced risk of nosocomial
- Chances of vectors becoming high, like mosquitoes, flies, cats, rats, and stray dogs getting infected or becoming carriers, which can spread diseases among the
- Management of waste improperly can lead to microbial ecological changes and the spread of resistance to
- The preparation of contingency plans is a must for health care facilities to deal with refrigerated or frozen waste. If waste is produced in excess, then the facilities of disposal or equipment become inoperative, and thus special care must be taken in this regard (www.enr.gov.nt.ca).

CONCLUSION

Management of biomedical waste is one of the major social responsibilities of individuals as well as government and state officials. For proper management of biomedical wastes, lack of concern and awareness, as well as cost factors, are certain problems or limitations. Therefore, the general public should be educated and must be concerned regarding the health hazards that are associated with biomedical waste. Ultimately, sensitizing ourselves is of utmost importance for the protection of the environment and our own health. Thus, knowledge of BMW is of general interest to the community as a whole, rather than the health-associated employers. In the present-day world of health, the proper management of biomedical waste is of significant importance. This will ensure the maintenance of ecological balance, biodiversity, and the health of the global community as a whole.

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