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BIO-MEDICAL WASTE MANAGEMENT

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ABSTRACT

In India, population explosion and steady economic growth lead to fast depletion of natural resources and pose a significant challenge to the country's sustainable and ecological development (CPCB 2000, 2003). Because of rapid growth in population, severe environmental degradation has resulted. Environment and natural resources can be polluted, and consequently human beings, animals and plants can be impacted. Increased awareness about the health care has created a need for a wide variety of medical facilities. It is indisputable that society is continually looking to improve its health standards. A way to improve the standards can be achieved by establishing various public or private healthcare services. Hospitals are health institutions providing patient care services by ensuring a clean, healthy environment for their employees and the community. Nevertheless, consequences from the healthcare establishments are not always in parallel with the benefits. As a result of developing healthcare technology, the amount of hospital wastes being generated is increasing due to the use of more disposable products and these healthcare activities can lead to the generation of various types of biomedical wastes. Relatively large quantities of wastes with a broad range of compositions and characteristics can be generated by the establishment of healthcare service centers. Hospital wastes, because of their infectious nature, are one of the most dangerous causes of pollution. Though hospitals are meant to restore human health, the disposal of hospital wastes is a matter of concern. Biomedical waste can be categorized based on the risk of causing injury and/or infection during handling and disposal include sharps (needles or scalpel blades), pathological wastes (anatomical body parts, microbiology cultures and blood samples) and infectious wastes (items contaminated with body fluids and discharges such as dressing, catheters and I.V. lines). Other wastes generated in healthcare settings include radioactive wastes, mercury containing instruments and polyvinyl chloride (PVC) plastics.

The inefficient handling of biomedical waste is more likely to cause problems such as blood-borne pathogens to the groups involved namely, healthcare staff, scavengers, and municipal workers (from needle sticks for example, if the biomedical wastes are handled and disposed together with domestic wastes) at highest risk.

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INTRODUCTION

Biomedical waste may have adverse effects on flora, fauna and on the environment. If the healthcare waste is inadequately managed, waste products should be considered as a reservoir of pathogenic microorganisms, which can be transmitted by direct contact through injuries from syringes and needles contaminated with human blood or in the air or by a variety of sectors, will cause environmental pollution, unpleasant smell, growth and multiplication of insects, rodents and worms may lead to the transmission of diseases like typhoid, cholera, hepatitis and AIDS. WHO (1999, 2001, 2004) stated that 85% of hospital wastes are actually non-hazardous, around 10% are infectious and around 5% are non-infectious but hazardous wastes. In the 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.

Although the portion of infectious and hazardous waste is relatively small, improper waste management in which the infectious waste is mixed with the general waste can lead to the entire bulk of the wastes becoming potentially infectious. Inability to follow minimum standards of hospital waste management not only decreases the quality of life and health in a society but also increases the workload of health services. One of the essential requirements of this management is the availability of reliable data and analysis corresponding to hospital wastes. Unfortunately, appropriate investigations and statistical analysis is insufficient in this regard for Indian Hospital wastes. Management of healthcare waste is an integral part of infection control and hygiene programs in healthcare settings. Despite the fact that current medical waste management practices differ from hospital to hospital, the problematic areas are approximately the same for all healthcare units. After notification of the Bio-medical waste (Handling and Management) Rules 1998, waste management technologies are slowly streamlining through an appropriate method of separation from the source, collection, proper packaging, storage, safe transportation, disinfection, treatment and disposal preventing environmental pollution.

DEFINING BIOMEDICAL WASTE

Biomedical waste is defined as any solid, fluid or liquid waste including container and any intermediate product, which is generated during diagnosis, treatment or immunization of human beings or animals or in research activities or in the production or testing of biological products.

SOURCES OF BIOMEDICAL WASTE

All types of health care facilities, laboratory, clinics, nursing homes and medical, dental and veterinary hospitals generate a waste stream varied in its composition. Health care wastes are generated from different sources.

Major sources are: a) Hospitals, e.g. general hospital, district hospital; b) Healthcare establishments, e.g. emergency medical care services, healthcare centres and dispensaries,

Saarth E-Journal of Research

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obstetric and maternity clinics, outpatient clinics, dialysis centres, first-aid posts and sick bays, long-term healthcare establishments and hospices, transfusion centres, military medical services; c) Related laboratories and research centres, e.g. medical and biomedical laboratories, biotechnology laboratories and institutions, medical research centres; d) Mortuary and autopsy centres; e) Animal research and testing facilities; f) Blood banks and blood-collection services; and g) Nursing homes for the elderly.

Minor sources are: a) Small healthcare establishments, e.g. physician's office, dental clinics, and acupuncturists. b) Specialized healthcare establishments and institutions with low waste generation, e.g. convalescent nursing homes, psychiatric hospitals, institutions for disabled persons; c) Non-health activities involving intravenous or subcutaneous interventions, e.g. cosmetic piercing and tattoo parlors; d) Funeral services; e) Ambulance services; f) Home treatment.

IMPACT OF INFECTIOUS AGENTS ON HUMAN HEALTH AND ENVIRONMENT

Hospital wastes have always been considered as potentially hazardous in view of the inherent potential for the spreading of infection. The major identified hazard was that of infection, because over millennium communicable diseases had been the most common cause of morbidity and mortality in the community and majority of persons receiving treatment in the hospitals were suffering from communicable diseases. Improper segregation of waste leads to the spread of communicable diseases to those who handle the wastes and people at the proximity of the disposal area. Figure 1.1 represents the hazards associated with health care wastes. Transmission of a disease involves the movement of an infectious agent from a source to the appropriate portal of entry in a susceptible host or individual. The four principal methods of disease transmission are: by physical contact with an infected person (including their secretions, excretions, body fluids, or tissues); through the air; through food and water; and by indirect contact through vectors or other objects.

BIOMEDICAL WASTE (MANAGEMENT AND HANDLING) RULES

The bio-medical waste (Management and Handling) rules apply to all persons who generate, collect, receive, store, transport, treat, dispose or handle bio-medical waste in any form. It shall be the duty of every occupier of an institution generating bio-medical waste which includes a hospital, nursing home, clinics, dispensaries, veterinary institution, animal house, pathological laboratory, blood bank or by whatever name called, to take all steps to ensure that such waste is handled without any adverse effect to human health and the environment. After the BMW guidelines were explained, observations indicate that proper management of BMW has improved and that the segregation of BMW is much better than before.

Categories of Biomedical Waste

As per the Biomedical waste (Management and Handling) Rules, 1998, Schedule I, the biomedical wastes are classified into 10 categories such as

Human anatomical waste (human tissues, organs, body parts)

Saarth
E-Journal of Research
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Animal waste (animal tissues, organs, body parts, carcasses, bleeding parts, fluids, blood and experimental animals used in research, waste generated by veterinary hospitals, colleges, discharges from hospitals, animal houses)

Microbiology and Bio-technology waste (waste from laboratory cultures, stocks or specimen of microorganisms live or attenuated vaccines, human and animal cell culture used in research and industrial laboratories, waste from production of biological, toxins, dishes and devices used for transfer of cultures)

Waste sharps (needles, syringes, scalpels, blades, glass etc which cause puncture and cuts. This include both used and unused sharps)

Discarded medicines and Cytotoxic drugs (waste containing out-dated, contaminated and discarded medicines)

Solid waste (items contaminated with blood and body fluids including cotton, dressings, soiled-plaster casts, lines, bleedings, other materials contaminated with blood) and also (waste generated from disposable items other than the waste sharps such as tubing, catheters, intravenous autoclaving sets etc)

Liquid waste (waste generated from laboratory washing, cleaning, house-keeping and disinfecting activities)

Incineration ash (ash from incineration of any bio-medical waste)

Chemical waste (chemical used in production of biological, chemicals used in disinfection, as insecticide etc).

BIOMEDICAL WASTE MANAGEMENT STRATEGIES

Handling, segregation, mutilation, disinfection, storage, transportation and final disposal are vital steps for safe and scientific management of biomedical waste in any establishment. The key to minimization and effective management of biomedical waste is segregation and identification of the waste. The most appropriate way of identifying the categories of biomedical waste is by sorting the waste into color coded plastic bags or containers. It is necessary to have careful survey for active planning of hospital waste management. The types of quantities of different kinds of wastes which are expected to be generated need to be estimated. In estimation of these quantities, due consideration should be given to be types of medical establishment, number of the beds for indoor patients, facilities for outdoor patients, pathological laboratories and other facilitates. The management of the health care establishment should make an action plan to implement the recommendations of the rules framed by the Government of India (Ministry of Environment of Forests).

IMPORTANCE OF SEGREGATION OF BIOMEDICAL WASTE

Healthcare services generate huge quantities of waste with a broad range of compositions and characteristics which carry a higher potential for infection and injury than any other type of waste. The current waste management practices observed at many hospitals is that all wastes,

Saarth E-Journal of Research

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potentially infectious, office, general, food, construction debris, and hazardous chemical materials are improperly segregated and mixed during transportation and finally disposed/ treated off. As a result of this failure to establish and follow segregation protocols and infrastructure, the wastes leaving hospitals, as a whole is both potentially infectious and potentially hazardous (chemical). At greatest risk are the workers who handle the wastes (hospital workers, municipal workers and rag pickers). The risk to the general public is secondary and occurs in three ways: a) accidental exposure from contact with wastes at municipal disposal bins; b) exposure to chemical or biological contaminants in water; c) exposure to chemical pollutants (e.g. mercury, dioxin) from incineration of the wastes.

TREATMENT METHODS

Incineration

Incineration is a process where complete combustion takes place in the presence of fuel and air. The fuel provides heat energy to attain incineration temperature and air provides oxygen for combustion. In some cases, the waste itself provides heat energy. Incineration is effective when the waste is combustible, which is reduced to exhaust gaseous products and the incombustible waste is reduced to ash. The nature of gaseous emissions and ash from an incinerator depends upon the type of waste being incinerated and incineration conditions.

Autoclaving

Steam autoclaving is an appropriate method for treating microbiology laboratory waste, human blood and body fluid waste (if applicable), waste sharps, and non- anatomical animal wastes. Personnel who operate steam autoclaves must be thoroughly trained in the use of the equipment.

Microwaving

Microwave disinfection technology is relatively advanced and the latest in the field of medical waste management. The process uses microwave radiation to heat and destroys micro-organisms. Microwaving makes it possible for treatment of waste at site (point of generation). Microwaving utilizes electromagnetic, microwaves that enter into or penetrate materials.

Hydroclave

The hydroclave is an innovative combination of waste sterilization (similar to autoclaving), and waste fragmentation and dehydration. A hydroclave is a double-walled cylindrical vessel, horizontally mounted, with one or more top-loading doors, and a smaller unloading door at the bottom, the vessel is fitted with a motor-driven shaft, to which are attached powerful fragmenting/mixing arms that slowly rotate inside the vessel. When steam is introduced in the vessel jacket, it transmits heat rapidly to the fragmented waste, which in turn, produces steam of its own. The resultant dynamic interaction within the hydroclave will sterilize the waste by high temperature and pressure steam, similar to an autoclave but with faster and more even

ISSN NO: 2395-339X

heat penetration. Thus, they offer both pathogen destruction and waste reduction by 80% in its volume and 50% by its mass.

Superheated Steam Sterilization

This technology comprises a heated shredder and sterilization unit. In the shredder, organic liquids are vaporized and solids reduced to gas by 'super-heated' steam at temperatures between 500°C and 700°C. The sterilization unit also employs steam at high temperatures and increased atmospheric pressure, further reducing the overall weight of waste. The temperatures used – up to 1500°C – exceed ordinary steam sterilization. The process employs a continuous batch-system and has been shown to reduce medical waste by 50% to 80% of its original volume. It is claimed that this technology can handle all wastes including chlorinated plastic products and low-level radioactive waste. However, the superheating of PVC plastic waste can result in the formation of hydrochloric acid (HCL). HCL can, in turn, react with the many additives present in PVC, creating even greater volumes of toxic fumes. The capital and operating costs of this technology are prohibitively high.

Gas Sterilization

Gas sterilization is the treatment of infectious waste by exposing to a high concentration of a sterilizing gas under the required conditions for the designated treatment period. Ethylene oxide and formaldehyde are sterilizing agents usually used in gas sterilization. There is now substantial evidence that both ethylene oxide and formaldehyde are probable human carcinogens. The hazards that accompany the use of these chemicals impose strict constraints on gas sterilization operations and greatly limit the usefulness of this technology for treatment of infectious wastes. Ethylene oxide is highly flammable and reactive which requires special permits for storage on site. Use of this technology for infectious waste treatment should be limited to special situations such as temporary unavailability of other treatment equipment and the need to sterilize the infectious wastes that otherwise would be accumulating untreated. The cost of treatment is also high when compared to other technologies.

Bio-Oxidizer Technology

The bio-oxidizer system is an innovative medical waste processing technology that safely disposes of a wide range of medical waste. This technology handles the complete range of medical waste maximum reduction volume 100% destruction of bacteria, viruses and pathogens. The principle of operation is the electro-pyrolysis of organics followed by two phases of electro-oxidation. The bio-oxidizer system electrically heats the organic solids and liquids, turning them into vapor, and then oxidizes the vapors in two oxidizers. The remaining residue, which is typically less than 5% of the organic weight and volume, is sterile, inert, and may be discarded as municipal waste in most instances or possibly recycled as road aggregate.

Background cross connected (BGX) Technology

ISSN NO: 2395-339X

BGX Technology is an effective technology for treating medical wastes. Utilizing BGX Technology, small low power units can be set up in various areas of a facility where medical waste is produced. The systems reduce waste into its elemental, non-hazardous components that can be eliminated through conventional waste disposal facilities. The high temperatures at which a BGX system works, along with its ability to function in a system isolated completely from the atmosphere are the key components of this technology. The unit operates silently without producing offensive wastes streams. The systems can be constructed in a variety of shapes and sizes. Waste is deposited through an opening at the top. Control panel and indicators are situated on the front portion. Residue from the waste destruction accumulates in a heavy wall plastic bag at the base. The systems operate under vacuum and do not use hydrocarbon fuel.

Needle Melter (for needle)

The needles are at disinfection prior to melting by soaking them for a period of at least 30 minutes in a freshly prepared 1% hypochlorite solution. It is used to destroy needles immediately after use. The needle is put inside a hole for few seconds and it just melts without any trace. Thus it ensures sterilization due to high temperature and eliminates chances of hepatitis and AIDS.

Needle cutters or Destroyers

Needle cutters or destroyers are of two types – mechanical or electrically operated. This equipment can be fixed on the bench and are light and portable. They can be used at blood collection centres, nursing stations, clinics and at all locations where needles are used. The purpose of using these instruments is to avoid the reuse of disposable syringes.

Syringe Crushers

These are not popular, however they can be used to safely destroy the syringe after the needle has been removed. This is mainly to prevent the reuse of syringes, especially those used to draw blood samples. This instrument is usually used in immunization camps and health camps where large numbers of disposable syringes are used and waste shredders are not available. The syringe crushers consist of two plates – one fixed and the other movable. The movable plate is operated by a lever. The syringes are kept between the two plates and crushed. More than one syringe, depending on the size of the plates, can be crushed at a time.

Shredders

Shredders are used to destroy plastic and paper waste to prevent their reuse. Only waste that is disinfected should be used in a shredder. The function of a shredder is to mutilate the already-disinfected waste. The shredder is usually used in combination with an autoclave or a microwave. It could be used in individual institutions or in common treatment-and-disposal facilities. This also reduces the bulk of waste making transportation easy. The waste is fed into a hopper leading to a set of revolving blades/shafts which cut the waste into small pieces. These pass through a mesh and are collected at the bottom. Larger particles retained on the

Saarth E-Journal of Research

ISSN NO: 2395-339X

mesh are once again passed through the cutters. The problems with shredders are mainly due to the shafts or blades which undergo wear and tear and need periodic replacement. The shredder should be cleaned every month or when particles accumulate between the blades. A shredder occupies around 1.5 sq. m and consumes about 15 kW of power.

Electron Beam gun Technology

Hospital waste is exposed to an ionized electron beam inducing chemical and biological changes in the waste material. Decontamination occurs when nucleic acids in living cells are irradiated. The equipment emits sufficient radiation to destroy micro-organisms and change the molecular structure of materials. However, the technology produces radioactive fields that require costly shielding. Additionally, ozone is produced, but this can be destroyed using a catalyst. The volume of waste is reduced by about 20% and the disinfected remains are shredded and land filled. The high capital and operating cost are limiting factors for commercial utilization of this technology.

Plasma Pyrolysis

The plasma pyrolysis medical waste disposal system combines plasma with pyrolysis. The extreme temperatures convert organic material to mid-grade fuel gas which is primarily hydrogen and carbon monoxide. Acidic material is removed by a scrubbing process and inorganic materials can be recovered or vitrified with glass. The process can handle all types of waste and results in reductions of up to 90% in volume and 80% in weight. The market for plasma pyrolysis technology includes very large hospitals and regional treatment facilities. The technology is still at the demonstration scale.

Treatment for hospital liquid waste

The institutions which generate bio-medical liquid waste should have treatment facilities installed at the tail end of the sewage stream before entering the municipal sewer. The treatment could consist of chemical disinfection using pre-chlorination with a contact time of 15 to 45 minutes (to be determined from plant studies) and dosing of 6-25 mg/L of chlorine, neutralization, coagulation and flocculation, skimming and filtration and post chlorination with 1-5 mg L**-1** of chlorine. The resultant effluent can be let into the public sewers. The resultant effluent should conform to the standards prescribed in Schedule V of the Bio-Medical Waste (Management and Handling) Rules, 2000.

DISPOSAL METHODS

Deep Burial

The burial site should be relatively impermeable and no shallow well should be close to the site. Burial must be performed under close and dedicated supervision. When fresh waste is added to the pit, layer of 10cm of soil shall be added to cover the fresh waste. The pit should be safely away from any habitation, and sited so as to ensure that no contamination occurs to

Saarth E-Journal of Research

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any surface or underground water source. The area should not be prone to flooding or erosion. The location of the site shall be authorized by the prescribed authority and the institution shall maintain a record of all pits for deep burial.

Sanitary Landfill

The sanitary landfill is an operation in which the wastes to be disposed of are compacted and covered with a layer of soil at the end of each day's operation. Factors must be considered in evaluating potential solid waste disposal sites include i) availability of land area ii) impact of processing and resource recovery iii) haul distance iv) soil condition and topography v) Climatologically conditions vi) surface water hydrology vii) geologic and hydro geologic conditions viii) local environmental conditions and potential ultimate uses for the completed site. The conventional method of sanitary landfill is used when the terrain is unsuitable for the excavation of trenches in which the solid wastes are placed.

CONCLUSION

Unscientific disposal of health care waste may lead to the transmission of communicable diseases such as gastro-enteric infections, respiratory infection, spreading through air water and direct human contact with the blood and infectious body fluids. However, the transmission modes of agents associated with blood-borne diseases are still not understood. The rag pickers and waste workers are often worst affected, because unknowingly they rummage through all kinds of poisonous material while trying to salvage items which they can sell for reuse. Therefore, the disposal of health care wastes and their potential health impact are an important public health issue. Even though the consequences of discarding such waste carelessly are well known, recently adequate initiatives are being taken to manage this waste in a scientific manner in India.

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Saarth
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