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Biomedical waste management

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ABSTRACT

Hospital wastes pose a significant impact on health and environment. From this study it can be said that there is an urgent need for raising awareness and education on medical waste issues. Proper waste management strategy is needed to ensure health and environmental safety. For further study, it is needed to collect more information on impacts, disposal and management to draw a clear conclusion. Need to collect information and examples from developed country or the country, which has sound medical waste management system. Find alternatives and appropriate technologies for developing countries. Need extensive study on this medical waste and its management aspects as well. All over the world, there is an exodus of people from villages to cities, partly for education and employment and partly because agriculture has become less and less profitable. It is estimated that 65% of the world's population will live in cities by 2030. The infrastructure required for this lop-sided growth of the cities is resulting in mountains of garbage collecting in the unplanned extensions in larger cities, because of poor conservancy services and lack of civic amenities. It is estimated that the domestic garbage produced per day in Mumbai is of size of an eight stored building complex. The quality of air in the surroundings of the cities is so poor that it is estimated about two million children under five die each year from respiratory infections

Falling in line with the general situation, we find certain public places like hospitals, vegetable, fish and other market places, Railway stations, Bus stands, Parks and Cinema halls are maintained unhygienically contributing to the spread of infectious diseases. It is wonder how the elite like doctors and higher officials who work in such public places and spend major part of their day time in these places are callous to the environment. Particularly, hospitals generate an enormous amount of dangerous waste. The amount of solid waste generated by hospitals has been increasing rapidly in developing countries like India and its management can no longer be ignored. Increasing concern for community health standards and pollution control requirements demand that the huge mass of infectious waste be rendered as harmless as possible before it is disposed. Against this background, an attempt is made in this paper to discuss the problem of disposal of wastes in Indian hospitals and various legislations relating to environmental protection in general and Bio-medical waste (Management and Handling) rules,1998 (amended in 2000) based on the environmental (protection) Act, 1986 in particular. This Paper also suggests a few measures for the effective management of waste disposal.

KEYWORDS

Biomedical waste;
Environmental issues;
Control strategies;
Disposal methods.

Critical Review

INTRODUCTION

Man is the most dominant being in the biosphere. A unique combination of certain physical and mental abilities has made him more powerful than other living beings. With the accumulation of knowledge and increase in the sophistication of artifacts and machines, man has acquired the capacity to change the environment to suit his needs. Human needs and greed coupled with short-sightedness have disturbed the delicate ecological balance by depleting and degrading the vital life supporting systems such as air, water and land – which rightfully belong to the generations that succeed us. The biosphere is rapidly changing from a naturally self-sufficient system to a system of resources for just one of its inhabitants – MAN. The present day man is plundering the environment as though he is the last to inhabit the earth.

Environment is the Surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans and their inter relations. Surrounding in this context, extend from within an organization to the global system. Basic functions of environment are to support life, provide material and energy, and absorb and recycle the toxins and wastes. Impact of human activity on environment is positive or negative, improving or degrading, polluting the atmosphere and resulting in possible damage to plant and animal life.

All over the world, there is an exodus of people from villages to cities, partly for education and employment and partly because agriculture has become less and less profitable. It is estimated that 65% of the world's population will live in cities by 2030. The infrastructure required for this lop-sided growth of the cities is resulting in mountains of garbage collecting in the unplanned extensions in larger cities, because of poor conservancy services and lack of civic amenities. It is estimated that the domestic garbage produced per day in Mumbai is of size of an eight stored building complex. The quality of air in the surroundings of the cities is so poor that it is estimated about two million children under five die each year from respiratory infections

High income Countries can generate up to 6 kg of hazardous waste per person per year. In the majority of low Income countries like India, health care waste is usually not separated into hazardous or non-hazardous waste. In these countries, the total health care waste per person per year varies from 0.5 to 3 kg. Preserving the environment, which is essential for the survival of humanity, is the biggest problem faced by India. By nature, environmental preservation and development of urban and rural infrastructure are the two things that do not always go hand - in- hand. Development of urban infrastructure and irrigation facilities invariably reduce the forest areas and the greenery in the urban areas producing dangerous waste material of unmanageable proportions

Further, the growth of chemical industry with dangerously toxic effluents let out into open areas and nearby rivulets and establishment of large hospitals and health care units that create infectious and hazardous wastes is the greatest problem to be surmounted by Environmentalists and civic authorities. The dilemma of the problem is that one cannot be sacrificed for the other. Sustaining the development and protecting the environment is a difficult balancing act, which the civic authorities have to perform. Invariably, it is a compromise, but to what extent? On the one hand, development is essential for the economic growth and on the other a clean environment is as much essential for the survival of the humanity

Health-care activities like immunizations, diagnostic tests, medical treatments, and laboratory examinations, protect and restore health and save lives. But what about the wastes and by-products they generate? Of the wastes generated by health-care activities, almost 80% is the general waste comparable in safety to domestic waste. The 20% of wastes are hazardous materials that may be infectious, toxic or radioactive. The wastes and by-products cover a diverse range of substances and materials. The amount of solid waste generated by hospitals has been increasing rapidly and ranges from 2-5 kg/bed/day in developed countries and 0.5-2.0 kg/bed/day in developing countries like India. Of course, the total amount of waste produced in a hospital each day depends on the type of specialization and the standard of the hospital. Cities consume 75% of the planet's natural sources and at the same time

discharge equal percentage of waste. For instance, Delhi hospitals alone produce more than 30 tons of biomedical waste every day. Hospital waste has increased to such proportions that it can no longer be ignored. Increasing concern for community health standards and pollution control requirements, demands that the mass of infectious waste be rendered as harmless as possible before it leaves the hospital. It is imperative that the problem of ever increasing garbage, toxic and bio-medical wastes has to be tackled in an efficient and effective manner, so that both the fruits of development and the nature's gifts of clean air and water are enjoyed by the people. One estimate shows that some 5.2 million people (including 4 million children) die each year from waste-related diseases. Globally, the amount of municipal waste generated will double by the year 2000 and quadruple by year 2025"

Against this background an attempt is made in this paper to discuss the problem of disposal of wastes in Indian hospitals and a few measures for the effective management of waste disposal have been suggested.

Hospital waste (bio-medical waste) - environmental pollution

It is matter for concern that even hospitals, like other public places-Railway stations, Bus complexes or Fish markets-are very unhygienically maintained: it is a wonder that people who should know better, the Doctors and other officials who spend most of their time in these surroundings, are insensitive to this issue. Particularly Hospitals generate an enormous amount of dangerous waste. The amount of solid waste generated by hospitals has been increasing rapidly in developing countries like India. Hospital waste has increased to such proportions that it can no longer be ignored. Increasing concern for community health standards and pollution control requirements demand that the huge mass of infectious waste be rendered as harmless as possible before it is disposed.

It has been established beyond doubt that improper management of hospital waste has been responsible for spread of infectious diseases among the general public. Hospital employees, patients and the attendants are susceptible to diseases due to infected tissues, biological fluids, and infected materials of patients. The patients themselves are at the risk of cross infection, if adequate precautions are not taken. It has been observed that many hospitals and nursing homes dump the waste at the garbage collection site from where garbage is cleared away by the vehicles for final disposal. The sites are visited by rag pickers looking for disposables may get infected while handling infected items. The greater danger is that items picked are often cleaned and sold in the market and may find their way back to the hospitals. For instance used needles, syringes, gloves, discarded drugs etc. get recycled increasing the risk of infection.

Categories of bio-medical waste

According to Bio-medical waste (management and handling) rules,1998 (amended in 2000),based upon the Environmental (protection) Act 1986,the categories of bio-medical waste are as follows.

1) Human Anatomical Waste : Human tissues, organs, body parts
2) Animal Waste**:** Animal tissues, organs, body parts, carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals, colleges, discharge from hospitals, animal houses.
3) Microbiology & Biotechnology Waste**:** Wastes from lab. cultures, stocks of specimens of micro-organisms, live or attenuated vaccines, human and animal incineration cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biological toxins, dishes and devices used for transfer of cultures.
4) Waste Sharps**:** Needles, syringes, scalpels, blades, glass etc. that may cause puncture and cuts. This includes both used and unused sharps.
5) Discarded Medicines & Cytotoxic drugs**:** Wastes comprising outdated, contaminated and discarded medicines
6) Soiled Waste**:** Items contaminated with blood, and body fluids including cotton, dressing, soiled plaster casts, lines, beddings, other material contaminated with blood

7) Solid Waste**:** Waste generated from disposable items other than sharps such as tubing's catheters, intravenous sets, etc.
8) Liquid Waste**:** Waste generated from laboratory and washing, cleaning house-keeping and disinfecting activities
9) Incineration Ash**:** Ash from incineration of any bio-medical waste
10) Chemical Waste**:** Chemicals used in production of biologicals, chemicals used in insecticides etc.

In addition to the above, waste is also generated from the following sources

- Left-over food in patients' and visitors' plates, fruits waste
- Blood bank waste: Discarded, expired, infected blood or its products

Wastes from health-care activities- WHO classification

1) Infectious wastes — cultures and stocks of infectious agents, wastes from infected patients, wastes contaminated with blood and its derivatives, discarded diagnostic samples, infected animals from laboratories, and contaminated materials (swabs, bandages) and equipment (disposable medical devices etc.)
2) Anatomic-recognizable body parts and animal carcasses- Infectious and anatomic wastes together represent the majority of the hazardous waste, up to 15% of the total waste from health-care activities.
3) Sharps — syringes, disposable scalpels and blades etc. Sharps represent about 1% of the total waste from health-care activities.
4) Chemicals — for example solvents and disinfectants; and
5) Pharmaceuticals — expired, unused, and contaminated, whether the drugs themselves (sometimes toxic and powerful chemicals) or their metabolites, vaccines and sera Chemicals and pharmaceuticals amount to about 3% of waste from health-care activities.
6) Genotoxic waste — highly hazardous, mutagenic, teratogenic or carcinogenic, such as cytotoxic drugs used in cancer treatment and their metabolites; and
7) Radioactive matter, such as glassware contaminated with radioactive diagnostic material or radiotherapeutic materials;
8) Wastes with high heavy metal content, such as broken mercury thermometers. Genotoxic waste, radioactive matter and heavy metal content represent about 1% of the total waste from health-care activities.

Health impacts

The status of poor waste management currently practiced poses a huge risk towards the health of the general people, patients, and professionals, directly and indirectly through environmental degradation. Communicable diseases like gastro-enteritis, hepatitis - A and B, respiratory infections and skin diseases are associated with hospital waste either directly as a result of waste sharp injuries or through other transmission channels. The hosts of micro organisms responsible for infection are entero-cocci, non-haemolytic streptococci, anaerobic cocci, clostridium tetani, klebshella, HIV and HBV.

Health-care waste is a reservoir of potentially harmful micro-organisms which can infect hospital patients, health-care workers and the general public. Other potential infectious risks include the spread of, sometimes resistant, micro-organisms from health-care establishments into the environment. These risks have so far been only poorly investigated. Wastes and by-products can also cause injuries, for example radiation burns or sharps-inflicted injuries; poisoning and pollution, whether through the release of pharmaceutical products, in particular, antibiotics and cytotoxic drugs, through the waste water or by toxic elements or compounds such as mercury or dioxins.

The potential risk to health care workers comes from the handling of infected sharps; 60 percent of them sustain an injury from sharps knowingly or unknowingly during various procedures. The practice of re-sheathing the needle after use is the major factor for needle stick injuries. Through poor waste management practices, all health care workers (nurses, doctors, and lab technicians), service personnel, rag pickers and the general public are at risk of contracting infections while

handling storage, and treatment. Incinerators operating at sub-optimal conditions are an added environmental and health hazard.

Sharps

Throughout the world every year an estimated 12,000 million injections are administered. And not all needles and syringes are properly disposed of, generating a considerable risk for injury and infection and opportunities for re-use.

Regarding injection practices, public health authorities in West Bengal, India, have recommended a shift to re-usable glass syringes, as the disposal requirements for disposable syringes could not be enforced. Hazards occur from scavenging on waste disposal sites and manual sorting of the waste recuperated at the back doors of health-care establishments. These practices are common in many regions of the world. The waste handlers are at immediate risk of needle-stick injuries and other exposures to toxic or infectious materials.

Vaccine waste

In June 2000, six children were diagnosed with a mild form of smallpox (vaccinia virus) after having played with glass ampoules containing expired smallpox vaccine at a garbage dump in Vladivostok (Russia). Although the infections were not life-threatening, the vaccine ampoules should have been treated before discarding.

Radioactive wastes

Radiation is part of Man's environment. The use of radiation sources in medical and other applications is widespread through the world. Occasionally, the public is exposed to radioactive waste, usually originating from radiotherapy treatments that have not been properly disposed of. The sources of radiation exposure: 1) Medical and Dental X-rays, Radio Isotopes, 2) Occupational exposure. Ionizing Radiations are finding increasing application in Medicine. For eg, X-rays and radioactive Isotopes. Important radio isotopes are cobalt 60 and phosphorus 32. Certain tissues such as bone marrow are more sensitive than others and from a genetic standpoint; there are special hazards when the gonads are exposed. The radiation hazards comprise genetic changes, malformation, cancer, leukemia, depilation, ulceration, sterility and in extreme cases death. The international commission of radiological protection has set the maximum permissible level of occupational exposure at 5 rem per year to the whole body. Serious accidents have been documented in Goiânia, Brazil in 1988 in which four people died from acute radiation syndrome and 28 suffered serious radiation burns. Similar accidents happened in Mexico City in 1962, Algeria in 1978, Morocco in 1983 and Ciudad Juárez in Mexico in 1983.

Risks associated with other fractions of health-care wastes, in particular blood waste and chemicals, have been relatively poorly assessed, and need to be strengthened. In the meantime, precautionary measures need to be taken. In addition; perceived risks related to health-care waste management may be significant. In most cultures, disposal of health-care wastes is a sensitive issue that has ethical dimensions too. Personnel involved in final disposal of waste may be at risk due to improper wrapping or loose pathological waste. Personnel handling waste that contains blood-soaked material from patients in dialysis units need protection against Hepatitis B infection.

Biomedical waste (management and handling) rules, 1998 and amended in 2000

Hospitals should act not only as 'healer' but also prevent the spread of diseases. The responsibility to ensure that the hospitals not only attend to the health needs of patients but also maintain an acceptable hygienic condition squarely rests on the hospital authorities. Scientists in search of new products for mankind have succeeded in making products of convenience. The entrepreneurs and industrialists in turn engage in mass production of these products. The Supreme Court took the initiative and entrusted the Ministry of Environment and Forests to come out with suitable guidelines for the proper disposal of medical waste.

The Central Govt. has framed the bio-medical waste (management and handling) rules 1998 (amended 2000 and 2003) making use of section 6,8,and 25 of the Environmental (protection) Act 1986. These rules apply to all persons who generate, collect, receive, store, transport, treat, dispose, or handle bio-medical waste

in any form. Section 6, empowers the central Government to make the "rules to regulate Environmental Pollution". Section 8, explains regarding the "persons handling hazardous substances to comply with procedural safeguards". Section 25; provides the "power to make rules" for carrying out the purposes of the act. As per the bio-medical waste (management and handling) rules 1998 (amended 2000 and 2003), safe and effective disposal of waste generated in hospitals, the following principles are followed.

- Segregation
- Disinfection
- Storage
- Transport
- Final Disposal

Segregation

The objective of separation would be to separate the infected waste from the non infected domestic waste, sharps etc., If this mix up is avoided, entire mixture has to be considered as infected waste. The cost of treatment and disposal of this waste goes up due to the larger bulk. The advantage of segregation include : 1) Treatment cost can be reduced 2) Non infected waste can be recycled 3) general waste does not become infectious 4) segregation reduces enhances of infection of staff.

Specific color code is followed for easy identification of different types of wastes.

a) Yellow: Yellow plastic bags are used for segregating Human anatomical waste, dissected parts, tissue removed at surgery, laboratory cultures and specimens etc.,Method of Disposal: (1) incineration (2) deep burial

b) Red: Red plastic bags are used for segregating laboratory waste, culture plates, items contaminated with blood, non-sharp disposable items like gloves, tubings, intravenous sets, etc.,

Method of Disposal: Tubings are shredded to prevent reuse. After shredding, they are disinfected by autoclaving, micro waving or using chemicals. Finally they are sent for incineration.

Blue or White: Puncture proof container like empty cans or thick card board boxes, translucent plastic bags of blue or white color are used to store sharp items like needles, syringes, scalpel blades and broken glass items.

Method of Disposal

After shedding these items either autoclaving, micro waving or Chemical treatment is carried out. The waste then is sent for deep burial or incineration

Black: Black plastic bags are used to segregate discarded medicines, cyto toxic drugs, chemicals which have been used for disinfection, insecticides and incineration ash.

Method of Disposal

Disposal in secured landfill.

Liquid: This waste is disinfected and discarded in rains.

Radio active waste: This waste is hazardous, it is stored in lead containers in the basement of hospital building for 3 to 6 weeks for the radioactivity to disappear and then discharged in drains.

Disinfection

To render infectious items free from pathogenic organism disinfection is carried out before transporting and disposing them.

Methods of Disinfection

- Thermal: This disinfection can be dry or wet (autoclaving)
- Chemical : i) using formaldehyde ii) sodium hypo-chloride iii) ethylene oxide iv) bleaching powder
- Irradiation and exposure to ultra violet rays
- Use of Microwave: Small microwave is used for small quantities of laboratory waste. Large units are required for larger quantities of waste. Large units incorporate: i) grinding ii) steam spraying iii) microwave irradiation

Collection

The collection and transportation of bio-medical waste shall be carried out in a manner so as to avoid any possible hazard to human health and environment. Collection and transportation are two operations where the chances of segregated bio-medical waste coming in

contact with the public, rag pickers, animals/birds, etc are high. Therefore, all care shall be taken to ensure that the segregated bio-medical waste, handed over by the different departments, reach local storage place without any damage, spillage or unauthorized access by public, animals etc.

Storage

It is necessary to use coloured bags and also label them at the time of storage of the waste. Waste bags or containers are carried to specific local storage places. It is necessary to have security at this place to prevent unauthorized persons and ragpickers handling waste material.

Methods of treatme3nt

Treatment of waste is the process which modifies the waste in some way before it is taken to its final resting place. It can be disinfected, baling and size reduction and shredding to make recyclable items unusable breaking tip of the syringe, needles etc.

Transport

Internal and External. for internal transportation, trolleys, carts are used. For external transportation, vehicles are used to transport waste from hospital dumping place to the appropriate place for incineration, land fill and vermiculture. Vehicles carry the Hospital waste should not carry general municipal garbage.

Bio-medical waste treatment and disposal (final disposal)

Final disposal of waste depends on its category. Non infectious waste like paper can be recycled. Bio degradable waste can be used for land fill, vermiculture or buried. Infectious liquid waste is disinfected and discharged in the drains. Infectious solid waste is incinerated.

- Chemicals treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent would ensure disinfection.
- Mutilation/shredding must be such so as to prevent unauthorized reuse.
- There will be no chemical treatment before incineration. PVC shall not be incinerated.

The Central Pollution Control Board has recommended two types of incinerators:

Incinerators for individual hospitals/nursing homes/ medical establishments.

Common incinerator to handle waste from a number of hospitals/nursing homes/pathological laboratories etc.

Risks associated with waste disposal

Although treatment and disposal of health-care wastes aim at reducing risks, indirect health risks may occur through the release of toxic pollutants into the environment through treatment or disposal.

Incineration

Inadequate incineration, or incineration of materials unsuitable for incineration can result in the release of pollutants into the air. The incineration of materials containing chlorine can generate dioxins and furans, which are classified as possible human carcinogens and have been associated with a range of adverse effects. Incin-

S.No.	Waste category	Treatment and Disposal
01	Human Anatomical Waste, Animal Waste	incineration and deep burial
02	Microbiological and Bio-technology Waste	Autoclaving/micro- waving
03	Waste Sharps, Needles, Syringes, Scalpels, Blades, Glass etc	Chemical disinfection autoclave/micro-waving and mutilation/shredding
04	Discarded Medicines and Cytotoxic drugs	incineration/destruction and drugs disposal in secured landfills
05	Soiled Waste	incineration/autoclave micro-waving
06	Solid Waste	Chemical disinfection autoclave/micro-waving and mutilation/shredding
07	Liquid Waste	Disinfect-chemically and discharge into drains
08	Incineration Ash	Disposal in municipal landfill
09	Chemical Waste	Chemically treated disinfection and discharge of drains for liquid and secured landfillfor solid

eration of heavy metals or materials with high metal contents (in particular lead, mercury and cadmium) can lead to the spread of heavy metals in the environment. Dioxins, furans and metals are persistent and accumulate in the environment. Materials containing chlorine or metal should therefore not be incinerated. In the last few years there has been growing controversy over the incineration of health care waste. Under some circumstances including when wastes are incinerated at low temperatures or when plastics that contain poly vinyl chloride (PVC) are incinerated, dioxins, and furans and other toxic air pollutants may be produced as emissions and/or in bottom or fly ash (ash that is carried by air and exhaust gases up the incinerator stock). Exposure to dioxins, furans and co planar PCBs (poly chlorinated Biphenyls) may lead to adverse health effects.

Long-term, low-level exposure of humans to dioxins and furans may lead to the impairment of the immune system, the impairment of the development of the nervous system, the endocrine system and reproductive functions. Short-term high level exposure may result in skin lesions and altered liver function. WHO has established a provisional tolerable Monthly intake (PTMI) for dioxins, furans, and PCBs of 70 picograms (10^{-12} grams) per kilogram of body weight. The PTMI is an estimate of the amount of chemical per month that can be ingested over a life time without appreciable health risk. WHO has established tolerable intake limits for dioxins and furans, but not for emissions. A number of countries have defined emission limits that range from 0.1 ng TEQ/m^3 (Toxicity Equivalence) in Europe to 0.1ng to 5ng TEQ/m^3 in Japan, according to incinerator capacity.

Only modern incinerators which are able to work at 800-1000 °C, with special emission-cleaning equipment, can ensure that no dioxins and furans (or only insignificant amounts) are produced. Smaller devices built with local materials and capable of operating at these high temperatures are currently being field-tested and implemented in a number of countries.

Standards for incinerators

All incinerators shall meet the following operating and emission standards

Operating standards

(1) Combustion efficiency (C.E) shall be at least 99.00%
(2) The Combustion efficiency is computed as follows:

$$C.E = \frac{\%CO_2}{\%CO_2+\%CO} \times 100$$

(3) The temperature of the primary chamber shall be 800±50 ^{0}C
(4) The secondary chamber gas residence time shall be at least 1 (one) second at
1050 ± 50 ^{0}C, with minimum 3% Oxygen in the stack gas.

Parameter	Concentration mg/Nm^3 at (12% CO_2 correction)
(1) Particulate matter	150
(2) Nitrogen Oxides	450
(3) Hydrogen Chloride	50
(4) Minimum stack height shall be 30 meters above ground	
(5) Volatile organic compounds in ash shall not be more than 0.01%	

Emission standards

Landfill

Land filling can potentially result in contamination of drinking water. Occupational risks may be associated with the operation of certain disposal facilities.Sanitary Landfilling or Controlled Tipping is the most suitable for large towns. In modified landfilling, the solid wastes are compacted and spread in thin (2-2.5 cm) layers, each layer being uniformly covered by a layer of soil of same thickness. The final layer is covered by a final cover of about one meter of earth to prevent rodents from burrowing into the refuse and scattering. The size of the pit is about 2-3 m deep and 4-8 m wide

Types of landfill

1) Trench type: This process is adopted in plain area
2) Ramp Type : This process is adopted in hilly area
3) Area type :This process is adopted when disused quarries are available. Disadvantage of this

type is supplementary earth is required.

Mechanism

With in one week after filling the waste, the temperature rises to 60 ^{0}C. At this temperature all the pathogens are killed. Cooling ensures and temperature returns to normal in two to three weeks time. It takes four to six months for complete decomposition and for the matter to be absolutely harmless.

Standards for deep burial

1) A pit or trench should he dug about 2 meters deep. It should be half filled with waste, then covered with lime within 50 cm of the surface, before filling the rest of the pit with soil.
2) It must be ensured that animals do not have any access to burial sites. Covers of galvanised iron/wire meshes may be used.
3) 3. On each occasion, when wastes are added to the pit, a layer of 10 cm of soil shall be added to cover the wastes.
4) Burial must be performed under close and dedicated supervision.
5) The deep burial site should be relatively impermeable and no shallow well should be close to the site.
6) The pits should be distant from habitation, and sited so as to ensure that no contamination occurs of any surface water or ground water. The area should not be prone to flooding or erosion.
7) The location of the deep burial site will be authorized by the prescribed authority
8) The institution shall maintain a record of all pits for deep burial

Standards of microwaving

- Microwave treatment shall not be used for cytotoxic, hazardous or radioactive wastes, contaminated animal car cases, body parts and large metal items.
- The microwave system shall comply with the efficacy test / routine tests and a performance guarantee may be provided by the supplier before operation of the unit.
- The microwave should completely and consistently kill the bacteria and other pathogenic organisms that is ensured by approved biological indicator at the maximum design capacity of each microwave unit. Biological indicators for microwave shall be Bacillus Subtilis spores using vials or spore strips with at least $1x10^4$

Autoclaving

The principle of autoclave or steam steriliser is that water boils when its vapour pressure equals that of the surrounding atmosphere. Hence when pressure inside a closed vessel increases, the temperature at which water boils also increases. Saturated steam has penetrative power. When steam comes into contact with a cooler surface it condenses to water and gives up its latent heat to that surface (1600 ml steam at 100 ^{0}C and at atmosphere pressure condenses into one ml of water at 100 ^{0}C and releases 518 calories of heat). The large reduction in volume sucks in more steam to the area and the process continues till the temperature of the surface is raised to that of the steam. The condensed water ensures moist conditions for killing the microbes present. Sterilization by steam under pressure is carried at temperatures between 108 ^{0}C and 147 ^{0}C. By using the appropriate temperature and time, a variety of materials such as dressings, instruments, laboratory ware, media and pharmaceutical products can be sterilized. Aqueous solutions are sterilized between 108 ^{0}C and 126 ^{0}C. Heat is conducted through the walls of the sealed containers until temperature of the fluid inside is the same as that of the steam outside.

Types of steam sterilizers

1. Laboratory autoclaves 2. Hospital dressing sterilizers 3. Bowl and instrument sterilizers 4. Rapid cooling sterilizers

Even the domestic pressure cooker can be used as a sterilizer.

Defect of autoclaving

- The method of air discharge is inefficient, and it is difficult to decide when the discharge is complete. If the air is not completely removed, the desired temperature will not be attained

- There is no facility for drying the load after sterilization and before taking it out

Standards for waste Autoclaving

The autoclave should be dedicated for the purposes of disinfecting and treating bio-medical waste.
(I) When operating a gravity flow autoclaving, medical waste shall be subjected to:

- a temperature of not less than121 ^{0}C and pressure of 15 pounds per square inch (psi) for an autoclave residence time of not less than 60 minutes; or
- a temperature of not less than135 ^{0}C and pressure of 31 pounds per square inch (psi) for an autoclave residence time of not less than 45 minutes; or
- a temperature of not less than149 ^{0}C and pressure of 52 pounds per square inch (psi) for an autoclave residence time of not less than 30 minutes.

(II) When operating a vacuum autoclave, medical waste shall be subjected to maximum of one pre-vacuum pulse to purge the autoclave of all air. The waste shall be subjected to the following:

- a temperature of not less than121 ^{0}C and pressure of 15 pounds per square inch (psi) for an autoclave residence time of not less than 45 minutes; or
- a temperature of not less than135 ^{0}C and pressure of 31 pounds per square inch (psi) for an autoclave residence time of not less than 30 minutes.

(III) Medical waste shall not be considered properly treated unless the time, temperature and pressure indicators indicate that the required time, temperature and pressure were reached during the autoclave process. If for any reasons, time,temperature or pressure indicator indicates that the required temperature,pressure or residence time was not reached,the entire load of medical waste must be autoclaved again until the proper temperature,pressure and residence time were achieved.
(IV) Recording of operational parameters

Each autoclave shall have graphic or computer recording devices which will automatically and continuously monitor and record dates, time of day, load identification number and operating parameters throughout the entire length of the autoclave cycle.

(V) Validation test

Spore testing

The autoclave should completely and consistently kill the approved biological indicator at the maximum design capacity of each autoclave unit. Biological indicator for autoclave shall be Bacillus stearosporesthermophilus using vials or spore strips, with at least $1x10^4$ spores per milliliter. Under no circumstances will an autoclave have minimum operating parameters less than a residence time of 30 minutes, regardless of temperature and pressure, a temperature less than 121 ^{0}C or a pressure less than 15 psi
(VI) Routine Test

A Chemical indicator strip/tape that changes colour when a certain temperature is reached can be used to verify that a specific temperature has been achieved. It may be necessary to use more than one strip over the waste package at different location to ensure that the inner content of the package has been adequately autoclaved.

Standards for liquid waste

The effluent generated from the hospitals should conform to the following limits:

Parameter	Permissible limits
pH	6.5-9.0
Suspended solids	100 mg/l
Oil and grease	10 mg/l
BOD	30 mg/l
COD	250 mg/l
Bio-assay test	90% survival of fish after 96 hours in 100% effluent

These limits are applicable to those hospitals which are either connected with sewer without terminal sewage treatment plant or not connected to public sewers. For discharge in to public sewers with terminal facilities, the general standards as notified under the Environment (Protection) Act,1986 shall be applicable. At present, there are practically no environment-friendly, low-cost options for safe disposal of infectious wastes. Incineration of wastes has been widely practised, but alternatives are becoming available, such as autoclaving, chemical treatment and micro-waving, and these may be pref-

erable under certain circumstances. Landfilling may also be a viable solution for parts of the waste stream if practised safely. However, action is necessary to prevent the important disease burden currently created by these wastes.

Suggestions for better management of waste in hospitals

Waste management — reasons for failure

The absence of waste management, lack of awareness about the health hazards, insufficient financial and human resources and poor control of waste disposal are the most common problems connected with health-care wastes. Many countries do not have appropriate regulations, or do not enforce them. An essential issue is the clear attribution of responsibility of appropriate handling and disposal of waste. According to the 'polluter pays' principle, this responsibility lies with the waste producer, usually being the health-care provider, or the establishment involved in related activities.

Environmental awareness

The Indian macro environment consisting of demographic, economic, technological, political, legal, physical and socio-cultural environments have been changing very rapidly resulting in changes in every walk of life of Indian people. The doctors or the patients did not bother that much about the physical environment prevailing in the hospitals. They show greater interest about the curative aspects than the cleanliness and beauty of the surroundings. There is tremendous change in the attitude of the doctors as well as patients. In Corporate Hospitals, separate departments are being maintained for in-house maintenance and interior decoration. These hospitals, almost all built and arranged like five star hotels, take care in the management of all types of wastes. In fact, they have professionals to destroy or manage not only biological wastes but also for providing cleanliness and interior decoration. Unfortunately, the managers of the public hospitals are unable to upkeep the environment at satisfactory levels. The doctors including the specialists, para-medical staff, IV class employees, patients and the visitors is even today responsible for the bad management of the wastes and environmental pollution. Probably the first change we have to bring about in the functioning of majority of the hospitals in India is not on the matters relating to the curing process or the equipment which is fairly satisfactory but the maintenance and cleanliness of these hospitals. The hospital managements have to meticulously plan the sanitation system as this is of primary importance to avoid infections. Good occupational health and safety measures include:

- Proper training
- Protective clothing and equipment
- Effective occupational health programmes including immunization (against hepatitis B) and post exposure prophylaxis along with medical surveillance
- Conveniently placed washing and bathing facilities.

Environmental education

Present situation of formal Environmental education in India: several educational Institutions and Universities are offering Degree or Diploma programmes covering all aspects of environmental Sciences and Engineering. Technical Institutions are offering M.E., M.Tech., and Ph.D programmmes in environmental engineering in the Departments of Chemical and Civil Engineering. Following the directive of the Supreme Court, the UGC has taken the necessary steps to introduce a course "Environmental Science" at under graduate level. The syllabus prescribed for the above course covers various types of diseases like HIV/AIDS due to the improper handling of hospital waste, Environment and human health, value education, public awareness, environmental Acts and Laws. Hence by maintaining the proper environment in and around Hospitals, we can avoid diseases caused due to wastes produced in hospitals

Non formal education: Majority of the population that still do not have adequate access to formal education are visiting the Govt. Hospitals where improper unhygienic conditions prevail due to waste which is not properly handled or treated before it dispossess. Hence Govt. organizations like Central Pollution Control Board, State Pollution Control Boards, Media and Non Govt. organizations like

IMA and voluntary organisations have to educate the people, particularly patients, by conducting eco development camps, exhibitions, nature camps, mobile exhibitions, audio visual presentations, seminars, workshops, camp/ padayatras/rallies, competitions, festivals, street theatre, science fairs and poster presentations etc. The environmental education should be a continuous process

Attitudinal change

Management of hospital waste requires diligence and care from a chain of people starting from the ward attendant, nurse, doctor, labour staff, persons transporting waste, persons handling mechanical and technical aspects. If need for safe disposal is stressed, cooperation for segregation, storage, disinfection will not be difficult.Truly speaking, an attitudinal change is required at the level of top management. Waste disposal should be a management's policy. Chief Executive Officer or the Doctors are to be held responsible. Employees at all levels must be trained and motivated. The hospitals cannot be disease generators. The general public also should be their concern, not those patients who contribute to their revenue. It is desirable to specify job responsibility. If there are failures or problems, proper communication will sort out the same and decide on better alternatives. The risk due to occupational hazards is the highest for the staff themselves. Waste disposal involves expenditure but it is not an area to look for saving on expenditure. After all, the expenditure does not go beyond 0.2 to 0.5% of the total running cost of the hospital.

Surveillance

The following steps are to be taken to help rag pickers

- Emphases on dangers of handling infected waste and recycling
- Train rag pickers in acquiring recyclable waste
- Public awareness about segregation of waste and role of rag picker's activities, must be created.
- Establishment of linkages between formal system and rag pickers
- Medical assistance and health education for rag pickers and their families.
- General public must be convinced about reducing the quantity of garbage by utilizing reusable and recyclable items.

Staff training

Those who handle garbage are often not aware of the risk and hazard of the activity. They are also not aware of the importance of their contribution. Training of the staff is therefore necessary. The goals of training should be

- Information on all aspects of hospital waste policy
- Information on the role and responsibilities of each hospital staff members in implementing the policy
- Technical instructions, relevant for the target group, on the application of waste management practices
- Clarify the components of the waste management system
- Explain the assigned roles and responsibilities to the personnel involved
- Educate and ensure proper use of the protective equipment
- Information regarding the procedure to be followed for a needle stick or other exposures
- Get an honest feedback from the workers
- Suggest preventive remedies to their problems, if required

Waste management committee

Waste Management Committee: The most important factor in successful implementation of medical waste management lies in the cooperation of the hospital staff and medical personnel. Proper management of hospital wastes calls for a well-coordinated approach which involves Planning, Organizing, Communicating and Monitoring. The role that the administration plays in this is of vital importance. Ideally a hospital should form a waste management committee representing the following Departments, which has the responsibility to design and implement a policy.

- Hospital Administrator - Chairman
- Microbiologist - Secretary
- Representative from Accounts Section
- One or Two Members from Basic Specialities like Medicine, Surgery,Gynecology, Pediatrics, etc.,
- One or Two Members from Superspecialities like Cardiac Surgery, Nephrology, Neurosurgery, Hematology etc.,
- Senior Member of the Nursing Section
- Representative from Maintenance Department
- Representative from House Keeping Department

CONCLUSIONS

Health-care waste management is an integral part of health-care, and creating harm through inadequate waste management reduces the overall benefits of health-care. Improvements in health-care waste management rely on the following key elements: The buildup of a comprehensive system addressing responsibilities, resource allocation, handling and disposal. This is a long-term process, sustained by gradual improvements. Awareness raising and training about risks related to health-care waste, and safe and sound practices; Selection of safe and environmental-friendly management options, to protect people from hazards when collecting, handling, storing, transporting, treating or disposing of waste. Government commitment and support is needed to reach an overall and long-term improvement of the situation, although immediate action can be taken locally. Finally there should be proper coordination between Hospital administration/committee and Municipal administration for collection and disposal of Biomedical waste.

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