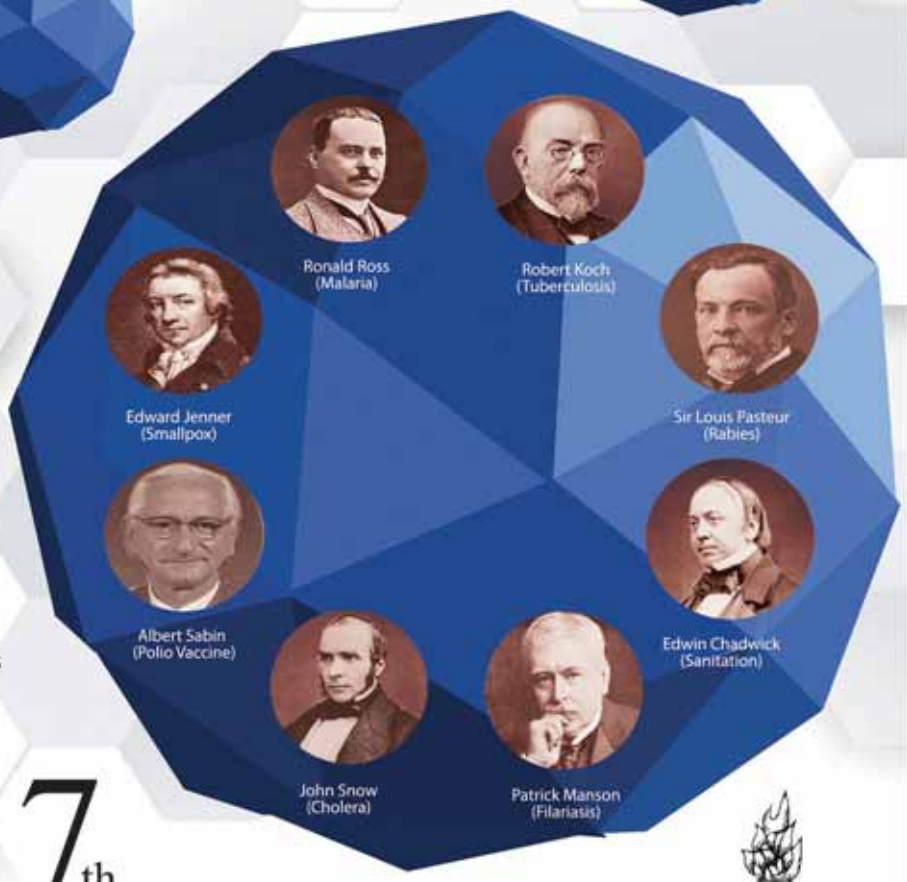
COMMUNITY MEDICINE

with

Recent Advances

As per the Competency Based Medical Education Curriculum (NMC)

AH Suryakantha



Highlights

- Research Methodology
- National Programme for Prevention and Management of Trauma and Burn Injuries
- Clinical Establishment Act, 2010
- National Action Plan for Dog Mediated Rabies
- National Family Health Survey-5
- Child Trafficking
- Role of Computers in Health Care
- RMNCAH+N Strategy
- Elimination of Cervical Cancer
- Omicron Virus Disease

7th Edition

JAYPEE

Contents

Chapter 13

Management of Hospital Waste

Any waste generated out of hospitals can be said to be "Hospital waste." Any waste generated consequent to healthcare activity including those at home is "Healthcare waste." According to Biomedical Waste (Management and Handling) Rules 1998 of India, "Biomedical Waste" (BMW) is defined as a waste generated during diagnosis, treatment, immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals. Thus, BMW encompasses a wider category of waste and includes waste from veterinary institutions and slaughter houses also. However, radioactive waste is not included under BMW.

Hospitals generate large volumes of wastes as a by-product of a variety of health services and procedures carried out such as surgery, dressing of the wounds, dialysis, deliveries, laboratory and dental procedures, postmortem procedures, etc. Such a waste may be infectious or noninfectious. If such a waste is not collected, transported and disposed off, it not only results in causation of "hospital-acquired infections" (nosocomial infections) but also poses a major public health hazard by causing pollution of air, water, and soil. Persons who are constantly exposed to these wastes especially waste-sharps, are hospital workers (nurses), rag pickers, cleaners, laundry staff, etc. who are always at a risk of getting fatal diseases like Hepatitis B and C and HIV through injuries by contaminated needles and sharps as an occupational hazard. Indiscriminate dumping of the hospital wastes into the backyards or into open municipal pits, become breeding places for disease spreading mosquitoes, flies, rodents, and microbes. Epidemics can result from the contamination of drinking water and food sources with these infectious wastes, which are washed by rains. Indiscriminate open burning of infectious waste, especially plastics will result in emission of noxious gasses, which may produce cancer. Further, there is scope for (improper) reuse of syringes, needles, polythene bags, catheters and other rubber tubes, bottles, etc.

Not all the waste from a healthcare setting is infectious or hazardous. There is a mixture of different types of waste. The twin problems of healthcare waste are its characteristics and quantity.

CHARACTERISTICS OF HEALTHCARE WASTE

It is estimated that about 10–15% of healthcare waste is "infected waste." Noncontaminated or noninfectious waste becomes infected when it gets mixed with infected waste. Hence one should not allow mixing of infected waste with household (noncontaminated) waste. This is possible only if the waste is segregated or sorted into "Infected" and "Household" waste at the source or point of generation.

QUANTITY OF HEALTHCARE WASTE

This depends upon the type of healthcare setting and the services offered.

A survey of wastes generated in different healthcare settings (waste survey) is a basic prerequisite for planning and implementing a waste management endeavor. This is known as "waste audit."

With an estimated 0.5–1.0 kg of wastes per bed per day, state hospitals like Community Health Centers, Taluka Hospitals and Sub-District Hospitals with bed strength of 30–100 can produce 15–50 kg of wastes per day whereas District and Teaching Hospitals including private hospitals in urban cities may need to handle 200–1000 kg of hospital wastes daily. With improved services and more health seeking population in years to come, this load is likely to get doubled or even tripled. Extensive use of disposables has added another dimension to the problem. Health institutions are being shunned away not so much because of inadequate patient care or drugs but more because of the dirty wards, toilets, and the labor rooms. Management of hospital waste has thus become a growing concern.

OBJECTIVES OF THE WASTE MANAGEMENT SYSTEM

- To reduce the infectious/hazardous nature of the waste
- To reduce the volume of the waste
- To prevent misuse or abuse of the waste
- To ensure occupational safety and health
- To consider esthetics
- To reuse the items that can be of repeat utility

- To recycle the waste so that it can serve as another utility item.

(Recycling is a process by which the waste materials are transformed into new products in such a manner that the original products lose their identity).

Safe waste management practices help

- To maintain order and cleanliness in the hospital
- To maintain a healthy environment for patients, staff, and public
- To prevent spread of infectious diseases
- To project good impression of the management
- To attract more clientele
- To generate revenue for the institution.

BIOMEDICAL WASTE MANAGEMENT RULES, 2016

The Biomedical Waste (Management and Handling) Rules 1998 and further amended in 2000 and 2003 has been reviewed by the Ministry of Environment, Forest and Climate Change, Govt. of India, on 28th March 2016 and is called "Biomedical Waste Management Rules 2016" (BMWM Rules 2016). It was amended in 2016 in order to implement the rules more effectively and to improve the collection, segregation, processing, treatment and disposal. The norms of the color coding containers is shown in **Figure 13.1**.

The new rules will bring in a wider and more comprehensive regime for BMW management. The new rules will change the way the country used to manage this waste earlier. Under the new regime, the coverage has increased and also provides for pretreatment of laboratory waste, blood samples, etc. It mandates bar code system for bags for proper control and immunization of health workers upon induction and every year. It has simplified categorization and authorization. Thus, it will make a big difference to Clean India Mission.

The total BMW generated in the country is 484 tonnes per day (TPD), from 1,68,869 healthcare facilities (HCFs) out of which only 15% is hazardous and 85% is nonhazardous. If not segregated and mixed up, the entire waste becomes contaminated and hazardous. Therefore, it is necessary to segregate and treat before disposal. Out of 484 tones, only 447 tonnes per day is treated before disposal. Improper disposal increases the risk of infection, encourages recycling of prohibited disposals, and disposed drugs and develops resistant microorganisms.

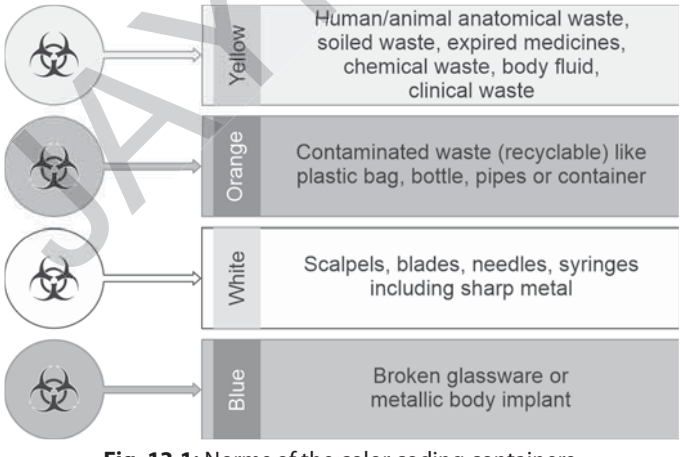


Fig. 13.1: Norms of the color coding containers.
(For color version, see Plate 1)

The Major Salient Features of BMW Management Rules, 2016

a. The ambit of the rules has been expanded to include vaccination camps, blood donation camps, surgical camps or any other healthcare activity.
b. Phase out the use of chlorinated plastic bags, gloves and blood bags, within 2 years.
c. Pretreatment of the laboratory waste, microbiological waste, blood samples and blood bags through disinfection or sterilization on-site in the manner as prescribed by World Health Organization (WHO) or National AIDS Control Organization (NACO).
d. Provide training to all its healthcare workers and immunize all health workers regularly.
e. Establish a bar code system for bags or containers containing BMW for disposal.
f. Report major accidents.
g. Existing incinerators to achieve the standards for retention time in secondary chamber and Dioxins and Furans within 2 years.
h. BMW has been classified into four categories instead of ten to improve the segregation of waste at source.
i. Procedure to get authorization simplified. Automatic authorization for bedded hospitals. The validity of authorization synchronized with validity of consent orders for bedded HCFs. One time authorization for nonbedded HCFs.
j. The new rules prescribe more stringent standards for incinerator to reduce the emission of pollutants in environment.
k. Inclusion of emissions limits for Dioxins and Furans.
l. State Government to provide land for setting up common BMW treatment and disposal facility.
m. No occupier shall establish on-site treatment and disposal facility, if a service of common BMW treatment facility is available at a distance of 75 km.

These rules consist of four schedules and five forms.

- *Schedule I*: BMW categories and their segregation, collection treatment, processing, and disposal options **(Table 13.1)**.
- *Schedule II*: Standards for treatment and disposal of BMW.
  - Operating standards
  - Emission standards
  - Standards for autoclaving of BMW
  - Standards of microwaving
  - Standards for deep burial

- Standards for efficacy and chemical disinfection
- Standards for dry heat sterilization
- Standards for liquid waste

- *Schedule III*: List of prescribed authorities and their corresponding duties
- *Schedule IV*:
  - Part A—label for BMW containers or bags biohazard and cytotoxic hazard
  - Part B—label for transporting BMW bags or containers
- Form I—Accident reporting
- Form II—Application for authorization or renewal of authorization
- Form III—Authorization
- Form IV—Annual report
- Form V—Application for filing appeal against order passed by the prescribed authority.

SCHEDULE I: PART – 1

TABLE 13.1: Biomedical wastes categories and their segregation, collection, treatment, processing and disposal options.

Category	*Type of waste*	*Type of bag or container to be used*	*Treatment and disposal options*
(I)	*(II)*	*(III)*	*(IV)*
Yellow	**(a) Human anatomical waste:** Human tissues, organs, body parts and fetus below the viability period (as per the Medical Termination of Pregnancy Act 1971, amended from time to time)	Yellow colored nonchlorinated plastic bags	Incineration or plasma pyrolysis or deep burial
	(b) Animal anatomical waste: Experimental animal carcasses, body parts, organs, tissues, including the waste generated from animals used in experiments or testing in veterinary hospitals or colleges or animal houses		
	(c) Soiled waste: Items contaminated with blood, body fluids like dressings, plaster casts, cotton swabs and bags containing residual or discarded blot id and blood components		Incineration or plasma pyrolysis or deep burial In absence of above facilities, autoclaving or micro-waving/hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery
	(d) Expired or discarded medicines: Pharmaceutical waste like antibiotics, cytotoxic drugs including all items contaminated with cytotoxic drags along with glass or plastic ampoules, vials, etc.	Yellow colored non-chlorinated plastic bags or containers	Expired cytotoxic drugs and items contaminated with cytotoxic drugs to be returned back to the manufacturer or supplier for incineration at temperature >1,200°C or to common biomedical waste treatment facility or hazardous waste treatment, storage and disposal facility for incineration at >1,200°C Or Encapsulation, or Plasma pyrolysis at >1,200°C All other discarded medicines shall be either sent back to manufacturer or disposed by incineration
	(e) Chemical waste: Chemicals used in production of biological and used or discarded disinfectants	Yellow colored containers or nonchlorinated plastic bags	Disposed of by incineration or plasma pyrolysis or encapsulation in hazardous waste treatment, storage and disposal facility
	(f) Chemical liquid waste: Liquid waste generated due to use of chemicals in production of biological and used or discarded disinfectants, silver X-ray film developing liquid, discarded Formalin, infected secretions, aspirated body fluids, liquid from laboratories and floor washings, cleaning, house-keeping and disinfecting activities, etc.	Separate collection system leading to effluent treatment system	After resource recovery, the chemical liquid waste shall be pre-treated before mixing with other wastewater. The combined discharge shall conform to the discharge norms given in Schedule-III

Category	*Type of waste*	*Type of bag or container to be used*	*Treatment and disposal options*
(I)	*(II)*	*(III)*	*(IV)*
	(g) Discarded linen, mattresses, beddings contaminated with blood or body fluid.	Nonchlorinated yellow plastic bags or suitable packing material	Nonchlorinated chemical disinfection followed by incineration or plasma pyrolysis or for energy recovery. In absence of above facilities, shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery or incineration or Plasma Pyrolysis
	(h) Microbiology, biotechnology and other clinical laboratory waste: Blood bags, laboratory cultures, stocks or specimens of microorganisms, live or attenuated vaccines, human and animal cell cultures used in research, industrial laboratories, production of biological, residual toxins, dishes and devices used for cultures	Autoclave safe plastic bags or containers	Pretreat to sterilize with nonchlorinated chemicals on-site as per National AIDS Control Organization or World Health Organization guidelines thereafter for Incineration
Red	**Contaminated waste (recyclable)** (a) Wastes generated from disposable items such as tubing, bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles and fixed needle syringes) and vacutainers with their needles cut and gloves.	Red colored nonchlorinated plastic bags or containers	Autoclaving or microwaving/hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent to registered or authorized recyclers or for energy recovery or plastics to diesel or fuel oil or for road making, whichever is possible. Plastic waste should not be sent to landfill sites
White (translucent)	**Waste sharps including metals:** Needles, syringes with fixed needles, needles from needle tip cutter or burner, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts. This includes both used, discarded and contaminated metal sharps	Puncture-proof, leak proof, tamper-proof containers	Autoclaving or dry heat sterilization followed by shredding or mutilation or encapsulation in metal container or cement concrete; combination of shredding cum autoclaving; and sent for final disposal to iron foundries (having consent to operate from the State Pollution Control Boards or Pollution Control Committees) or sanitary landfill or designated concrete waste sharp pit
Blue	**(a) Glassware:** Broken or discarded and contaminated glass including medicine vials and ampoules except those contaminated with cytotoxic wastes. **(b) Metallic body implants**	Cardboard boxes with blue-colored marking Cardboard boxes with blue-colored marking	Disinfection (by soaking the washed glass waste after cleaning with detergent and sodium hypochlorite treatment) or through autoclaving or microwaving or hydroclaving and then sent for recycling

Disposal by deep burial is permitted only in rural or remote areas where there is no access to common BMW facility. This will be carried out with prior approval from the prescribed authority and as per the Standards specified in Schedule-III. The deep burial facility shall be located as per the provisions and guidelines issued by Central Pollution Control Board (CPCB) from time to time.

STRATEGIES ADOPTED FOR HOSPITAL WASTE MANAGEMENT

- Waste reduction and management strategy
- Waste assessment strategy
- Waste recycling strategy
- Hospital waste disposal

Waste Reduction and Management Strategy

The objectives of this strategy are:

- Reducing the waste quantity by a significant percentage
- Decreasing waste disposal efforts and expenses (e.g., construction of landfills, operational cost of equipment like incinerators, etc.)

A technique which decontaminates the wastes to destroy spores of Bacillus subtilis at concentration of 10^4 is said to have attained Level III disinfection, resulting in reduction of volume and making the waste unrecognizable with minimum handling and transportation.

AVAILABLE TREATMENT AND DISPOSAL TECHNOLOGIES

Available Technologies

- Incineration
- Chemical disinfection
- Wet and dry thermal treatment
- Deep burial or landfilling
- Recycling
- Worm composting.

Incineration (Mass Burn Technology)

This method consists of burning the waste in a simple kiln or incinerator to a very high temperature of about 1,000°C, resulting in reduction of organic and combustible solid waste to inorganic, incombustible matter, thus converting the waste into bottom ash (incombustible matter) and fly ash (containing particulate matters and hazardous noxious gasses). Incineration offers a direct disposal technology with zero occupational hazards and a volume reduction of 85–95%. The process of burning is usually selected to treat waste that cannot be recycled, reused, or disposed off in a landfill site.

Proper source segregation and installing multichambered electrical incinerators with pollution control technology are key points to ensure environmental safe use of this technology, as recommended by Environmental Protection Agency (EPA). Incineration as a process involves waste preparation (segregation), waste charging and combustion, treatment of emission through controls and handling of incinerator ash. The ash may be collected in thick puncture proof bags and stored for periodic dumping into community landfill. Presorting is done to eliminate bulky and nonburnable items.

There are basically three types of incinerators:

1. Double chamber pyrolytic incinerators, for burning the infectious healthcare waste **(Fig. 13.2)**.
2. Single chamber furnaces, which are next best.
3. Rotary kilns, operating at high temperatures capable of causing decomposition of genotoxic substances and heat resistant chemicals.

Double chamber pyrolytic incinerator: This is designed to burn the infectious healthcare waste, at temperatures between 900°C and 1200°C and has pollution control devices. Thus, the technology is environment-friendly. So, the pyrolytic incineration is also called "controlled-air incineration" **(Fig. 13.2)**.

Function: The waste is thermally decomposed through an oxygen deficient, medium temperature of 800–900°C

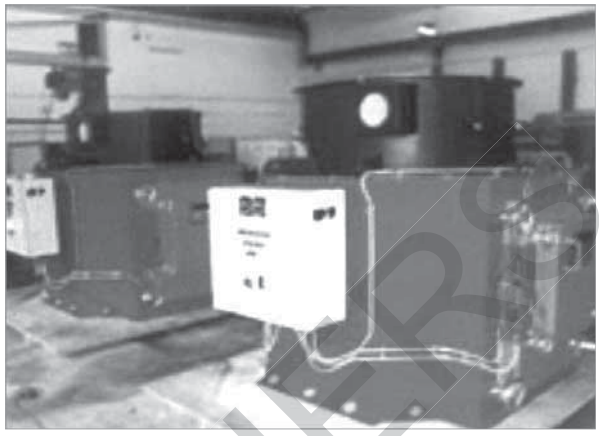


Fig. 13.2: Double chamber incinerator (Capacity: 2 × 800 kg/day).

combustion process, producing solid ashes and gases. The process starts with a fuel burner.

The gases produced in the primary chamber are then burnt in the second, postcombustion chamber at 900–1,200°C, using an excess of air to minimize smoke and odors.

For effective operation, the incinerator should fulfill the following criteria:

- The temperature in the postcombustion chamber should reach at least 1,000°C
- Gas residence time should be at least 2 seconds
- Air inflow with 100% excess oxygen and high turbulence should be ensured.

Design: The incinerator is designed for capacity of 50–250 kg of waste per hour (for incineration of above 250 kg/hour, rotary kiln incinerators are preferred). The waste is fed into the incinerator in small batches. The refractory lining and insulation bricks shall be strong enough to sustain the high temperature. There are separate burners for primary and secondary chambers, with automatic switching "Off/On" control and equipped with spark igniter. The secondary burners are positioned in such a way that the flue gas passes through the flame. There is no manual handling of the waste. On the other hand, the waste is charged through automatic feeding device. It has a computer recording devices which will automatically and continuously monitor and record dates, time of day, batch number and operating parameters such as temperature in both the chambers, and emissions of CO, CO_2 and O_2 periodically.

Standards for Incinerators

Operating Standards

- Combustion efficiency at least 99.99%
- Primary chamber temperature 800 ± 50°C
- Secondary chamber gas residence time at least 1 second; temperature at 1050 ± 50°C; minimum 3% oxygen in the stack gas
- Temperature of the waste gas leaving the secondary chamber brought down immediately to 230°C.

may be disinfected by using neutral disinfectants. Chemical disinfection is most suitable for treating liquid waste such as blood, urine, stools, or hospital sewage. However, solid wastes may also be disinfected chemically with certain limitations. Chemically disinfected wastes should continue to be treated hazardous, unless bacterial testing shows complete disinfection. The main disadvantage of chemical disinfectants is that there is no disinfectant which attains the desirable level III disinfection and there is no test to judge the efficacy of disinfection.

Wet and Dry Thermal Treatment

Wet thermal treatment (autoclaving): In this technology, the infectious wastes are steam heated at specified temperature and pressure for specific period of time. Decontamination occurs when steam penetrates the waste. The equipment requires supply of high temperature and pressurized steam from a boiler unit. A gravity-flow autoclave or a vacuum autoclave which functions within specified range of temperature (121–149°C), pressure (15–51 psi), and time (60–30 minutes) should be used. Vacuum autoclaves are more efficient as absence of air ensures uniform and total penetration of waste by steam and thus total disinfection **(Fig. 13.5)**. The treated waste from an autoclave remains wet with no change in volume. The emission is foul smelling and infectious. Autoclaves can decontaminate most categories of waste except biodegradable organic waste and toxic waste. Autoclaves with superior technology conforming to regulations of CPCB are efficient and offer advantages of volume reduction and odorless and nontoxic emission. But they may cause more occupational hazards and are not cost-effective.

An autoclave should completely and consistently kill the approved biological indicator, i.e. *Bacillus stearothermophilus* spore using vials or spore strips, with at least 1×10^4 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°C or a pressure less than 15 psi. A strip/paper that changes color at a particular temperature can be used as a chemical indicator to assess that a specific temperature has been achieved.

Dry Thermal Treatment (Screw-feed Technology)

In this dry thermal, disinfection, nonburning process, the waste is heated in a rotating auger. The waste is reduced by 80% in volume and 20–35% in weight. This process is suitable for treating infectious waste and sharps, but it should not be used to process pathological, cytotoxic or radioactive waste.

Deep Burial

Wastes belonging to Category I, III and VI collected in yellow containers are disposed by deep burial **(Fig. 13.6)**.

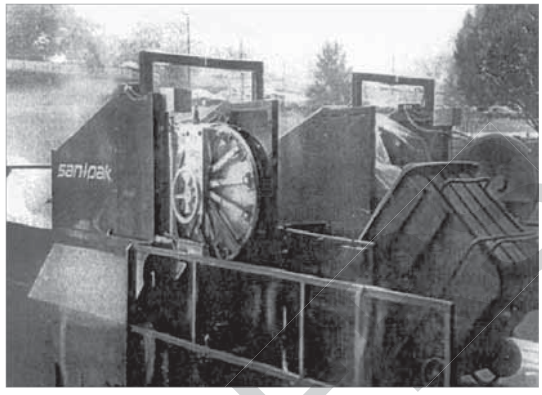


Fig. 13.5: Autoclave.

Fig. 13.6: Deep burial—a pit for disposal of organic (biodegradable) waste. *(For color version, see Plate 2)*

Standards for Deep Burial

- A pit or trench should be dug about 2 m deep and measuring 1.5 m^2.
- The site should be impermeable, away from habitation and not prone for flooding or erosion and authorized by the prescribed authority.
- It is ensured that the site does not contaminate the surface water or the groundwater. No shallow well should be close to the site.
- The pit is half filled with waste, then covered with lime within 50 cm of the surface, before filling the rest of pit with soil.
- On each occasion of adding waste to the pit, a layer of 10 cm of soil shall be added to cover the wastes.
- Burial must be performed under close and dedicated supervision.
- It must be ensured that animals do not have any access to burial sites. Covers of galvanized iron/wire meshes may be used.
- The institution shall maintain a record of all pits for deep burial.

Landfilling

Landfilling means disposal of residual solid wastes on land in a facility designed with protective measures against pollution of groundwater, surface water, air, and ground erosion. Water

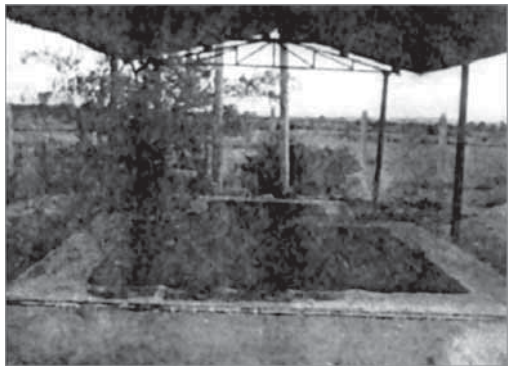


Fig. 13.7: An engineered landfill for safe final disposal of waste.
Source: Government of Karnataka. Karnataka Health Systems Development Project Management of Hospital Waste, 2001.

becomes contaminated by the leachate of the waste. Leach/leachate means the liquid that seeps through the waste and has dissolved or suspended extracts of the waste.

Sanitary landfills are especially constructed for disposal of nonbiodegradable infectious hospital wastes **(Fig. 13.7)**. This method is simple and cost-effective. The area should be away from the residential area. A hospital with a bed strength of 100 may require a landfill site of about 500–600 cu ft.

The basic features of an engineered landfill are:
- An impermeable clay and pebble base
- Graded base creates leachate collection
- Stored earth for covering at the end of each disposal operation.

The essential features of operation of sanitary landfilling are:
1. That all the waste bags are completely pushed into the landfill without getting opened up.
2. Enough earth and hay is put to cover the entire waste so that stray animals do not pick the waste.
3. Frequent spray of the insecticide is done.
4. Personnel protective measures are taken by wearing boots, gloves and aprons.

Landfills are still the most popular method for disposal. But the strict guidelines are that the landfill should be double lined, it should have leachate collection system and a ground water monitoring system to check for the failure of the leachate collection system.

Worm Composting

In this method, not actually the hospital waste but the biodegradable general waste from areas of the hospital like kitchen, dining places, cafeteria, which mostly contain organic food wastes, peelings of vegetables, etc., collected in white containers with black-stripes, are disposed off. A rectangular pit about 1 m deep bound by brick wall will serve the purpose. A few hundred earthworms are introduced to the earth bed on which the waste can be dumped and some water sprinkled daily. The worms will facilitate microbial decomposition of waste which will form the agriculturally useful compost in 2–3 months. Periodically, the compost may be collected either for the hospital kitchen garden or for marketing. A wire mesh may cover the area to prevent birds and animals from picking up the waste.

Newer Technologies

- Microware irradiation
- Plasma torch technology
- Inertization
- Gamma irradiation
- Hydroclave
- Pyrolator
- Bacterial cultures
- Electron beaming

Microwave Irradiation

In this technique, heat is generated inside the equipment during bombardment of electromagnetic waves into the rotating molecules of the waste. The waste should have some water content to enhance molecular mobility, because the water contained within the waste is rapidly heated by the microwaves and the pathogens are destroyed. However, this technique is not suitable for the wastes of the category I and II. Any microwave equipment must comply with efficacy tests stipulated under the biomedical rules. At the maximum design capacity, microwave unit should show total destruction of *Bacillus subtilis* spores (used as biological indicator) at a concentration of 10^4 spores per minute. A modern microwave machine is shown in **Figure 13.8**.

The main advantages of this technology are high efficiency, 30–40% volume reduction, minimal environment pollution and occupational risk, compact nature of equipment, and cost-effectiveness.

Plasma Torch Technology

Plasma torch technology (PTT) consists of using a flame at about 6000°C, hotter than the surface of the sun to turn

Fig. 13.8: Microwave technology.

everything that it touches into fourth state of matter, i.e., plasma which is an ionized gas. It takes in various types of garbage and vaporizes most of it. What is produced is a gas that can be burnt for energy and a solid black rock like material, used in construction. The glossy rock is not leachable and nontoxic. This technique was developed by NASA in 1960s.

Pros and cons at plasma torch technology

Pros	*Cons*
PTT reduces trash that otherwise would fill up landfills. It can dispose off biohazardous waste safely. It produces useful materials that energy of otherwise useless objects	PTT is extremely costly. It is a complex set up that requires two separate factories to be productive

Locations of current facilities of PTT

- St Lucie county, Florida
- Utashinai, Japan
- Yoshii, Japan.

Plasma torch waste disposal is an interesting and useful application of plasma technology. However, until it can be made cheaper and easier to comprehend, it is unlikely that it will become popular among the general public.

Inertization

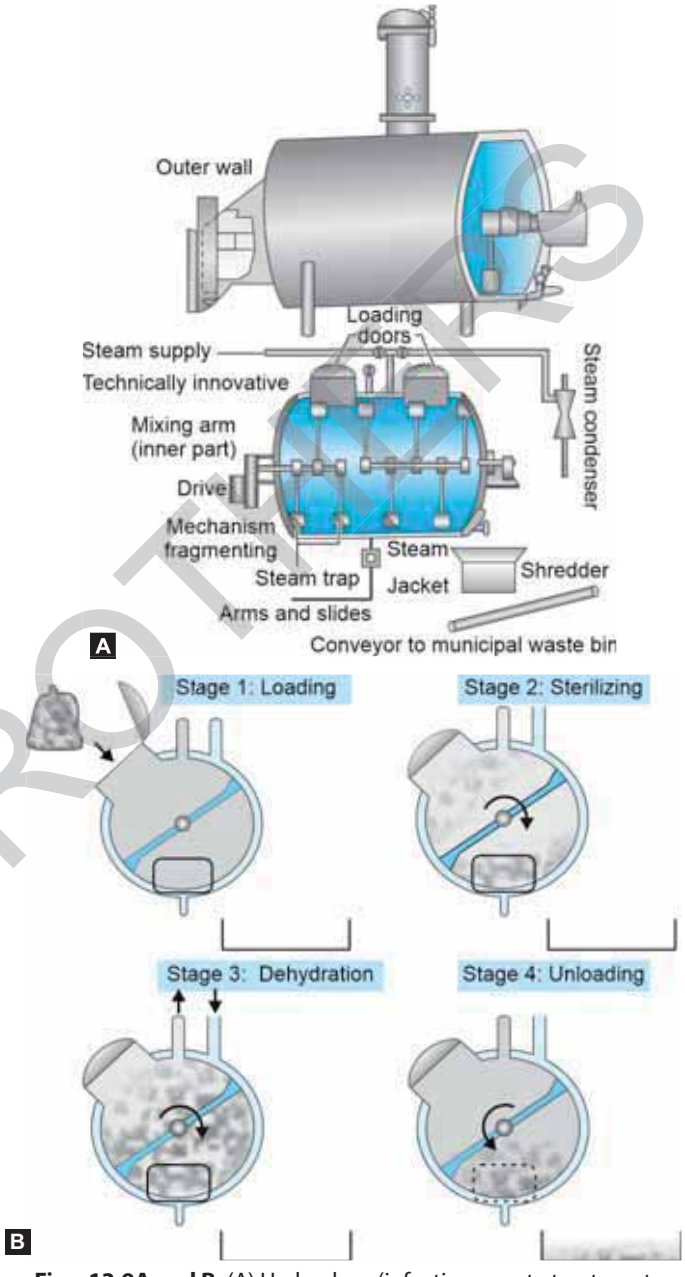
In this process, the waste is mixed with other substances like cement, lime and water, in the ratio of 65%, 15%, and 5%, respectively, before disposal so that the risk of toxic substances migrating into the surface water or ground water is minimized. A homogeneous mass is formed and then transported to suitable sites.

Hydroclave

It is an advanced autoclave method for treating infectious waste, utilizing steam, but with much faster and much more even heat penetration. It is a double-walled cylindrical vessel, mounted horizontally. The vessel is fitted with a mixing arm that rotates slowly inside the vessel **(Fig. 13.9A)**.

Hydroclave works in the following stages:

- *Stage 1: Loading*—hydroclave is loaded. It can process the bagged waste (in ordinary bags), sharp containers, liquid containers, cardboard containers, metal objects, and pathological waste **(Fig. 13.9B)**.
- *Stage 2: Sterilizing*—the powerful rotators mix the waste and breaks it into small pieces. Steam is filled in the double wall jacket of the vessel, which heats the interior of the vessel. The liquid in the waste turns to steam. After 20 minutes all the waste and liquids become sterile.
- *Stage 3: Dehydration*—the vent is opened. The vessel is depressurized via a condenser and the sterile liquid is drained into sanitary sewer. Steam heat and mixing a continued until all the liquids are evaporated and the waste becomes dry.
- *Stage 4: Unloading*—the unloading door is opened. The mixer is now rotated in the opposite direction, so that all the waste is pushed out. The dry sterile waste is further fine shredded or dropped in a waste disposal bin. The waste is now ready for safe disposal.



Figs. 13.9A and B: (A) Hydroclave (infectious waste treatment system); (B) Hydroclave (treatment process).

Note: The Tata Memorial Hospital, Mumbai, has installed, an advanced hydroclave, for treating its nonpathological waste.

Advantages of hydroclave

- Totally sterilizes the waste (for treating nonpathological waste)
- Treats all infectious waste (except anatomical and cytotoxic waste), even bulk liquid and pathological

TABLE 13.2: Advantages and disadvantages of different treatment and disposal technologies.

	Treatment method	*Advantages*	*Disadvantages*
1.	Incineration		
	• Pyrolytic incineration	Highly efficacious for all infectious wastes	Incomplete destruction of cytotoxics. Investing and operation cost is very high. Significant emission of atmospheric pollutants
	• Single chamber incineration	Disinfection efficiency is reasonably good. Drastic reduction of waste in volume and weight. Residue may be disposed off in landfills. Does not require highly skilled persons. Investment and operation cost is low	Slag and soot to be removed periodically. Thermal resistant chemicals and cytotoxic drugs are not efficiently destroyed
	• Rotary kiln	Effective for all infectious wastes	Investment and operation is very costly
	• Drum or brick incineration	Drastic reduction of the waste by weight and volume. Investment is cheap. Destroys 99% of pathogens	Chemicals and pharmaceutical wastes are not destroyed. There is massive emission of black smoke, fly ash, toxic flue gas and odors
2.	Chemical disinfection	Highly efficient method. Disinfectants are cheap	Requires the services of highly skilled persons. Requires safety measures
3.	Autoclaving method	No environmental pollution; cost-effective	Requires the services of qualified persons. Frequent breakdown can occur. Not suitable for category I, V, and X
4.	Deep burial	Low cost, relatively safe and simple process	Site should be accessible; certain precautions to be taken
5.	Microwave irradiation	Highly efficient, 30–40% volume reduction, minimal environmental pollution and occupational risk, and compact nature of the equipment	Investment and operating cost is relatively high
6.	Inertization	Inexpensive	Not applicable to infectious waste

- Complete dehydration of the waste, reducing the volume by 70%
- No harmful emissions
- Very low operating cost
- Steam is not lost. It is returned back to the boiler in the form of clean, hot water, ready for reuse.

In most of the newer technologies, disadvantages outweigh the advantages **(Table 13.2)**. There is no ideal waste disposal strategy. Therefore, a method which satisfies most conditions and is cost effective is the one likely to be sustainable.

The working group of WHO in this report on management of waste from hospitals and healthcare establishments (1985) have made the following recommendations:

- A systematic approach in handling, transporting, treating, and disposing wastes in a safe way
- Training all health personnel in waste management so that they are aware of potential risk of mishandling waste
- Emphasis on strategies for source segregation of "risk" waste from other waste
- Basic approach for waste reduction and waste recycling schemes
- Pathological and infectious wastes are preferably disposed by incineration adhering to pollution control standards
- As radioactive wastes in HCFs have very low level radioactivity and short half-life, they should be stored till they are no more radioactive
- Comprehensive waste disposal plan for all healthcare institutions.

Comparison between Hydroclave, Autoclave and Microwave

Sl. No.	*Feature*	*Hydroclave*	*Autoclave*	*Microwave*
1.	Cost	Low cost (steam recycled)	High cost (steam not recycled)	High cost (electricity)
2.	Sterility	Consistently high	Spotty sterility	Only disinfection
3.	Bags	No special bags required	High temperature bags required	Pre-shedding required
4.	Wet waste	Treated	No	No
5.	Weight and volume reduction	Yes	No	No

Waste Sharps Management

- Waste sharps are needles, syringes, scalpels, blades, broken glass, etc. capable of causing injuries or introducing infection
- Their segregation (separate collection) reduces the chance of injury
- Their decontamination/disinfection reduces the chances of infection (explained below)
- Their destruction/deformation prevents misuse of needles and syringes (It is done not by hand but by cutting-pliers or by mechanical or electrical needle cutter)
- They should be collected in a puncture-proof (heavy duty) plastic container, with a narrow mouth, so that it facilitates collection, minimizes unnecessary handling

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