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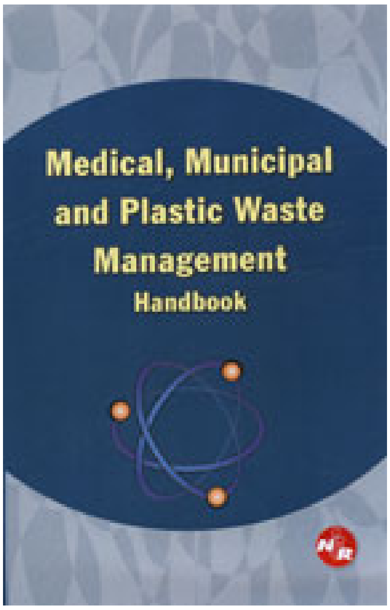
Medical, Municipal and Plastic Waste Management Handbook



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Waste management is the collection, transport, processing, recycling or disposal, and monitoring of waste materials. Concern over environment is being seen a massive increase in recycling globally which has grown to be an important part of modern civilization. The consumption habits of modern consumerist lifestyles are causing a huge global waste problem. Rapid urbanization and industrial diversification has led generation of considerable qualities of municipal, plastic, hazardous and biomedical waste. Further the rapid industrial developments have, led to the generation of huge quantities of hazardous wastes, which have further aggravated the environmental problems in the country by depleting and polluting natural resources. Therefore, rational and sustainable utilization of natural resources and its protection from toxic releases is vital for sustainable socioeconomic development. Hazardous waste management is a new concept for most of the Asian countries including India. The utilization of resources and generation of waste is for beyond the limit that the biosphere was made to carry. Recycling of plastics should be carried in such a manner to minimize the pollution level during the process and as a result to enhance the efficiency of the process and conserve the energy. The concern for bio medical waste management has been felt globally with the rise in infectious diseases and indiscriminate disposal of waste. It is to be understood that management of bio medical waste is an integral part of health care. There is a clear need for the current approach of waste disposal in India that is focussed on municipalities and uses high energy/high technology, to move more towards waste processing and waste recycling (that involves public private partnerships, aiming for eventual waste minimization driven at the community level, and using low energy/low technology resources.

This book basically deals with characterization of medical waste, medical waste data collection activities, medical waste treatment effectiveness, gas sterilization , medical waste reuse, recycling and reduction, selection of waste management options, fundamental concepts related to hospital waste incineration , linkage of bio medical waste management with municipal waste management , waste identification and waste control program for the health care establishments, waste treatment and disposal : the rules and the available options , recycle spoiled photographic film and paper etc.

Waste management is one of the essential obligatory functions of the country. This service is falling too short of the desired level of efficiency and satisfaction resulting in problems of health, sanitation and environmental degradation. This book provides overview of the status of medical, municipal and plastic waste management. A treatment technique includes sterilization, incineration and number of recycling methods.

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(Following is an extract of the content from the book)

Treatment of Infectious Waste

1. INTRODUCTION

The purpose of treating infectious waste is to change its biological character so as to reduce or eliminate its potential for causing disease. Incineration and steam sterilization are the most frequently used infectious waste treatment techniques. However, other processes are effective in treatment infectious waste.

Facilities involved with the treatment of infectious waste should establish standard operating procedures for each treatment process. Standardization of procedures should include establishing acceptable operating limits which take into account all factors that may effect the treatment process.

The following treatment techniques are :

1.Steam sterilization (autoclaving)

2.Incineration
3.Thermal inactivation
4.Gas/vapour sterilization
5.Chemical disinfection
6.Sterilization by irradiation

Sample Chapter:

A convenient approach for determining treatment effectiveness is the use of biological indicators. Biological indicators are standardized products that are routinely used to demonstrate the effectiveness of the treatment process. It is now current practice to use spores of a resistant strain of a particular bacterial species for testing each specific treatment process. The United States Pharmacopeia recommends the use of biological indicators for monitoring treatment processes such as steam sterilization, incineration, and thermal inactivation.

There are other indicators that provide an instantaneous indication usually by a chemically induced colour change of the achievement of a certain temperature. However, these indicators are not suitable for use in monitoring the sterilization process because each treatment technique involves a combination of factors; therefore, no single factor is a valid criterion for indicating the effectiveness of the sterilization process. (For example, in steam treatment, the wastes must be exposed to a certain temperature for at least a minimum period of time in order to achieve sterilization. Therefore, any indicator that indicates only the attainment of a particular temperature is not suitable for monitoring the effectiveness of steam sterilization).

Other indicators which monitor the treatment process may be used. However, it is recommended that the appropriateness and reliability of these indicators be confirmed before they are used to monitor infectious waste treatment.

It is essential that indicators be properly placed within the waste load so that they will indicate accurately the effect of treatment on the entire waste load. Therefore, to assure accurate monitoring, the biological indicators should be distributed throughout the waste load.

Monitoring is essential in development of standard operating procedures for each treatment technique to verify that the treatment process is effective. Monitoring also permits refinement of the operating procedures so that excess processing can be avoided while savings are realized in expenditures of time, energy, and/or materials. Subsequent periodic monitoring serves to demonstrate sterilization, thereby confirming that proper procedures were used and that the equipment was functioning properly.

2. Steam Sterilization

Steam sterilization of infectious waste utilizes saturated steam within a pressure vessel (known as steam sterilizer, autoclave, or retort) at temperatures sufficient to kill infectious agents present in the waste).

There are two general types of steam sterilizers the gravity displacement type, in which the displaced air flows out the drain through a steam-activated exhaust valve, and the pre-vacuum type, in which a vacuum is pulled to remove the air before steam is introduced into the chamber. With both types, as the air is replaced with pressurized steam, the temperature of the treatment chamber increases. This, results in temperature increases within the waste load which under most conditions are sufficient to treat the waste.

Treatment by steam sterilization is time and temperature dependent; therefore, it is essential that the entire waste load is exposed to the necessary temperature for a defined period of time. (Heating of the containers and the waste usually lag behind heating of the chamber.)

In steam sterilization, decontamination of the waste occurs primarily from steam penetration. Heat conduction provides a secondary source of heat transfer. Therefore, for effective and efficient treatment, the degree of steam penetration is the critical factor. For steam to penetrate throughout the waste load, the air must be completely displaced from the treatment chamber. The presence of residual air within the sterilizer chamber can prevent effective sterilization by: reducing the ultimate possible temperature of the steam, regardless of pressure; causing variations in temperature throughout the chamber; prolonging the time needed to attain the maximum temperatures; and inhibiting steam penetration into porous materials.

Factors that can cause incomplete displacement of air include: use of heat resistant plastic bags (which may exclude steam or trap air), use of deep containers (which may prevent displacement of air from the

bottom), and improper loading (which may prevent free circulation of steam within the chamber).
The principal factors that should be considered when treating infectious waste by steam sterilization are:
1.type of waste
2.packaging and containers
3.volume of the waste load and its configuration in the treatment chamber.
Types of Waste. Infectious waste with low density (such as plastics) is more amenable to steam sterilization. High density wastes such as large body parts, and large quantities of animal bedding and fluids inhibit direct steam penetration and require longer sterilization time. Alternative treatment methods should be considered (e.g., incineration) for these wastes.
Packaging and Containers. A variety of containers are used in steam sterilization including plastic bags, metal pans, bottles, and flasks. One consideration with plastic bags is the type and thickness of the plastic and its suitability for use in steam treatment. As discussed earlier, some plastic bags are marketed as autoclavable (i.e., they are heat resistant and do not melt). These bags are constructed of high density polyethylene or polypropylene plastic and, therefore, do not facilitate steam_penetration to the waste load. Bags made of heat-labile plastic have been found to crumble and melt during steam treatment which allows steam penetration of the waste but destroys the bag as a container. When heat-labile plastic bags are used, they should be placed within another heat stable container which allows steam penetration (e.g., strong paper bag). It is good policy to place plastic bags within a rigid container before steam treatment in order to prevent spillage and drain clogging. To facilitate steam penetration, bags should be opened and bottle caps and stoppers should be loosened immediately before placement in the steam sterilizer.
Volume and Configuration of the Waste Load. The volume of the waste is an important factor in steam sterilization as it can be difficult to attain sterilizing temperatures in large loads. It may be more efficient to autoclave a large quantity of waste in two small loads rather than one large load.
Many infectious wastes that have multiple hazards should not be steam sterilized because of the potential for exposure of equipment operators to toxic, radioactive, or other hazardous chemicals. Infectious wastes that should not be steam sterilized include those that contain anti-neoplastic drugs, toxic chemicals, or chemicals that would be volatilized by steam.
Persons involved in steam sterilizing infectious waste should be educated in proper techniques to minimize personal exposure to the hazards posed by these wastes. These techniques include use of protective equipment, minimization of aerosol formation, and prevention of spillage of waste during autoclave loading. A recording thermometer should be used to ensure that a sufficiently high temperature is maintained for an adequate period of time during the cycle. Failure to attain or maintain operating temperature may indicate mechanical failure.
All steam sterilizers should be routinely inspected and serviced. Monitoring the steam sterilization process is required to ensure effective treatment. The process should be monitored periodically to check that proper procedures are being followed and that the equipment is functioning properly. Bacillus stearothermophilus is recommended by The United States Pharmacopeia as the biological indicator for monitoring steam sterilization. There are other indicators that may effectively monitor the treatment process; however, because steam sterilization is both time and temperature dependent, any indicator that is used should effectively monitor both these factors.

3. Incineration

Incineration is a process which converts combustible materials into non-combustible residue or ash. The product gases are vented to the atmosphere through the incinerator stack while the treatment residue may be disposed of in a sanitary landfill. Incineration provides the advantage of greatly reducing the mass and volume of the waste-often by more than 95 per cent which, in turn, substantially, reduces transport and

disposal costs.
Incineration can be a suitable treatment technique for all types of infectious waste. Incineration is especially advantageous with pathological waste and contaminated sharps because it renders body part unrecognizable and sharps unusable. Incinerators that are properly designed, maintained, and operated are effective in killing organisms that are present in infectious waste. However, if the incinerator is not operating properly, viable pathogenic organisms can be released to the environment in stack emissions, residue ash, or wastewater.
The principal factors that should be considered when incinerating infectious waste are:
1.variation in waste composition
2.waste feed rate
3.combustion temperature
Variations in Waste Composition. Waste composition affects combustion conditions due to variations in moisture content and heating value. It is important to adjust loading rate and combustion temperature, as needed, to maintain proper incinerating conditions.
Waste Feed Rate. The rate at which waste is fed into the incinerator also affects the efficacy and efficiency of treatment. It is important to avoid overloading which often results in incomplete combustion and unsatisfactory treatment of infectious waste.
Combustion Temperature. An optimum temperature must be maintained during combustion to ensure proper treatment of infectious waste. The combustion temperature can be maintained, a necessary, by adjustments in the amount of combustion air and fuel. With pathological incinerators, in particular, it is essential that operating temperatures be attained before loading the waste. The amount of air and fuel should be adjusted to maintain the combustion temperature at the necessary level. Adjustments should be made as the composition of the waste changes.
For infectious waste with multiple hazards, special considerations are appropriate. For example, infectious waste that contains or is contaminated with anti-neoplastic drugs should be incinerated only in an incinerator that provides the high temperature and long residence (dwell) time that are necessary for the complete destruction of these compounds.
The plastic content of the waste also should be considered before incineration is selected as a treatment technique. Many incinerators can be damaged by temperature surges caused by combustion of large quantities of plastic (such as contaminated disposables). Another factor to be considered is the chlorine content of polyvinyl chloride and other chlorinated plastics that may be present in the waste. The combustion products of these plastics include hydrochloric acid which is corrosive to the incinerator and may damage the refractory (lining of the chamber) and the stack. Limiting the plastic content of waste loads burned in incinerators will extend the life of these units.
Since infectious waste must be exposed to a sufficiently high temperature for an adequate period of time to ensure destruction of all pathogenic organisms, specific standards should be established to define minimum operating temperatures. For example, the Massachusetts policy for incineration of infectious waste specifies that all new incinerators must operate at a minimum temperature of 1600Â°F in the secondary combustion chamber and a minimum residence time of one second.
In addition to operating procedures design features can also affect the incineration process or example, mechanical controls can help ensure that infectious waste is exposed to the appropriate combustion temperature. Lock-out devices can be installed to prevent ignition of the primary chamber until the secondary chamber is at operating temperature. Shut-down devices will keep the secondary chamber at operating temperature for a certain period of time after the primary chamber is shut off or until it cools to a certain temperature. Monitors which provide continuous information on combustion temperature, waste feed rate, fuel feed rate, and air feed rate are essential for monitoring the process.

Pathological incinerators have traditionally been used by hospitals to incinerate pathological and other infectious waste. These incinerators have relatively small capacity, and generally are operated intermittently. Some large facilities have considered installation of resource recovery incinerators (i.e., heat recovery from incineration of all wastes - including infectious wastes). However, these incinerators may be subject to regulation under the Federal Clean Air Act, or the Resource Conservation and Recovery Act (hazardous waste regulations) if certain hazardous waste are burned. At present, pathological incinerators are not subject to Federal regulations promulgated under either the Clean Air Act or Resource Conservation and Recovery Act. However, many States and localities have frequently applied emission standards, in particular, standards for particulate emissions and carbon monoxide, to all incinerators (including pathological) within their jurisdictions.

The absence of regulations that apply to hospital incinerators does not relieve a hospital of responsibility for meeting the criteria for proper incineration of infectious waste. Therefore, even though infectious waste incinerators may not be regulated, hospitals and other facilities treating infectious waste by this method should ensure that the waste is being properly incinerated.

4. Thermal inactivation

Thermal inactivation includes treatment methods that utilize heat transfer to provide conditions that reduce the presence of infectious agents in waste. Generally this method is used for treating larger volumes of infectious wastes (such as industrial applications). Different thermal inactivation techniques are used for treatment of liquid and solid infectious wastes.

1. Thermal Inactivation of Liquid Infectious Waste

Batch-type liquid waste treatment units consist of a vessel of sufficient size to contain the liquid waste generated during a specific operating period (e.g., 24 hours). The system may include a second vessel that provides continuous collection of waste without interruption of activities that generate the waste.

The waste may be pre-heated by heat exchangers, or heat may be applied by a steam jacket that envelopes the vessel. Heating is continued until a pre-determined temperature (usually measured by a thermocouple) is achieved and maintained for a designated period of time (analogous to steam sterilization). Mixing may be appropriate to maximize homogeneity of the waste and temperature during the loading and heat application steps of the treatment cycle.

The temperature and holding time depends on the nature of the pathogens present in the waste. Since this treatment method is used most often in industrial applications, the identity of the pathogens are usually known. Time and temperature requirements can be selected on the basis of the resistance of either the pathogen present in the waste or of a pathogen that is more resistant than those being treated.

After the treatment cycle is complete, the contents of the vessel/tank are discharged. These discharges, which are normally to the sewer, must comply with the local, State, or Federal requirements. Since these requirements usually include temperature restrictions, a second heat exchanger may be necessary to remove excess heat from the effluent.

The continuous treatment process for treating liquid infectious waste is actually a semi-continuous process. The system can provide on demand thermal inactivation without the need for a large vessel or tank. A typical system consists of a small feed tank, an elaborate steam-based heat exchanger, a control and monitoring system, and associated piping.

Liquid waste is introduced into the small feed tank, pumped across the heat exchanger at a constant fixed rate of flow, and then recirculated through the feed tank and the rest of the system until the required temperature has been achieved. Because of the relatively shorter contact time, the treatment temperature may be higher than those in a batch-type system. The treated waste may be cooled by a second heat exchanger before discharge to the sanitary sewer of the facility.

2. Thermal Inactivation of Solid Infectious Waste

Dry heat treatment may be applied to solid infectious waste. In this technique, the waste is heated in an oven which is usually operated by electricity. Dry heat is a less efficient treatment agent than steam and, therefore, higher temperatures or longer treatment cycles are necessary. A typical cycle for dry heat sterilization is treatment at 320Â° to 338Â°F for two to four hours.

The extensive time and energy requirements of thermal inactivation preclude common use of this technique for treatment of solid infectious waste.

5. Gas/Vapour Sterilization

Gas/vapour sterilization is an option that may be used for treating certain infectious waste. In this method, the sterilizing agent is a gaseous or vapourized chemical. The two most commonly used chemicals are ethylene oxide and formaldehyde. There is substantial evidence that these chemicals are probable human carcinogens, and caution must be exercised when they are used. Therefore, when the use of gas /vapour sterilization is considered, the relative hazard of the treatment itself should be weighed against the benefits resulting from the treatment.

Ethylene oxide gas is often used to sterilize thermolabile supplies but, because of its toxicity and because other options are available, ethylene oxide is not recommended for treating infectious waste.

Formaldehyde gas is used to sterilize certain disposable items which may be contaminated (e.g., HEPA filters from biological safety cabinets). Formaldehyde sterilization procedures should be performed only by persons trained in the use of formaldehyde as a gaseous sterilant.

With both ethylene oxide and formaldehyde, there is the potential for additional exposure after treatment has been completed. Ethylene oxide is absorbed by porous materials, and formaldehyde frequently forms a residue. Both of these phenomena result in continued release of the gases from the treated waste for substantial periods of time after treatment.

6. Chemical Disinfection

Chemical treatment is most appropriate for liquid wastes, however, it also can be used in treating solid infectious waste.

In order to use chemicals effectively, the following factors should be considered:

1.type of micro-organism
2.degree of contamination
3.amount of proteinaceous material present
4.type of disinfectant
5.concentration and quantity of disinfectant
6.contact time
7.other relevant factors (e.g., temperature, pH, mixing requirements, biology of micro-organism)

The disposal of chemical treatment waste should be in accordance with State and local requirements.

7. Sterilization by Irradiation

An emerging technology for treating infectious waste involves the use of ionizing radiation. Experience being gained from irradiation of medical supplies, medical components, food, and other consumer products is providing a basis for the development of practical applications for treatment of infectious waste.

The advantages of ionizing radiation sterilization for treatment of infectious waste relative to other available treatment methods include:

1.nominal electricity requirements
2.no steam requirements
3.no residual heat in treated waste
4.performance of the system.

The principal disadvantages of a radiation sterilization facility are:

1.high capital cost

2.requirement for highly trained operating and support personnel

3.large space requirement

4.problem of ultimate disposal of the decayed radiation source.

When properly used and monitored, ionizing radiation may provide an effective method of treating infectious waste.

8. Other Treatment Methods

Other methods of treating infectious waste should be demonstrated as effective before being used routinely. Efficacy of the method should be demonstrated by the development of a biological testing program. Monitoring should be conducted on a periodic basis using appropriate indicators.

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