ORIGINAL ARTICLE

SYSTEMS APPROACH IN BIOMEDICAL WASTE MANAGEMENT

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SUMMARY

This article addresses the Role of a systems approach and to understand the reduction of the adverse impacts related to human health and environment. It examines the existing situation of Bio-medical waste management which is a serious concern in India. Moreover, smaller facilities such as Community Health Centres and Primary Health Centres are widely dispersed throughout the country thereby increasing the risks in the absence of environmentally sound management. These facilities lack the requisite standards and procedures for waste management. In the absence of treatment, poor handling practices and rudimentary methods for disposal, there are adverse effects on public health and environment. This article focuses on need of systems approach in biomedical waste management. The regulations in India has started in 1992 with special focus on Biomedical waste (Management and Handling) Rules 1998. These rules were further amended in 2003 and 2016. Interventions by prescribed authority are necessary in order to achieve environmentally benign behaviour. The government has a key role in collaborating with the stakeholders involved in health-care waste management as well as changing behaviour through regulation and increasing the level of awareness. Once system is established in an Institution, the biomedical waste will treated and disposed of in a scientific manner without harming human health and environment.

ABBREVIATIONS

- APCD - Air Pollution Control Device
- BMWM Rules - Bio-medical Waste Management Rules
- CBWTF - Common Bio-medical Waste Treatment and Disposal Facility
- CO - Carbon Monoxide
- CO2 - Carbon Dioxide
- CPCB - Central Pollution Control Board
- CRZ - Coastal Regulation Zone
- DG - Diesel Generator

- EC - Environmental Clearance
- EIA - Environment Impact Assessment
- ETP - Effluent Treatment Plant
- GPS - Global Positioning System
- HCFs - Health Care Facilities
- HCl - Hydrochloric Acid
- HOWM & TM Rules - Hazardous and Other Waste (Management & Transboundary Movement) Rules, 2016
- MHz - Mega Hertz
- MoEF& CC - Ministry of Environment, Forest & Climate Change
- KM - Kilometer
- KW - Kilowatt
- MoU - Memorandum of Understanding
- NABL - National Accreditation Board for Testing and Laboratories
- NOx - Oxides of Nitrogen
- O2 - Oxygen
- PCC - Pollution Control Committee
- PLC - Programmable Logical Control
- SEIAA - State Environment Impact Assessment Authority
- SLF - Secured Landfill
- SPCB - State Pollution Control Board
- TSDF - Treatment Storage and Disposal Facility
- TOC - Total Organic Carbon
- VOCs - Volatile Organic Compounds

INTRODUCTION

As per the Bio-medical Waste Management Rules, 2016 (hereafter referred as BMWM Rules) it restricts occupier for establishment of on-site or captive bio-medical waste treatment and disposal facility, if a service of Common Bio- Medical Waste Treatment and disposal facility is available within a distance of seventy-five kilometre, as installation of individual treatment facility by health care facility (HCF) requires comparatively high capital investment. The concept of CBWTF not only addresses such problems but also prevents proliferation of

treatment technologies in a town or city. In turn, it reduces the monitoring pressure on regulatory agencies. By running the treatment equipment at CBWTF to its full capacity, the cost of treatment of per kilogram bio-medical waste gets significantly reduced. Its considerable advantages have made CBWTF popular and proven concept in most part of the world.

The Major components of waste management systems approach are:

1. **Generation**
2. **Accumulation/ Segregated Collection**
3. **Handling**
4. **Storage**
5. **Transport**
6. **Treatment**
7. **Disposal**

Health care Waste management is 80 % segregation and 20 % technology.

<u>On site Management</u>

On site management should ideally have a system in place which when set up can effectively manage the health care waste disposal system smoothly. A system can be set up with this fact in mind which will be the foundation of onsite Health care

Before the actual disposal of waste, there should be a system for pre treatment of waste. It is the duty of the Occupier or the Generator of healthcare waste to not only ensure the disposal but also to ensure the Pre-Treatment of the laboratory waste, microbiological waste, blood samples and blood bags through disinfection or sterilisation on-site in the manner as prescribed. Although the most essential part of hospital waste management even before the pre-treatment is the segregation of Bio-medical waste. The segregation of the waste should be performed within the premises of the hospital/nursing homes. The colour coding, type of container to be used for different waste category have been dealt in later paragraphs and it has been mentioned about the new categories as per BMWM rules 2016 in India.

PRE TREATMENT OF BIO MEDICAL WASTE

What is Pre-treatment of HCW – Pre-treatment is the method of reducing or eliminating the contaminants of health care waste or altering its nature before being sent for final disposal.

Important Points-

- *There will be no chemical pre-treatment before incineration, except for microbiological, lab and highly infectious waste.*

- *Chemicals treatment to be done using at least 1% hypochlorite solution or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfections.*
- *Mutilation/shredding must be such so as to prevent unauthorised reuse*.

Pre-treatment procedures are

a. Use of Chemicals (reagents)
b. Thermal (by autoclave) and
c. Physical (mutilation)

Here are the Category wise pre-treatment procedures:

Mutilation of plastics and sharps- To prevent reuse of plastics and sharps, mutilation is required on-site before transportation to CBWTF

Discarded medicines (cyto-toxic drugs and antibiotics)- Cytotoxic wastes including all items contaminated with cytotoxic drugs are put in a non-chlorinated yellow container, which is mandatorily sealed and labelled as cytotoxic.

- Expired cyto-toxic drugs are returned to the manufacturer or supplier for incineration at temperature > 1200°C.
- No chemical pre-treatment is required in these cases.
- The antibiotic and other drugs are discarded in yellow bag with biohazard label. Dilution in water and discharge into a sewer for solutions containing vitamins, cough syrups, IV solutions and eye drops, salts, amino acids is deemed sufficient.

Liquid chemical waste:

Liquid waste generated due to the use of chemicals in production of biologicals, used or discarded disinfectants, infected secretions, aspirated body fluids liquid from laboratory, labour room, operation theatre, floor washings, cleaning, housekeeping and disinfecting activities should be collected separately and directed to effluent treatment plant (ETP). Prior to that the infected body secretions such as blood and faeces should be pre-treated and then disposed of in ETP.

Pre-treatment for faeces or vomit during an outbreak such as cholera involves decontamination with lime milk (hydrated calcium oxide or calcium hydroxide) – ratio of 1:2 for stool and vomit with lime for 6 hours minimum; ratio of 1:1 for urine with lime for 2 hours minimum.

Laboratories:

The blood sample glass vials or broken or discarded and infected glass need to be disinfected/autoclaved, (pre-treatment), wherever applicable and then packed in cardboard boxes with plastic liner with blue-coloured marking and sent to CBMWTF for autoclaving or microwaving for final recycling.

The non-infected glass does not need on-site pre-treatment.

Microbiology, biotechnology waste and infectious waste:

Laboratory waste including microbiology laboratory cultures, stocks or specimens of microorganisms and infectious waste of patients in isolation have to be pre-treated on site by autoclaving in an autoclave safe plastic bags or containers as per the WHO guidelines and there after sent for final disposal of autoclaved hazardous waste in yellow bag to CBMWTDF for incineration.

Blood bank

The discarded blood bags are to be counted, sealed, weighed and all the records to be made; then packed in autoclave-safe plastic bags or containers to be autoclaved on site which are sent for incineration.

Note: 5% hypochlorite is not effective for high organic loads like blood.

- Pre-treatment for the dental department requires installing amalgam separators in sinks, especially by patient treatment chairs; the separated mercury waste must be safely stored.
- Silver X-ray film developing liquid, after resource recovery, the chemical liquid waste needs to be pre-treated before mixing with waste water.
- Pre-treatment for the radiotherapy department involves separate collection of radioactive wastewater (e.g. urine of patients from the thyroid treatment) and storage for decay in a secured die-away basin until background concentrations have decreased; after the required storage time (Ten half lives), the wastewater can be disposed of in the sewer system

On Site Biomedical Waste Treatment Options

Before we proceed to the Onsite Biomedical Waste Treatment Options let us recapitulate a bit on the background.

BMW management and handling rules in India were formulated in 1998, which were again amended in 2016.

Some Major Differences in the rules of 1998 and 2016

Sl. No	1998	2016
1	Occupiers with more than 1000 patients required to obtain authorisation	Every occupier generating BMW, including health camp or AYUSH requires to obtain authorisation
2	Occupier duties absent	Duties of the operator listed
3	BMW divided into ten categories	Biomedical waste divided into 4 categories
4	Rules restricted to HCEs with more than 1000 beds	Treatment and Disposal of BMW made mandatory for all the HCEs
5	No format for Annual Report	A format for Annual report appended with the rules
6	Schedule I, II , III, IV and V	Change of schedule I, II, III and IV

The current categories of BMW as per BMW management rules of 2016 are as follows:

Category	Type of Bag/Container used	Type of Waste	Treatment/ Disposal Options
Yellow 	Non- chlorinated plastic bags Separate Collection System leading to effluent Treatment System	a) Human Anatomical Waste b) Animal Anatomical Waste c) Soiled Waste d) Expired or Discarded Medicines e) Chemical Waste f) Micro, Bio–technology and other clinical lab waste g) Chemical liquid Waste	Incineration or Plasma Pyrolysis or deep Burial*
Red 	Non- chlorinated plastic bags or containers	**Contaminated waste (Recyclable)** tubing, bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles) and gloves.	Auto/Micro/ Hydro and then sent for recycling not be sent to landfill
White 	(Translucent) Puncture, Leak,	**Waste sharps including Metals**	Auto or dry Heat Sterilization followed by

	Tamper proof containers		shredding or mutilation or encapsulation
Blue	Cardboard boxes with blue collared marking	**Glassware**	Disinfection or auto/Micro/hydro and then sent for recycling.

Bar Coded waste bags for BMW handling

Provision of colour coded bags as per BMWR-2016 for storage and transport of biomedical waste. Most institutions have started providing barcode for bags for biomedical waste storage and handling.

Packaging: The containers or bags referred to in sub-rule are labelled as specified in Schedule IV. The Bar code is placed on the packages.

Transportation: Internal transportation is done through Transport trolleys as shown below.

The operator of common bio-medical waste treatment facility transports the bio-medical waste from the premises of the hospital to common bio-medical waste treatment facility. The vehicles are labelled as provided in part 'A' of the Schedule IV along with necessary information as specified in part 'B' of the Schedule IV. The vehicles used for transportation of bio-medical waste shall comply with the conditions if any stipulated by the State Pollution Control Board or Pollution Control Committee in addition to the requirement contained in the Motor Vehicles Act, 1988 (59 of 1988), if any or the rules made there under for transportation of such infectious waste. Dedicated Vehicles are required to be deployed for transportation of Bio-Medical waste from Health Care Establishments to the facility. All the vehicles should be covered and having GPS System.

Various Methods of waste disposal

Often the waste categorised as per various methods of waste disposal is spoken of in the same terms as type of waste which may not be categorically same. But methods of disposal are one of the principal players in the biomedical waste management system

<u>Some important methods of disposal</u> :-

Incineration - Controlled incineration at high temperatures (over 1000°C) is one of the few technologies with which all types of health-care waste can be treated and it has the advantage of significantly reducing the volume and weight of the wastes treated. However, Incinerators require special infrastructure and are suitable for central networks and not the hospitals.

Chemical disinfection: - Chemical disinfection, which is commonly used in health facilities to kill micro-organisms from medical equipment, has been extended to the treatment of health-care wastes. However, the chemicals that are used themselves entail a health risk for the people who handle them and a risk of environmental pollution.

This form of disposal is more suited to disposing infectious fluid waste like body fluids and hospital sewage. Although it has its downside in that certain harmful gases may be released on chemical disinfection of urine with bleach.

Autoclaving: - Autoclaving is a thermal process at low temperatures where waste is subjected to pressurized saturated steam for a sufficient length of time to be disinfected (60 minutes at

121°C and 1 bar). Where prions (which cause Creutzfeldt Jakob's disease) are present, a cycle of 60 minutes at 134°C is recommended, since they are exceptionally resistant. Efficiency tests (biological or thermal) must in any case be carried out regularly. Autoclaving is environmentally safe but in most cases, it requires electricity, which is why in some regions it is not always feasible for treating wastes.

Needle Extraction or Destruction: This practice is followed in certain circumstances, mainly for two reasons: when the needles are removed from used syringes they cannot be re-used, and, secondly, the volume of sharps is reduced.

Microwave treatment technologies

Microwave technology is a steam-based process where the treatment occurs through the action of moist heat and steam generated by microwave energy with a cycle of 30 min to 1 h. The types of waste treated are cultures and stocks, sharps, materials contaminated with blood and body fluids, other infected waste, laboratory waste and soft waste (e.g., gauze, bandages, gowns and bedding). Microwave treatment should not be used for cytotoxic, volatile compounds, hazardous or radioactive wastes, contaminated animal carcasses, body parts and large metal items. Biological indicators for microwave are *Bacillus atrophaeus* spores.

Autoclave and Shredders The autoclavable waste from Hospitals is also autoclaved in GB pant hospital in case LNH Autoclave is out of order but this waste is shredded in LNH itself.

Shredders cut the waste into small pieces. This technique requires competent staff for operating and maintaining the device, since some of these rotary devices are industrial models. They are often built into closed chemical or thermal disinfection systems. However, grain mills can be converted into simple shredders, but due to the risk for staff while the shredder is running only disinfected waste should be treated in these devices

Encapsulation: - Encapsulation (or solidification) consists of containing a small number of hazardous items or materials in a mass of inert material. The purpose of the treatment is to prevent humans and the environment from any risk of contact. Encapsulation involves filling

containers with waste, adding an immobilizing material, and sealing the containers. The process uses either cubic boxes made of high-density polyethylene or metallic drums, which are three-quarters filled with sharps, chemical or pharmaceutical residues, or incinerator ash. The containers or boxes are then filled up with a medium such as plastic foam, bituminous sand, lime, cement mortar, or clay. Once the medium has dried, the containers are sealed and disposed of in a sanitary landfill or waste burial pit[1].

Sanitary landfill or waste disposal pit: - The disposal of untreated health-care waste in an uncontrolled dump is not recommended and must only be used as a last resort. It can be disposed off in a sanitary landfill, subject to certain precautions: it is important that health-care waste be covered rapidly. One technique is to dig a trench down to the level where old municipal refuse (over three months old) has been buried and to immediately bury health-care waste that is discarded at this level under a 2-metre layer of fresh municipal refuse

Disposal of liquid wastes in the sewage: - In general, the sewage system should not be used to dispose of chemicals. It is strictly prohibited to dilute wastewater discharges so that the concentration falls below the exemption thresholds in force in a particular country.

Effluent Treatment Plant: - Facility for effluent treatment has to be provided and to ensure that all streams, sewage, sullage (floor wash, hand wash, bathroom wash and canteen effluent & laundry and disinfected biomedical liquid effluent) are connected to ETP. 80 % of the water consumption is considered as Effluent generation. Ensure adequate capacity for ETP and Water meters should be installed to record water consumption and monthly water consumption reports has to be submitted. Operation and maintenance of ETP is to be carried out at regular intervals. Effluent monitoring reports as per the periodicity specified and proper disposal of treated effluent as specified is to be carried out.

The waste treatment technologies in Developed countries include thermal, chemical processes, irradiation technologies, biological processes, disinfection and sterilisation.

Thermal: Autoclaves: Steam treatment technologies

Autoclaves sterilise a range of infectious waste (cultures, stocks, sharps, materials

contaminated with blood and fluids), laboratory waste, linen waste and medical instruments and as a part of pre-treatment of BMW. Unlike instrument-sterilisation autoclaves, waste-treatment autoclaves (or pre-vaccum autoclaves) must also treat the air that is removed at the start of the process to prevent the release of pathogenic aerosols through a high-efficiency particulate air filter before it is released and therefore require less time for action and have greater efficiency.

The autoclaves should be able to withstand the repeated build-up and release of steam pressures and should have construction materials, engineering design, fabrication, accuracy of pressure and temperature sensors, and testing must meet basic requirements to operate safely as per the international standards. The operation of autoclave requires a minimum of recommended temperature–exposure time criterion of 121°C for 30 min, pressure of 205 kPa or 2.05 bar

Unlike Autoclaves for medical devices which often use trays or stainless steel baskets, Waste autoclaves use autoclavable carts or bucket-shaped open containers into which the plastic waste bags are stacked. For the same, use of autoclavable plastic bags or liners that prevent sticking is an option.

A post-treatment shredder or grinder could be used if the waste is to be rendered unrecognisable and if reduction of waste volume is desired. Advanced single- or multiple-shaft shredders specially made for medical waste can reduce waste volume by about 80%. The advanced shredders are typically low-speed, high-torque, single-pass shredders with easily replaceable cutters and with discharge screens to control the size of shredded waste.

Dry heat treatment technologies

Hot air ovens have been used to sterilise glassware and other reusable instruments and infectious health waste. The waste is heated by conduction, natural or forced convection or thermal radiation at higher temperatures (up to 185°C) and longer exposure times (90–150 min)

than steam-based processes. It should completely and consistently kill the biological indicator Geobacillus stearothermophilus.

Chemical disinfectants: The disinfectants used are chlorine compounds, aldehydes, lime-based powders or solutions, ozone gas, ammonium salts and phenolic compounds.

Sodium hypochlorite (NaOCl, 2%–12%), (BMW Rules 2016 say 10%) it is active against bacteria, viruses and spores, not effective for disinfection of liquids with high organic content, (blood or stool) and is widely used owing to relatively mild health hazards. Unused solutions should be reduced with sodium bisulphite or sodium thiosulphate and neutralised with acids before discharge into sewers. PPEs should be worn to protect HCWs. Chlorine dioxide is an alternative to hypochlorite. It is a toxic but soluble and stable in water and can be generated onsite. Lime-based chemical treatment systems use dry powder or calcium hydroxide solutions. Glutaraldehyde and peracetic acid are used to disinfect instruments.

Other Emerging technologies

Emerging technologies include plasma pyrolysis, alkaline hydrolysis, superheated steam, ozone and promession.

Other emerging technologies for destruction of BMW include gas-phase chemical reduction, base-catalysed decomposition, supercritical water oxidation, sodium reduction, verification, superheated steam reforming, Fe-TAML/peroxide treatment (pharmaceutical waste), biodegradation (using mealworm or bacteria to eat plastics), mechanochemical treatment, sonic technology, electrochemical technologies, solvated electron technology and phytotechnology. These emerging technologies are not ready for routine application to health-care waste

Promession

Promession is an innovative method of ecological burial. Its primary principles are preservation after death in organic form, and shallow burial in living soil that quickly converts a body to a form that is primed to foster new life. Promession is a natural, practical, and some may even say a beautiful approach because of its focused intent to foster new life from death.

Susanne Wiigh-Masak, a Swedish biologist, spent over 20 years on the concept before making it public. She wondered how it would be possible to use human remains to create soil that was

primed to nurture new life, essentially, creating life out of death. While this concept can be observed in nature on a continual basis, it is a concept that may seem foreign and perhaps a bit uncomfortable when applied to the death of a human.

The process is described by Susanne as gentle and environmentally-friendly, especially in comparison to the process of cremation (which requires fire, fumes, etc.). The result is a product that is transformed into an organic, hygienic soil in about 6-12 months that can then act as a nutrient for new plants as a living memorial for family and friends.

The process of promession is simple and straightforward:

- The body is frozen to -18 ° C and is then placed into liquid nitrogen to make the body more brittle.
- The body is then vibrated, which causes it to break down into an organic powder.
- The body is then placed into a vacuum chamber to evaporate all liquid.
- The resulting dry powder passes through a metal separator where any metals and mercury are removed.
- The remains are now ready to be laid in a biodegradable coffin, which is buried in the living topsoil.
- The coffin and its contents become compost in about 6-12 months.
- A bush or tree can be planted above the coffin.
- The compost can be taken up by the bush or tree,
- The plant stands as a symbol of the deceased.

OFF SITE WASTE MANAGEMENT OPTIONS

A Common Bio-medical Waste Treatment and Disposal Facility (CBWTF) is a set up where biomedical waste generated from member health care facilities is imparted necessary treatment to reduce adverse effects that this waste may pose on human health and environment. The treated recyclable waste may finally be sent for disposal in a secured landfill or for recycling. According to the Bio-medical Waste Management Rules, 2016, "bio-medical waste treatment and disposal facility" means any facility wherein treatment, disposal of bio-medical waste or processes incidental to such treatment and disposal is carried out, and includes common bio-medical waste treatment facilities and "operator of a common bio-medical waste treatment facility" means a person who owns or controls a Common Bio-medical Waste Treatment and

Disposal Facility (CBWTF) for the collection, reception, storage, transport, treatment, disposal or any other form of handling of bio-medical waste. By running the treatment equipment at CBWTF to its full capacity, the cost of treatment of per kilogram bio-medical waste gets significantly reduced. Its considerable advantages have made CBWTF popular and proven concept in most part of the world. Since 1998, the CBWTF as an option for treatment of bio-medical waste also been legally introduced in India. Now the Bio-medical Waste Management Rules, 2016 restricts the Occupier (i.e., HCF) for ensuring treatment and disposal of generated bio-medical waste through a CBWTF, located within a distance of 75 KM. To facilitate the treatment and disposal of bio-medical waste generated from the HCFs, at present (as per Annual Report 2014 submitted by the SPCBs/PCCs), there are 192 no. of CBWTFs in operation and 33 no. of CBWTFs are under construction. Also, the Bio-medical Waste Management Rules, 2016 mandates that the operator of a CBWTF authorised by the prescribed authority is required to take all necessary steps to ensure that the bio-medical waste collected from the occupier is transported, handled, stored, treated and disposed of, without any adverse effect to the human health and the environment, in accordance with the BMWM Rules and the guidelines issued by the Central Government or the Central Pollution Control Board (CPCB) from time to time.

Criteria for development of a new Common Bio-medical Waste Treatment and Disposal Facility for a locality or region. Prior to allowing any new CBWTF, following criteria or steps may be followed:

a) Prescribed authority under the BMWM Rules, 2016 [i.e., State Pollution Control Board (SPCB)/committee is required to prepare an inventory or review with regard to the bio-medical waste generation at least once in five years in the coverage areas of the existing bio-medical waste treatment and disposal facility.
b) SPCB/PCC is required to conduct gap analysis w.r.to coverage area of the bio-medical waste generation and also projected over a period of next ten years, adequacy of existing treatment capacity of the CBWTF in each coverage area of radius 75 KM,
c) SPCB/PCC shall identify the coverage area, which require additional treatment facility and bring it to the notice of the concerned department in the business allocation of land assignment in the respective State Government or UT Administration.
d) Alternately, a CBWTF may also be allowed to be established on a land procured by an entrepreneur in accordance with the location criteria suggested under these guidelines.

e) The SPCB/PCC or concerned department in the business allocation of land assignment in the respective State Government or UT Administration may seek expression of interest from the proponents for development of new CBWTF (s) in the identified coverage area.
f) In the absence of expression of interest by any proponent, then SPCB/PCC shall insist health care facilities to form association and to develop its own CBWTF in line with these guidelines
g) In case of any regulatory action including closure of any existing CBWTF is inevitable, the respective SPCB/PCC may take action under the BMWM Rules including for making alternate arrangement to ensure safe disposal of the bio-medical waste generated from the member health care facilities of such default CBWTF through CBWTF located nearby.
h) In case of hilly areas considering the geography, only one CBWTF with adequate treatment capacity may be developed covering at least two districts to cater treatment services to the HCFs located in the respective Districts.

Duties of the operator of a common bio-medical waste treatment and disposal facility. Also, all the existing CBWTFs shall also complete augmentation of the existing incineration facility so as to comply w.r.to the residence time as well as emission norms including for Dioxins and Furans prescribed under BMWM Rules, 2016 within two years from the date of notification of the BMWM Rules, 2016 (i.e., prior to 27.03.2018). In addition to the above, to ensure proper management of bio-medical waste in the respective coverage area, as a mitigation measure, especially in the event of (a) a temporary break down (not more than a week) of a CBWTF especially for rectification of the refractory lining of the incineration chambers or change of requisite APCD due to failure

The action plan should also include:

a) A MoU made with the nearest CBWTF located within the respective State/UT, as alternate arrangement. In case, if there is no CBWTF located nearby then such CBWTF should have to install stand by treatment equipment (equal to the existing treatment capacity as per consents granted by the SPCB/PCC), and
b) Decontamination plan of the CBWTF for execution of such plan prior to closure of a CBWTF.

Applicability of these Guidelines: These guidelines are applicable to all the upcoming or new CBWTFs. In case of the existing CBWTFs, these guidelines shall be applicable in case

a) the existing CBWTFs desires to expand or enhance the existing treatment capacity (or)
b) the existing CBWTFs desires to modernize the existing treatment equipment with the new equipment with enhancement in the existing treatment capacity. Revised Guidelines for Common Bio-medical Waste Treatment Facilities 7

Environmental laws applicable for commissioning or operation of a CBWTF Operation of a CBWTF lead to air emissions as well as waste water generation as in case of an industrial operation. Most common sources of waste water generation in CBWTFs are vehicle washing, floor washing, and scrubbed liquid effluent from air pollution control systems attached with the incinerator/plasma pyrolysis. Incineration as well as DG Set is the general source of air emissions.

Consents under Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981 as well as Authorization under the BMWM Rules, 2016 The project proponent of the CBWTF is required to obtain 'Consent to Establishment' under Rule 25 of the Water (Prevention and Control of Pollution) Act, 1974 and under Rule 21 of the Air (Prevention and Control of Pollution) Act, 1981, from the respective prescribed authority i.e. SPCB/PCC.

Environmental Clearance under EIA Notification 2006 Ministry of Environment, Forest & Climate Change (MoEF & CC), notified amendment to the EIA Notification 2006 and published vide MoEF & CC Notification of S.O. 1142 (E) dated April 17, 2015. According to this notification, the 'bio-medical waste treatment facility' is categorized under the Item 7 (da) in the schedule, requiring 'environmental clearance' from the State Environment Impact Assessment Authority (SEIAA).

Location criteria: In the context of these guidelines, buffer zone represents a separation distance between the source of pollution in CBWTF and the receptor - following the principle that the degree of impact reduces with increased distance.

The location criteria for development of a CBWTF are as follows:

a. A CBWTF shall preferably be developed in a notified industrial area without any requirement of buffer zone (or)
b. A CBWTF can be located at a place reasonably far away from notified residential and sensitive areas and should have a buffer distance of preferably 500 m so that it shall Revised Guidelines for Common Bio-medical Waste Treatment Facilities 9 have minimal impact on these areas. In case of non-availability of such a land, the buffer

zone distance from the notified residential area may be reduced to less than 500 m by SPCB/PCC without referring the matter to

c. The CBWTF can also be developed as an integral part of the Hazardous Waste Treatment Storage and Disposal Facility (TSDF) subject to obtaining of necessary approvals from the authorities concerned including 'environmental clearance' as per Environmental Impact Assessment 2006 and further amendments notified under the Environment (Protection) Act, 1986, provided there is no CBWTF exist within 150 KM distance from the existing TSDF.

Land requirement: Sufficient land shall be allocated to the CBWTF to provide all requisite systems which include dedicated space for storage of waste (both treated and untreated), waste treatment equipment, vehicle washing bay, vehicle parking space, ETP, incineration ash storage provision, administrative room, space for DG Set etc.,.

Coverage area of CBWTF Suggested coverage area for development of a CBWTF is as follows:

A CBWTF located within the respective State/UT shall be allowed to cater healthcare units situated at a radial distance of 75 KM. However, in a coverage area where 10,000 beds are not available within a radial distance of 75 KM, existing CBWTF in the locality (located within the respective State/UT) may be allowed to cater the healthcare units situated upto 150 KM radius w.r.to its location provided the bio-medical waste generated is collected, treated and disposed of within 48 hours as stipulated under the BMWM Rules.

In case of hilly areas, considering the geography, only one CBWTF with adequate treatment capacity may be developed covering at least two districts to cater treatment services to the HCFs located in the respective Districts.

Treatment equipment: The Common Bio-medical Waste Treatment Facility should treat the bio-medical waste as per BMWM Rules and as per the authorisation granted by the prescribed authority.

The CBWTF should have the following treatment facilities:

a) Incineration/Plasma Pyrolysis Incineration is a controlled combustion process where waste is completely oxidized and harmful microorganisms present in it are destroyed/ denatured under high temperature. The guidelines for "Design & Construction Requirements of Bio-medical Waste Incinerators" by CPCB from time to time shall be

followed for selecting/or augmenting the incinerator. Revised Guidelines for Common Bio-medical Waste Treatment Facilities

Plasma Pyrolysis is an alternate to incinerator, Plasma Pyrolysis treatment technology can be installed for disposal of bio-medical waste categories as per BMWM Rules wherein destruction of bio-medical waste is similar to incineration can be achieved. In case of plasma pyrolysis, waste is treated at high temperature under controlled condition to form gases like methane, hydrogen and carbon monoxide which are subjected to combustion (oxidation) in secondary chamber. In the plasma pyrolysis process waste is converted into small clinker which can be disposed in secured landfills.

b) Autoclaving/Hydroclaving (i) Autoclaving is a low-heat thermal process where steam is brought into direct contact with waste in a controlled manner and for sufficient duration to disinfect the wastes as stipulated under the Bio-medical Waste Management Rules. For ease and safety in operation, the system should be horizontal type and exclusively designed for treatment of bio-medical waste. For optimum results, pre-vacuum based system be preferred against the gravity type system. It shall have tamper-proof control panel with efficient display and recording devices for recording critical parameters such as time, temperature, pressure, date and batch number etc. as required under the BMWM Rules. (ii) Hydroclaving is similar to that of autoclaving except that the waste is subjected to indirect heating by applying steam in the outer jacket. The waste is continuously tumbled in the chamber during the process.

c) **Microwaving:** In microwaving, microbial inactivation occurs as a result of the thermal effect of electromagnetic radiation spectrum lying between the frequencies 300 and 300,000MHz. Microwave heating is an inter-molecular heating process. The heating occurs inside the waste material in the presence of steam.

d) **Chemical disinfection**: Though chemical disinfection or alternates as stipulated under the BMWM Rules is also an option for treatment of certain categories of biomedical waste such as glass waste but looking at the volume of waste to be disinfected at the CBWTF and the

pollution load associated with the use of chemical disinfectants, the chemical disinfection for treatment of bio-medical waste as part of a CBWTF may be used sparingly or avoided as far as possible.

e) **Dry heat sterilization**: This is the additional option for treatment of waste sharps as stipulated under the BMWM Rules. In this method, waste sharps are treated using Revised Guidelines for Common Bio-medical Waste Treatment Facilities 12 dry heat (hot air) at a temperature not less than 1850 C, at least for a residence period of 150 minutes in each cycle (with sterilization period of 90 minutes).

f) Shredder: Shredding is a process by which waste are de-shaped or cut into smaller pieces so as to make the wastes unrecognizable. It helps in prevention of reuse of bio-medical waste and also acts as identifier that the wastes have been disinfected and are safe to dispose off. A shredder to be used for shredding bio-medical waste shall confirm to the following **minimum requirements**:

(i) The shredder for bio-medical waste shall be of robust design with minimum maintenance requirement;

(ii) The shredder should be properly designed and covered to avoid spillage and dust generation. It should be designed such that it has minimum manual handling;

(iii) The hopper and cutting chamber of the shredder should be so designed to accommodate the waste bag full of bio-medical waste;

(iv) The shredder blade should be highly resistant and should be able to shred waste sharps, syringes, scalpels, blades, plastics, catheters, intravenous sets/ bottles, blood bags, gloves, bandages etc. It should be able to handle/ shred wet waste, especially after microwave/ autoclave/hydroclave;

(v) The shredder blade shall be of non-corrosive and hardened steel;

(vi) The shredder should be so designed and mounted so as not to generate dust, high noise & vibration;

(vii) If hopper lid or door of collection box is opened, the shredder should stop automatically for safety of operator;

(xiv) The minimum capacity of the motor attached with the shredder shall be 3 KW for 50 Kg/hr, 5 KW for 100 kg/hr & 7.5 KW for 200 Kg/hr and shall be three phase induction motor. This will ensure efficient cutting of the bio-medical wastes as prescribed in the Bio-medical Waste Management Rules; and

Sharp pit/ Encapsulation: A sharp pit or a facility for sharp encapsulation in a metal container or cement concrete shall be provided for treated sharps (i.e., treatment by autoclaving or dry heat sterilization followed by shredding or mutilation).

Deep burial: Any SPCB/PCC should not allow the 'deep burial' of bio-medical waste as a part of CBWTF. Any existing CBWTF having disposal of bio-medical waste by deep burial should have the requisite treatment equipment as stipulated under the BMWM Rules, within six months from the date of finalization of these guidelines.

Vehicle/Containers washing facility: Every time a vehicle is unloaded, the vehicle and empty waste containers shall be washed properly and disinfected. Washing can be carried out in an open area but on an impermeable surface and liquid effluent so generated shall be conveyed and treated in an effluent treatment plant. The impermeable area shall be of appropriate size so as to avoid spillage of liquid during washing.

Effluent Treatment Plant: A suitable Effluent Treatment Plant (ETP) shall be installed to ensure that liquid effluent generated during the process of washing containers, vehicles, floors etc. is treated and reused after treatment.

ETP may also have the following provisions:

(i) separate 'energy meter' pH meter and A 'magnetic flow meter' should also be fitted so as to know total consumption of electricity for operation of the machinery attached with the ETP.

Infrastructure set up the CBWTF A CBWTF shall have the following infrastructure: a) Treatment Equipment Room A separate housing may be provided for each treatment equipment at the CBWTF such as incinerator room, autoclave room, microwave room etc., as applicable. Each room shall have well-designed roof and walls. Such room shall be well ventilated and easy to wash. The floor and interior finishing of the room shall be such that chances of sticking/harbouring of microorganisms are minimized. This can be attained by Note:

b) **All the treatment equipment** should be operated and complied with the norms as stipulated under Schedule II of the Bio-medical Waste Management Rules, 2016 published by MoEF & CC vide GSR 343 (E) dated 28th March, 2016.

c) Incinerator / Plasma Pyrolyisis/ Autoclaving/Microwaving/ Hydroclaving/ Shredder/ Dry Heat Sterilization/ ETP should be fitted with separate 'energy meter' for recording total energy consumed for operation of these equipment. all the CBWTF operators should also be provided with stand by treatment equipment especially incinerator/plasma pyrolysis/autoclave (or) alternately MoU made with the nearby CBWTF (located within the State/UT) shall be submitted to the respective SPCB/PCC,

Mercury storage The capacity of the mercury storage provision should be maximum of 90 days and by which the collected mercury bearing waste shall have to be disposed of through a TSDF located nearby following the manifest as per Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016.

d) **Administrative Room** This room shall be utilized for general administration, record keeping, billing etc.

e) **Generator set CBWTF** shall have a generator set of adequate capacity as standby arrangement for power, with sufficient capacity to run the treatment equipment during the failure of power supply. The generator set shall comply with the necessary requirement as per DG Set norms notified under the Environment (Protection) Act, 1986.

f) **Continuous emission monitoring system** (CEMS) Monitoring provision for continuous monitoring of the incinerator/plasma pyrolysis stack emission shall be installed by the CBWTF operators for the parameters as stipulated by the respective SPCB/PCC as per the authorisation granted under the BMWM Rules, 2016.

g) **Vehicle Parking** Provision for parking shall be made within the confines of the site for parking of required number of vehicles, loading and unloading of the vehicles meant for transporting waste to and from the facility, etc. In case of a CBWTF with space constraints, multy-storey parking or a separate provision may be allowed only for parking of vehicles.

h) **Display and sign board** An identification board (Display) of durable material and finish shall be displayed at the entrance to the facility. This shall clearly display the name of the facility, owner name, address and telephone number of the operator and the prescribed authority, no. of hours of operation & operational hours, telephone numbers of the personnel to be contacted in the event of an emergency, validity period of authorization as well as total daily waste treated and disposed. Also, sign boards should be provided at all the salient points (untreated waste storage area, treatment equipment, treated waste storage area, ETP, firefighting equipment) within the facility.

i) **Washing Room** A washing room shall be provided for eye washing/hand washing/ bathing etc. for the workers.

j) **Site Security** High walls, fencing and guarded gates shall be provided at the facility to prevent unauthorized access to the site by humans and livestock.

k) **Fire safety** Fire safety equipment such as sand buckets and fire extinguishers should be provided at all the salient points of the CBWTF including at the diesel storage areas, diesel tanks connected with the incinerator etc. Fire alarm also should be provided within the CBWTF

to prompt the workers in the event of any fire hazard. Workers should also be trained in First Aid administration.

l) **First Aid Box** First Aid Box with necessary provisions need to be provided at all the salient points within the facility.

m) **Green Belt** The open area available within the CBWTF shall be developed into green belt.

n) **Website:** (newly added as per BMWM Rules, 2016) All the existing CBWTFs shall develop own website by 27.03.2017 whereas the upcoming CBWTF shall develop the website prior to the commencement of the facility. The website should be uploaded with relevant information periodically (on monthly basis) especially as detailed below:

(i) A copy of the Environmental Clearance obtained;

(ii) **Copies of the Consents** under the Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981 as well as the Authorisation under the BMWM Rules obtained from the SPCB/PCC;

(ii) List of all the member Health Care Facilities with complete address, bedded or non-bedded HCFs, no. of beds, bar code, category-wise average bio-medical waste generation in kg/annum;

(iv) Charges levied on the member Health Care Facilities (HCFs) for treatment and disposal of bio-medical waste;

(v) Vehicles connected with a provision of GPS as per BMWM Rules and Vehicle-wise route chart for collection, transportation of bio-medical waste from the member HCFs;

(vi) Real time continuous online stack emission monitoring data;

(vii) Daily bio-medical waste collected, received and treated (Member HCF-wise);

(viii) Monthly details of total waste collected from the member HCFs, total waste treated, and treated recyclable plastic waste or glass waste sold to the parties and final mode of disposal of incineration ash;

(ix) A copy of the annual report submitted to the respective SPCB/PCC;

(x) Monitoring results of the stack emissions, treated wastewater and incineration ash, as per the frequency stipulated under the BMWM Rules;

(xi) List of HCFs (located within the coverage area) with complete address which have not taken membership of the CBWTF for disposal of Bio-medical waste;

- Contact person, contact telephone number and e-mail addresses of the facility; and. Revised Guidelines for Common Bio-medical Waste Treatment Facilities 20

- (xiii) Provision to have access to the SPCB/PCC/CPCB/MoEF & CC/MoH & FW especially on GPS, online monitoring system and the data. Besides the provisions suggested in the earlier paras,

Following important provisions should also be made in a CBWTF:

(i) A telephone shall be provided and maintained at the facility.

(ii) A First Aid Box shall be provided and maintained at the CBWTDF.

(iii) Proper lighting shall be provided at the facility.

(iv)Proper care shall be taken to keep the facility and surroundings free from odors.

(v) Measures shall be implemented to control pests and insects at the site.

(vi)Measures shall be implemented to control the escape of litter from the site.

(vii) Necessary provision shall be made to prevent and control noise generated, if any, due to the activities at the site.

(viii) Necessary protective gear for the waste handlers shall be provided.

(ix) Immunization to all the workers of CBWTF against all the diseases including especially Tetanus and Hepatitis -B as stipulated under the BMWM Rules.

(x) Workers should have provisions such as washing, toilet, and suitable place for eating.

(xi) Workers should also be provided with N-95 mask besides other PPEs such as hand gloves, gumboots, goggles etc. Every CBWTF operator shall submit a work-plan to the Prescribed Authority.

11) Record keeping: Maintenance of records for all operations carried out at the CBWTF is very important to monitor overall operation of the CBWTF. It also helps in submission of the required information to be submitted to the 'Prescribed Authority' by 30 th June of every year as per the format prescribed under the BMWM Rules or provided by the SPCB/PCC. A well-maintained record of all the activities at the CBWTF also enables the facility operator to produce all information of the activities on demand of the concerned prescribed authority. The record should include all information relating to each activity at the CBWTF site as per BMWM Rules which include accidents occurred (spills, injury, fire accident) and the measures taken and also, however, minimum requirement is outlined below:

Records of waste movements Daily records shall be maintained for the waste accepted and treated waste removed from the site. This record shall include the following minimum details:

(i) Waste accepted: -Records on day-to-day basis (as per the format given at Annexure-II) shall be maintained with respect to the waste collection date, name of the healthcare unit with bar code, waste category as per BMWM Rules, category-wise quantity of waste

accepted, vehicle registration number used for collection of bio-medical waste from member health care facilities, time at which waste collected from member HCFs, name of the vehicle driver and his signature and waste receiving date & time (at CBWTF site). Similar information to be acknowledged to the member health care facility by the CBWTF operator on daily basis.

(ii) Treated waste to be disposed:- Date, treated waste type, Quantity, vehicle number, disposal as stipulated under BMWM Rules.

b) **Logbook for the treatment equipment** A logbook shall be maintained for each treatment equipment installed at the site and shall include the following:

(i) The weight of each batch.

(ii) The categories of waste as per the Rules.

(iii) The time, date and duration of each treatment cycle and total hours of operations.

(iv) The complete details of all operational parameters during each cycle. Log book to be maintained for operating the incinerator/plasma pyrolysis as well as the autoclave as per the formats given at Annexure –III.

c) **Monitoring and reporting of operations in the CBWTF:** The monitoring of the key operating parameters of treatment equipment provides several benefits. First, monitoring provides the operator with information needed to make decisions on necessary combustion control adjustments. Second, properly maintained monitoring records can provide useful information for identifying operating trends and potential maintenance problems. Following are the suggested parameters for monitoring of the treatment equipment

(i) Monitoring of operating parameters of the incinerator/plasma pyrolysis: Following operating parameters can be monitored in case of incinerator/plasma pyrolysis: ¬ Waste charge rate. ¬ Combustion gas temperature in primary and secondary chamber as well as the temperature of the stack exit gas (flue gas). ¬ Condition of the draft (negative draft in primary chamber). ¬ Combustion gas oxygen level in primary and secondary chamber as well as stack exit gas. ¬ Air flow rate through the incinerator/plasma pyrolysis. ¬ Carbon-Di-Oxide (CO2), Oxygen (O2) and Carbon Monoxide (CO) level in the flue gas. ¬ Quantity of auxiliary fuel usage as well as the power consumption (in every batch). ¬ Pressure drop in the primary chamber and APCD attached with the incinerator/plasma pyrolysis and ¬ Bottom ash or slag quality (for Total Organic Carbon (TOC) as well as loss on ignition and the hazardous constituents (at least once in a quarter).

(ii) Monitoring of operating parameters of the Autoclave: Following operating parameters can be monitored during the sterilization using autoclave: ¬ Time at which sterilization started and time at which sterilization completed. ¬ Temperature conditions maintained throughout the sterilization ¬ Conditions of pressure maintained throughout the sterilization ¬ Duration of sterilization ¬ Validation test results Records concerning the above parameters need to be maintained and checked periodically for taking remedial measures during the operation of the incinerator or plasma pyrolysis or autoclave. In case of other treatment processes, the operational conditions as well as the efficacy tests to be complied with as per the standards prescribed under the BMWM Rules.

Frequency of monitoring: The CBWTF operator shall carry out following tests through a NABL approved laboratory or a laboratory approved under the Environment (Protection) Act, 1986,

- Suggested validation test for treatment of bio-medical waste by autoclave/microwave/chemical treatment/Dry heat sterilization S. No Type of equipment used for treatment of bio-medical waste Type of Validation Test Frequency (i) Autoclave (i) biological indicator strips or vials Geobacillus stearothermophilus spores with at least 1X106 spores), once in three months (ii) chemical indicator strip or tape each batch of waste treated (ii) Microwave Bacillus atrophaeus spores using vials or spore strips with at least 1 x 104 spores per detachable strip Recommended: once in three months (iii) Chemical treatment followed by shredding Bacillus Subtilis (ATCC 19659)- 4 Log10 reduction or greater Once in a week (iv) Dry heat sterilisation consistently kill the biological indicator Geobacillus Stearothermophillus or Bacillus Atropheaus spores using vials with at least 6 log10 spores per ml. Once in three months A chemical indicator strip or tape Once in a week d) Site Records:

Site records shall include the following:

(i) All the approvals obtained from other concerned departments other than the prescribed authority;

(ii) Details of construction or engineering works;

(iii) Maintenance schedule, breakdowns/trouble shootings and remedial actions;

(iv) Emergencies;

(v) Incidents of unacceptable waste received and the action taken; and

(vi) Details of site inspections by the officials of the regulatory authorities, purpose of visits with date and necessary actions initiated on the observations. Revised Guidelines for

Common Bio-medical Waste Treatment Facilities 25 Daily, monthly and annual summary records of all the above shall be maintained and made available at the site for inspection and same submitted whenever required by an authorized official of the concerned regulatory authorities.

12) Collection and transportation of bio-medical waste The collection and transportation of bio-medical waste shall be carried out in a manner so as to prevent any possible hazard to human health and environment. Collection and transportation are the 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 healthcare units reach CBWTF without any damage, spillage or unauthorized access by public, animals etc. A responsible person from the CBWTF operator shall always accompany the vehicle to supervise the collection and transportation of bio-medical waste. Also, the private transport vehicles should not be authorised by the SPCBs/PCCs only for transportation of the Bio-medical Waste. The CBWTF operator should be made responsible for collection and transportation of bio-medical waste.

a) Collection of bio-medical waste: Generator of the bio-medical waste is responsible for providing segregated waste in accordance with the provisions of the Bio-medical Waste Management Rules, 2016, to the CBWTF operator. Dedicated temporary storage at healthcare unit shall be designated. The coloured bags handed over by the healthcare units shall be collected in similar coloured containers with proper cover. Each bag shall be labelled as per Schedule IV of the Bio-medical Waste Management Rules as well as with bar coding system (to be complied by the occupier or operator of a CBWTF as per BMWM Rules) so that at any time, the healthcare units can be traced back that are not segregating the bio-medical wastes as per BMWM Rules. The coloured containers should be strong enough to withstand any possible damage that may occur during loading, transportation or unloading of such containers. These containers shall also be labelled as per Schedule IV of the Rules. Sharps shall be collected in puncture resistant container. The person responsible for collection of bio-medical wastes shall also carry a register with him to maintain the records such as name of the healthcare unit, the type and quantity of waste received, time at which waste collected from the member HCF, signature of the authorised person from the healthcare unit etc. During transportation, the containers should be covered in order to prevent exposure of public to odours and contamination.

(b) Transportation of the collected bio-medical waste to the CBWTF: CBWTF operator shall not sublet the vehicles used or contract vehicles should not be used by the CBWTF

operator. All the vehicles owned by the CBWTF operator and intended only for collection of bio-medical waste from the member health care facilities should be registered under the Motor Vehicle Act with the respective RTO/Transport Department and such vehicle numbers should also be registered with the respective SPCB/PCC for the purpose of collection of bio-medical waste from the member health care facilities. The bio-medical waste collected in designated coloured containers shall be transported to the CBWTF in a fully covered vehicle. Such vehicle shall be dedicated for transportation of bio-medical waste only. Depending upon the volume of the wastes to be transported, the vehicle may be a two or three-wheeler, light motor vehicle or heavy duty vehicle.

In either case, the vehicle must possess the following:

(i) Transportation vehicle shall be fitted with GPS to track the movement of the vehicle.

(ii) Separate cabins shall be provided for driver/staff as well as for placing the designated colour coded bio-medical waste containers.

(iii) Two wheeler registered under the Motor Vehicle Act shall be permitted for collection of bio-medical waste only from the clinics or dispensaries located in places where the lanes are narrow and not easily accessible to four wheeler vehicles. Such two wheeler vehicle (s) should have a provision of a suitable fixed waste collection box marked with bio-hazard symbol, contact details, proper lid, emergency spill collection procedure, first aid box and manifest record in accordance with the BMWM Rules

(iv) The base of the waste cabin shall be leak proof to avoid pilferage of liquid during transportation.

(v) The waste cabin may be designed for storing waste containers in tiers and also should be provided with a lighting provision.

(vi) The waste cabin shall be so designed that it is easy to wash and disinfect.

(vii) The inner surface of the waste cabin shall be made of smooth surface to minimize water retention.

(viii) The waste cabin shall have provisions for sufficient openings in the rear and/or sides so that waste containers can be easily loaded and unloaded.

(ix) The vehicle shall be labelled with the bio-hazard symbol (as per Schedule IV of the BMWM Rules) and should display the name, address and contact telephone and mobile number of the CBWTF.

(x) The vehicle driver should carry always valid registration of the vehicle obtained from the concerned transport authority and also carry valid ‘pollution under control certificate’ issued by the authorized certificate issuing agency.

Depending upon the area to be covered under the CBWTF, the route of transportation shall be worked out. The transportation routes of the vehicle shall be designed for optimum travel distance and to cover all member healthcare units of the CBWTF. The CBWTF operator should ensure online and real time tracking & monitoring provisions (GPS provision) should be given access with passwords to the SPCB/PCC and CPCB to cross check the movement of the transportation vehicles on any time by the SPCB/PCC/CPCB. As far as possible, the transportation shall be carried out during non-peak traffic hours. If the area to be covered is very large, a satellite station may be established to store the bio-medical waste collected from the adjoining areas. The wastes so stored at satellite station may then be transported to the CBWTF in a big vehicle. It shall be ensured that the total time taken from generation of bio-medical waste to its treatment, which also includes collection and transportation time, shall not exceed 48 hours.

Disposal option of solid waste generated from the CBWTF Treated plastic waste, incineration ash, treated waste sharps and glass waste, Oil & Grease waste and ETP sludge are generally generated from the CBWTF from the treatment systems such as autoclaving/microwaving, incineration, chemical disinfection and effluent treatment plant respectively. The treated bio-medical waste shall be disposed as per the options suggested in the Table 2 given below: Suggested Disposal option of solid waste generated from the CBWTF Sl. No. Treated Waste Category Suggested Treatment and Disposal Options

1. **Plastic wastes** after disinfection and shredding Plastic waste should not be sent to landfill sites. Treated plastic waste to be

(vii) sent to registered or authorized recyclers (or)

(viii) for energy recovery (or)

(ix) for diesel or fuel oil recovery (or) (iv) for road making, whichever is possible.

2. **Disinfected Sharps** (including needles and syringes) (i.e., Treatment by Autoclaving or Dry Heat Sterilization followed by shredding or mutilation combination of shredding cum autoclaving) Encapsulation in metal container or cements concrete; (or) sent for final disposal to iron foundries (having consent to operate from the SPCBs/PCCs (or) sanitary landfill or designated concrete waste sharp pit.
3. **Incineration ash** Incineration ash (ash from incineration of any bio-medical waste) shall be disposed through hazardous waste treatment, storage and disposal facility (TSDF), if toxic or hazardous constituents are present beyond the prescribed limits as given in

Schedule –II of the Hazardous and Other Waste Management & Transboundary Movement Rules or as revised from time to time.

4. **Other treated solid wastes** like Glass waste Disinfection (by soaking the washed glass waste after cleaning with detergent and Sodium Hypochlorite treatment) or through autoclaving or microwaving or hydroplaning and then sent for recycling.
5. **Oil & Grease** By Incineration
6. **ETP Sludge** After drying in sludge drying beds or removal of moisture content using 'Filter Press' and such ETP sludge shall be given to CBWTF for incineration or to the hazardous waste treatment, storage and disposal facility (HWTSDF) for disposal in Secured Landfill
7. **Hazardous Waste** Disposal through a TSDF located nearby following the manifest as per the Hazardous and Other Waste (Management & Transboundary Movement) Rules, 2016

Cost to be charged by the CBWTF Operator for the Health Care Facilities Cost to be charged from the healthcare facilities plays an important role in financial viability and sustainable operation of a CBWTF project.

Check list for development of CBWTF The criteria for development of CBWTDF have been discussed in detail in the Note: (i) Rates are required to be revised once in a year based on the Wholesale Price Index (WPI Index) or Consumer Price Index (CPI Index

Periodic inspection/monitoring or performance evaluation of the CBWTF To have uniformity in performance evaluation of the CBWTF throughout the country, a check list for performance evaluation of the CBWTF for carrying out inspection/monitoring/compliance verification has been prepared and is annexed (Annexure –V).

Disposal in a sanitary landfill or waste burial pit:-

The disposal of untreated health-care waste in an uncontrolled dump is not recommended and must only be used as a last resort. It can be disposed of in a sanitary landfill, subject to certain precautions: it is important that health-care waste be covered rapidly. One technique is to dig a trench down to the level where old municipal refuse (over three months old) has been buried and to immediately bury health-care waste that is discarded at this level under a 2-metre layer of fresh municipal refuse.

The following are the essential factors that must be taken into consideration in the design and use of a sanitary landfill:

- access must be restricted and controlled;
- competent staff must be available;

- the discarding areas must be planned;
- the bottom of the landfill must be waterproofed;
- the water table must be more than 2 metres below the bottom of the landfill;
- there must be no drinking water sources or wells in the vicinity of the site;
- chemicals must not be disposed of on these sites;
- the waste must be covered daily and vectors (insects, rodents, etc.) must be controlled;
- the landfill must be equipped with a final cover to prevent rainwater infiltration;
- leachates must be collected and treated.

Sanitary Landfill- Every method has its advantages and drawbacks.

	Advantages	**Drawback**
Sanitary landfill, trench method	Simple and inexpensive operating costs. Can be carried out using an existing municipal waste management system. Scavengers cannot access the health-care waste if the landfill is well managed.	The landfill must be secure, fenced in, and guarded. Scavengers and animals need to be controlled. A high degree of coordination is needed between collectors and landfill operators. Transport to the landfill can be a lengthy and costly operation. Risk of water pollution

NEWER TECHNOLOGIES:

Ozone (O3) can be used for especially pharmaceutical waste, water and air treatment. It is a strong oxidizer which breaks down to a more stable form (O2). But Ozone systems require shredders and mixers to expose the waste to the bactericidal agent.
Regular tests should be conducted to ensure that the microbial inactivation or elimination standard is met.

Promession: Promession is an innovative method of ecological burial. Its primary principles are preservation after death in organic form, and shallow burial in living soil that quickly converts a body to a form that is primed to foster new life.

Alkaline hydrolysis: It is a fast-upcoming process that converts body parts, specimens and cadavers into a decontaminated aqueous solution and destroys fixatives, hazardous chemicals and waste contaminated by prion. After the waste is loaded in the basket and into the hermetically sealed tank, alkali is added along with water at temperature of 127°C or higher and stirred. After digestion time of 6–8 h, by-products include mineral constituents of bones and teeth, solution of amino acids, sugars, soaps and salts. It can also destroy chemotherapeutic or cytotoxic agents and aldehydes (such as formaldehyde and glutaraldehyde) commonly used in hospitals.

Nanotechnology:

It is used to cleanse environmental air to improve indoor quality air and includes a photo catalyst with wide spectrum of light and is bactericidal and fungicidal. It utilises the energy from light to generate hydroxyl species and superoxide anion ($O2^-$) which decompose and oxidise toxic pollutants to carbon dioxide and water.

Membrane bioreactors

It combines the biological-activated sludge process with a membrane filtration step for sludge water separation.

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Box 1.2 UN Millennium Development Goals relating to health-care settings

Goal 4, Target 5 of the UN Millennium Development Goals aims at reducing by two thirds the death rate for children under five. Goal 5, Target 6 aims at reducing maternal mortality by three quarters.

Source : WHO