



INTERNATIONAL RESEARCH JOURNAL ON ADVANCED SCIENCE HUB

e-ISSN : 2582 - 4376
Open Access

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Biomedical Waste Management

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Abstract

Infectious and hazardous waste are engendering within health care and hospitals. The emissions of definite metals and chlorinated dioxins and furans in the flue gasses of medical waste are comparatively high as compared to the emissions from different combustion sources. Discriminate disposal of these wastes possesses a serious threat to the ecosystem and human health. Tremendous efforts have been made by the government to ensure the availability of medical disposal services. In general, the incineration method is one of the most extensively used techniques for the disposal of medical wastes. The process involves burning waste at a very high elevated temperature. The article deals with the fundamental problems as definition, categories of medical waste, and the process like segregation, storage, and transport and disposal methods are discussed. A statistics of CBMWTF operation under 11 districts surveyed. Effective biomedical waste management is mandatory for healthy humans and to the unstained environment.

Keywords: Waste Management, Biomedical.

Introduction

Biomedical waste is increasing day by day due to changes in the lifestyle and precautionary we do to prevent ourselves from the pandemic situation. Biomedical waste is any waste that is generated during the diagnosis, treatment, or immunization of human beings, or animals. It includes anatomical waste, expired medicine, mercury thermometers, etc. Biomedical waste is classified into two types. Hazardous waste (15% - 20%) and Non- Hazardous waste (80% - 85%). All these types of wastes are generated from hospitals, clinics, pharmacies, laboratories, healthcare facilities, and even from residential and public places. The development of the nation depends upon the best waste management method because proper waste management reduces major health issues whereas improper waste management

reduces the health quality of the population. Incineration is the preferred option in many areas and it is the frequent method of choice for most hazardous healthcare waste. It makes waste management easier and more efficient by reducing 90% of the total waste. Incineration summons wastes at high temperatures and removes pollutants like chemical solvents, polychlorinated biphenyls, pesticides and, Sulphur dioxide, which are harmful to people and the environment. The incineration process generates energy from wastes. The outcome of the energy can be used to generate electricity or heat. Recently biomedical waste management and the incineration process emerged as issues of major concern to hospitals and the environment. The major pitfall of the incinerator is it emits toxic smoke and toxic ash that debris a major source of dioxin in the atmosphere. The smoke includes nitrogen oxide, heavy metals, and

other venomous mixtures. A vast number of studies take-up globally to appraise the health impacts of the dioxin and furan on humans, animals, and ecosystems [1]. All research evidence that dioxin exposure is associated with cancer and other genetic disorders in humans. In this paper, we are going to discuss some of the effective technologies to use in addition to incineration to provide better environmental results.

2. Problem statement

The incineration method is widely used to narrow the properties and mass of infectious medical waste and to reduce the potential toxicity of hazardous chemical and biological waste. The incinerator produced pollutants have been the hinge to cause various adverse health possessions and the effects have been observed at much higher ambient concentration than the usually produced emissions [2]. The principal gaseous products of waste incineration are carbon dioxide and water vapor. In the process of segregation of waste from the hospitals or clinics, it is segregated based on potential hazards and the material of the waste is not concerned. Hence, some of the heavy metals are disposed of by incineration. During incineration, these heavy metals come out in the form of fine particles through smoke, which results in major respiratory problems. On the burning of biomedical waste, it releases harmful by-products like smoke, acid gas which consists of hydrochloric acid, sulfur dioxide, or sulfur trioxide. These cause serious health problems to human beings like shortness of breath, lung problems, and even lead to blindness. The bottom ash and fly ash which remains as a residue also causes environmental pollution. Dioxin and furan are the cancer-causing agents that must not be released into the environment without treatment. These toxic substances cause long term effects on humans, such as cancer, because developmental abnormalities in the children, damage to the immune system, etc.

3. Biomedical Waste Management

Biomedical waste generation has tripled due to the widespread use of COVID-19. Hence, there is an urgent need for the proper administration of biomedical wastes in both hospitals and public places [3].

Table.1. Categories of Biomedical Waste Management

Categories	Type Of Waste	Disposal Method
Category No. 1	Human anatomical waste	Incineration or deep burial (optional)
Category No. 2	Animal waste	Incineration or deep burial (optional)
Category No. 3	Microbiology and Biotechnology waste	Microwave or native autoclave or incineration (requires chemical treatment)
Category No.4	Waste sharps	Disinfection by chemical treatment or autoclave or microwaving and injury or shredding (mutilation)
Category No.5	Discarded Medicine and Cytotoxic drugs	Incineration(requires chemical treatment) or destruction and medical drugs disposal in secured landfills
Category No.6	Soiled waste	Incineration or autoclave
Category No. 7	Solid waste	Disinfection by chemical treatment or autoclave or microwaving and injury or shredding
Category No. 8	Liquid waste	Disinfectant by chemical treatment and discharge into drains
Category No. 9	Incineration ash	Disposal in municipal lowland
Category No. 10	Chemical waste	Chemical treatment and discharge into drains for liquids and secured land for soils

4. The Flow of Biomedical Wastes

The medical wastes are generated from treating the patient to diagnosing the patient. Hence at the most concentrations must incline to the flow of wastes

from the hospital to the disposal unit; the common wastes generated include all disposal material utilized in the hospital. The wastes generated must be collected in respective color-coded bags as mentioned in Biomedical Waste Management Guidelines. These bags must be stored in a covered environment such that it's not fused with the environment. It mustn't be stored within the hospital for more days without treatment. The Biomedical Waste Management staffs must manage the wastes properly at regular time intervals. It should be properly transported to the local Government-authorized CBMWTF. The wastes are going to be treated successfully by the CBMWTF per the CPCB Guidelines. During this sector, most of the biomedical wastes enter into the incinerator. The Incinerator is taken into account one among the foremost effective ways of disposal, though it emits some secondary pollutants which must be controlled.

4.1 Segregation

The segregation process is that the basic separation of a distinct group of waste generated at the hospitals. This process is employed to prevent a mixture of medical waste. Effective segregation ensures effective biomedical waste management. The waste must be segregated into containers or bags and no bags or containers to be opened once the waste has been put into it. The waste is sequestered within the color-coded bins as per the medical specialty waste management rules. The color-coding is yellow, red, white, and blue. The yellow color code covers most forms of biomedical waste. Categories 1, 2, 5, 6 fall on the yellow bag. The waste is collected in non-chlorinated plastic bags. These wastes are inclined of by the incineration method by CBMWTF.

4.2 Storage process

The health-care institutions must select a storage location for medical waste. The collected waste should be stored in a detached zone or room appropriate to the quantities of the waste produces [4]. It should be stored within the place with the identifiable container and the bags should carry the biohazard symbol. Cytotoxic waste should be stored separately and radioactive waste should be stored in containers and labeled with the sort of required storage in detail. The duration of storage time mustn't exceed 8 to 10 hours in hospitals.

Storage time differs according to the temperature. The International Committee of the Red Cross (ICRC) recommends storage time of waste should not exceed 72 hours in winter and 48 hours in the cooler season and 24 hours in the warmer season [5]. It is the responsibility of the administration, security, sanitation, and staff to ensure the safety and prevention of waste during this time.

4.3 Transportation

Transportation of health care waste is one of the most crucial steps in biomedical waste management. The waste should be transported either in a trolley or in a converted wheelbarrow carried out by bags and tight containers and it must be tightly lidded before transportation. The transportation in charge should follow the

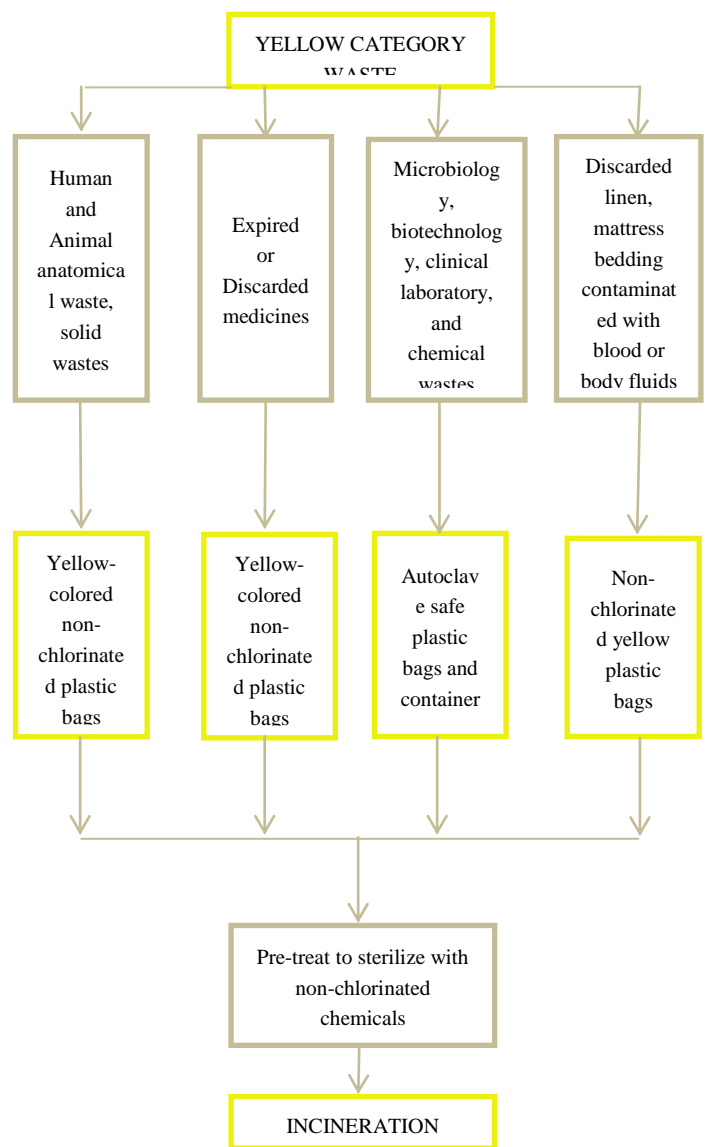


Fig.1. Segregation of wastes For Incineration

Following instructions whenever he starts his work, he should be accompanied by a signal document by a nurse/doctor. Waste category, data of collection, place in the hospital where waste is produced (Ex: ward, ICU), waste destination.

There are two types of transport involved:

On-site transport: Medical waste should be transported within the hospital or other facility through wheeled trolleys, containers, or carts.

Off-site transport: The waste which is treated apart from hospitals is known as off-site transport [6]. The health care producers are accountable for safe packaging and adequate labeling of waste and transported off-site and for authorization of its destination.

5. Incineration

The treatment of medical waste is known as incineration. The incineration of waste is a sterility (disinfected, hygiene) method of reducing its capacity and weight which also reduces its potentials to pollute the atmosphere. It involves the combustion of organic substances contained in waste materials. Incineration and the other waste that gets burned in a very high-temperature waste treatment process is called as thermal treatment. Combustion of waste materials converts the waste into ash, flue gas, and warmth. The ash is generally produced by inorganic constituents of the waste and it form solid lumps or particulate pollutants by flue gas. The flue gases should be cleaned of gaseous and chemical content before they are dispersed into the environment. In some cases, the warmth that's generated by combustion will be accustomed to generate electrical power [7]. Residues from the incineration process must still be landfilled, as must the non-combustible portion of the waste disposal solution. Most countries will need to employ several ways for their waste simply because of the waste diverse. Providing electricity and producing hot water or steam as a by-product of the incinerator process has dual advantages for this process. Hence incineration is a widely used method all over the world.

5.1. Types of incinerator

There are seven types of incinerator namely:

Rotary Kiln: The rotary kiln is a pyro-processing device, this incinerator is designed with two chambers primary and secondary chambers were

the combustion of the volatile fraction is done. In primary chambers, the waste materials get discharged from the feed end to the ash end and they get discharged by a slightly inclined rotating kiln. In the second chamber, the excess air gets operated and combustion of the volatile takes place completely in the secondary chamber. It also consists of add-on-gas cleaning devices.

Table.2. Total incineration in Coimbatore

2018	Incinerated per month(in tons)
Jan	45
Feb	49
March	54.5
April	51
May	49.8
June	47
July	53.8
August	52.5
September	48
October	34.9
November	51
December	51.2
Total	536.5

Fluidized Bed Incinerator: The main principle behind the process is to convert the granular materials which are in a solid-state into the fluid-like state by giving fluid (liquid/ gas) to it. This fluidized bed incineration is commonly used in sewage and industrial incinerators.

Liquid Injection incineration: It depends on high pressure to produce liquid waste for incineration by breaking the waste into tiny droplets that result in easier combustion.

Multiple Hearth Incineration: It is a series of circular hearths also known as vertical calcining used for continuous production of calcining of material. A vertical rotating shaft through the center of the furnace has rabble arms that move in a spiral path across each hearth below then reaches to hearth and the final material is discharged through to the outlet.

Catalytic Combustion Incinerator: It's a activity, the most target is to reinforce the specific oxidation reaction of a fuel and to cut back the assembly of an undesired product, mainly pollutant nitrogen gases (NOx). This process is also widely used all over the world.

Waste Gas Flare Incinerator: Gas flare is commonly a combustion process by using a combustion device to accomplice to burn the excess gas, liquid produces unwontedly by normal fire, or unplanned over-pressured operation in industries. Gas flaring is the primary source for Green House Gas Emission. This technique also consists of drawbacks by producing heat, noise, and acquires a large area.

Direct-Flame Incineration: The waste directly gets treated by the combustion process is known as direct- flame incineration. Here thermal oxides are used to control the excess gas exiting out from the combustion process when it is complete.

5.2. Need for incineration

Incineration results in a drastic reduction in the volume of waste, and a reduction in original volume and weight of 95% and 75% respectively. Incineration does not produce methane gas and reduces methane from landfills. It also provides better control over odorur and noise [8]. And it does not require more space. The net reduction in the quality of toxicity due to incineration of the infectious and hazardous waste is destroyed. And this helps to provide a renewable source and conserving valuable raw material.

5.3. Advantages

Incineration can decrease the quantity of waste by 95% and reduces the dependency on landfills. Incineration plants provoke energy from waste that can be utilized to initiate electricity or heat. The heat and energy from the incinerator waste are generated by using steam turbines. A single plant can burn up to 300 million tons of trash every year. It reduces the load on coal-fired plants which causes a distance for the environment. The current incinerator plants use filters to trap hazardous gases especially dioxin, but the success is partial. Incineration plants are near to the hospital unit, so waste does not have to be navigating for long distances for dumping [8]. This is the main advantage. Incineration plants do not produce methane like landfills so it is safer. The incineration method is very effective to eliminate clinical waste as it works at a very high temperature which can destroy germs and harmful

chemicals. It has a computerized monitoring system, and it can function in any type of weather.

5.4. Disadvantages

The paramount drawback of the incinerator is the requirement of high investment, but the process is not affordable. The biomedical waste consists of heavy materials that are shed for incineration; this result in the emission of fine particles along with the smoke is released to the environment called fly ash which needs a special disposal technique. Most incinerators at present are not equipped with Air Pollution Control (APC) system, because of high cost, and also running APC equipment discourages its uses. The result shows a plethora of organic and inorganic pollutants are released in the flue gas [9]. However, 90% of the waste is reduced, still, 10% remains in the form of bottom ash or sinter. These are the forms of inorganic materials which are mostly disposed of through landfills. Dioxin and furans are the main components that are released as cancer-causing agents in the environment.

5.5. Properties of dioxin:

Dioxin is obtained by flaming chlorine-based chemical compounds with the hydrocarbons [9]. The main supply of hydrocarbon within the surroundings comes from waste-burning incinerators of associated kinds and additionally from grounds burn-barrels.

Dioxin could be a collective name for a particular cluster of chlorinated organic molecules wherever some exhibit secretion disrupting and cancer properties. Dioxins will kind in waste burning because the flue gases quiet down.

When you incinerate waste, some hydrocarbon formation is inevitable, however with the trendy flue gas cleansing system the emission through the stack is decreased, the dioxin square measure filtered from the flue gases and find within the ash. The formation of dioxin at intervals the flue gas filters of a full-scale waste burning plant.

High-temperature PCDD (dioxin) sampling to avoid this prevalence, the effective result is additional cooling at a vital stage that then prevents the formation of dioxin.

Dioxins able to dissolve in following solvents like oil, fats, and organic solvents. Dioxin does not

dissolve in water, low vapor pressure, not broken down by microorganisms.

Plant roots do not take dioxin through O₂ and soil. Dioxin can be broken slowly by sunlight.

The timeline of dioxin in the soil is 1.5cm above soil surface-dioxin stays for 9-15 years,. 0,1cm below the soil surface-dioxin stays for 25-100 years.

6. Statistics

TNPCB has approved 6261 non-public and government hospitals in the state below the principles. These hospitals have created an agreement with the Common Bio-Medical Waste

Treatment Facility (CBMWTF) for the gathering, transport, treatment, and scientific disposal of medical waste [10]. The CBMWTF consists of autoclave, shredder, furnace, and secured landfill facilities. In Tamil Nadu, eleven CBMWTF area units are underneath operation. On a mean, daily forty-three tons of biomedical waste is handled by these facilities. Categories of biomedical waste management and the treatment methods are mentioned in the table (table number should be mentioned here.) Per day’s average waste from the year 2016 to 2018 also calculated and given in the table (table number) below.

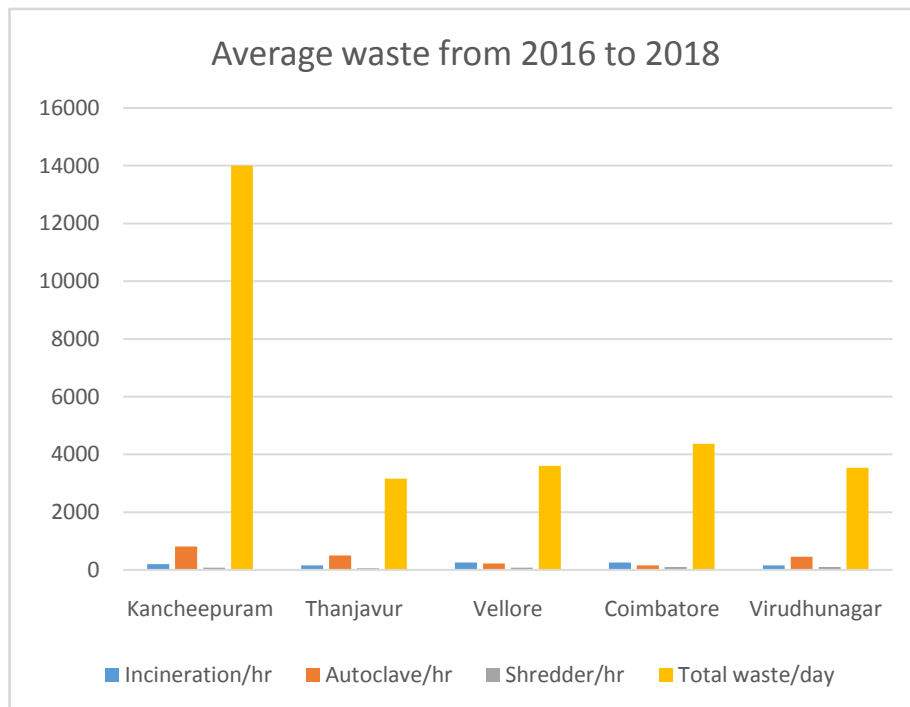


Chart.1. Average waste

6.1. CBMWTF Operation in 11 Districts

Every District handles an average of 43 tons of biomedical wastes per day.

7. Scrubber

Scrubbers or Exhaust Gas Cleaning Systems (EGCS) are used to draw out particulate matter and toxic components, such as Sulphur oxides (SOX) and nitrogen oxides (NOX) from the exhaust gases generated as a sum of the combustion process in marine engines, to perform pollution control [11]. Municipal solid waste and

waste, few layers of hazardous waste, municipal waste incineration is treated by the scrubbing process. Spray dryer scrubber like slurries of lime, sodium carbonate, sodium bicarbonate as an alkaline reagent. Use of catalyst sorbent based on alumina supported Cuo, Ceo₂, were applied to a dry scrubber to clean up the So₂/HCL/NO simultaneously from pilot-scale fluidized bed incineration flue gas[11]. It is a pollution control device by using chemical content to treat or remove particulate matter from the waste during the incineration process before leaving the chimney.

Table.3. CBMWTF Operation

S.No	DISTRICT	REGIONS COVERED	WASTE KG/MONTH
1.	Vellore	Vaniyambadi, Thiruvannamalai, Vellore	228,000
2.	Kancheepuram	Chennai (north), Cuddalore, Villupuram, part of Kancheepuram	199,800
3.	Kancheepuram	Part of Chennai, Kancheepuram, Tiruvallur	184,800
4.	Virudhunagar	Theni, Ramanathapuram, Dindigul, Madurai, Virudhunagar	120,000
5.	Coimbatore	Pollachi, Udmalpet, Tiruppur, Sathyamangalam, Coimbatore, Mettupalayam	75,000
6.	Thanjavur	Pudukottai, Perambalur, Thiruvarur, Karaikal, Trichy, Nagapattinam, Thanjavur, Ariyalur, Sivagangai	54,000
7.	Tirunelveli	Thoothukudi, Kanniyakumari, Tirunelveli	49,500
8.	Salem	Namakkal, Erode, Dharmapuri, Krishnagiri, Karur, Salem	45,000
9.	Coimbatore	Coimbatore, Nilgiris	43,500
10.	Nilgiris	Nilgiris	22,980
11.	Ramanathapuram	Ramanathapuram	630

Conclusion

Biomedical waste management was crucial parts in 2020 due to the generation of the maximum amount of biomedical wastes even from public places. It needs proper segregation, storage, transportation, and treatment methods to dispose of all kinds of biomedical wastes. One of the major methods used for proper disposal is incineration. Still, incineration needs some technological advances to reduce the number of secondary pollutants occurring from it. Our further work relies on the reduction of these secondary pollutants through the incinerator.

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