iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VII **Month of publication:** July 2021

DOI: https://doi.org/10.22214/ijraset.2021.36936

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VII July 2021- Available at www.ijraset.com

Biomedical Waste Management

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Abstract: ***Bio-medical waste (BMW) disposal is a very important yet a challenging task. Health-care waste contains potentially harmful microorganisms, which can infect hospital patients, health workers, and the general public. Exposure to hazardous health-care waste can result in disease or injury. The Government of India has been laying down rules, namely, Bio-Medical Waste (Management and Handling) Rules, in 1998, COVID-19 pandemic and its consequent biomedical waste is an unprecedented challenge worldwide. Biomedical waste generated during COVID-19 patient isolation, testing and care needs special consideration as it challenges the previous notion that only 15–20% of waste can be considered infectious. With establishment of new home quarantine facility, isolation/quarantine centers the chances of general waste getting contaminated with biomedical waste has increased exponentially. The key step in COVID19 waste management is segregation of biomedical waste from solid waste. Waste generated from COVID19 patients is like any other infectious waste, therefore creating public awareness about the COVID19 waste hazards and segregation at source is highlighted in all guidelines as a recommendation.***
Keywords: Bio medical waste, waste disposal practices, COVID-19, CPCB Guidelines, Waste Generation

I. INTRODUCTION

Bio-medical waste (BMW) differs from various hospital waste as it produces several health hazards. India is the second-most popular country after China and the second worst-hit nation by the coronavirus disease 2019 (COVID-19) after the United States of America (As of November 9, 2020).

Due to an inaccurate biomedical waste management system and lack of resources, India is facing grave consequences during COVID-19.

The assiduous handling and management of BMW can prevent the infection produced by the hospital waste and can decrease the transmission of diseases. According to the data proclaimed by the central pollution control board (CPCB) in the year 2018, the total amount of BMW generated in India is 517 tons/day in the year 2016 and around 501 tons/day in the year 2015, out of which around 4–5% remains untreated.

Currently, five million health workers are executing their responsibilities and cleaning the country; and the laborers (Safai karamchari) are simultaneously handling the biomedical waste as well.

Sadly, they are not provided with the necessary personal protective equipment and hence are at high risk and subsequently pose a threat to the residing community. According to the confirmation from scientific literature, the virus may stay for more than 24 h within the cardboard, boxes, other rigid substances and around 72 h on the metal surfaces and sharps, which is a remarkable threat for the workers collecting the waste.

II. CLASSIFICATION OF WASTE

The Medical Waste Tracking Act of 1988 defines waste as four requirements that were primarily identified; first, to provide a means of monitoring "the transportation of waste from the generator to the dumping ground" unless said waste had previously been incinerated. Secondly, to ensure the "transformer of the waste" that the waste had been "accepted by the disposal provision." Next to evolve a uniform method for tracking the materials developing a means to label and contain the wastes for the safety of the handlers. Medical waste can be distributed into four divergent categories:

1) Infectious
2) Hazardous
3) Radioactive
4) General waste

The following diagram shows the detailed classification of waste:

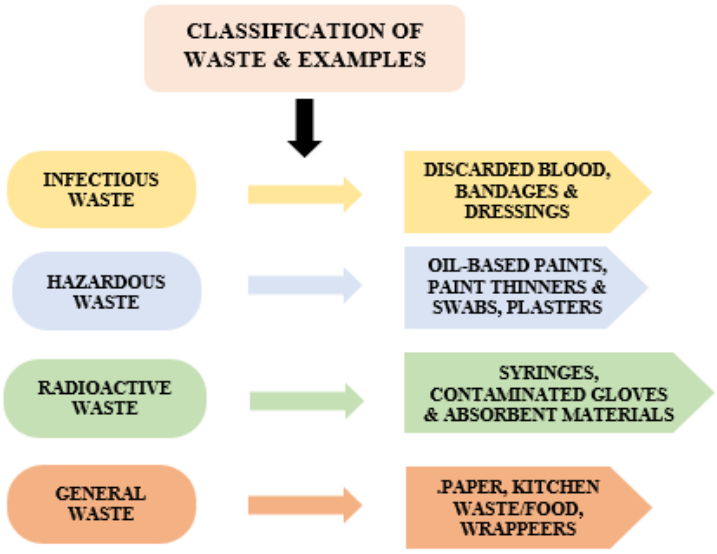

Fig. 1 Classification of Bio-Medical waste

A. Infectious waste

Waste that develops infections to humans. It contains human or animal tissue (blood or other body parts), blood-soaked bandages, discarded surgical gloves, cultures, stocks, or swabs to inoculate cultures. E.g., Waste from surgery on patients with infectious disease, infected animals from laboratories.

B. Hazardous waste

Waste that affect humans in non-infectious manner, but which encounter federal guidelines for hazardous waste under the Resource Conservation and Recovery Act (RCRA). Hazardous waste comprises chemicals, both medical and industrial. Most of the hazardous waste can also be contemplate as infectious waste, depending on its origin and exposure to human or animal tissue prior to discard. E.g., Old drugs, including chemotherapy agents, are sometimes hazardous.

C. Radioactive waste

Radioactive waste can be generated from nuclear medicine treatments, cancer therapies and medical equipment that uses radioactive isotopes. It is mainly classified as low-level waste (LLW), intermediate-level waste (ILW) & high-level waste (HLW). Low-level waste contains small amounts of short-lived radioactivity such as paper, rags, tools, and clothing. Intermediate-level waste contains higher amounts of radioactivity and requires some shielding. High-level waste which is highly radioactive and hot due to decay heat, requires cooling and shielding.

D. General waste

About 85% of waste generated at medical facilities is no different from general household or office waste, and includes paper, plastics, liquids and any other materials that do not fit into the previous three categories. Waste professionals refer to this as municipal solid waste, and it is usually disposed of in landfills.

The World Health Organization (WHO) classifies medical waste into:

1) Sharps
2) Infectious
3) Pathological
4) Radioactive
5) Pharmaceuticals
6) Other (including toilet waste produced at hospitals)

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
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III. SOURCES OF BIOMEDICAL WASTE

The sources of such waste can be categorized into two that is major sources and minor sources. The major sources of biomedical waste include hospitals, nursing homes, laboratories, clinics, offices of dentists, physicians and veterinarians, dispensaries and medical transporters. The minor sources, on the other hand, include households, industries, clinics, home care and other storage and treatment facilities of biological entities. Bio medical waste are hazardous due to two main reasons, one being infectivity and other being toxicity. Remunerative countries generate on an average up to 0.5 kg of hazardous waste per hospital bed per day; while impoverished countries generate on an average 0.2 kg. However, health-care waste is often not separated into hazardous or non-hazardous wastes in low-income countries making the real quantity of hazardous waste much higher.

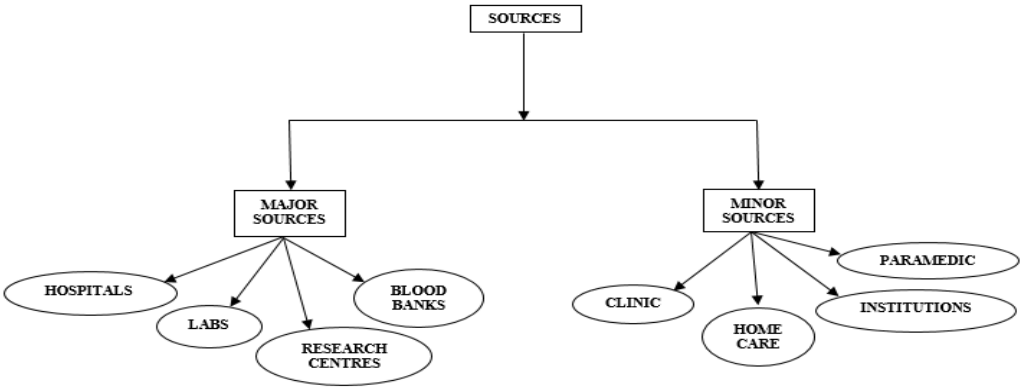


Fig. 2 Sources of Bio-Medical waste

IV. HAZARDS OF BIO-WASTE

Inappropriate separation and discarding of biomedical waste have the prospective to pollute groundwater sources, which in turn may infect humans and animals alike. Originating from a hospital's waste and storage receptacles to landfills, biomedical waste needs to be properly contained to keep it away from birds, rodents, and stray animals (as well as humans). If incongruous contained, segregated, and incinerated through on-site or off-site incineration, environmental hazards associated with improper healthcare waste management can contaminate the air we breathe through dangerous airborne particles. Health Impacts of BMW are:

1) Decomposing waste may generate foul odor inside the hospital premises and surroundings.
2) Waste dump may attract stray animals & birds that might spread waste materials leading to an unaesthetic environment.
3) Uncontrolled & open burning of wastes can generate dioxins and furans, thus polluting air.
4) Poor hospital waste management may lead to-
a) Hepatitis B & C
b) HIV Infection
c) Respiratory Infection
d) Blood stream Infection
e) Skin Infection

V. PROCESS OF MANAGING BIO-MEDICAL WASTE

Manipulating, insulation, disfigurement, sterilization, depository, transportation and final disposal are vital steps for safe and scientific management of bio-medical waste in any establishment. There are various categories of Biomedical Wastes. The key to minimization and effective management of biomedical waste is segregation (separation) and identification of the waste.

1) *Source Identification:* Identification of source required both at The macro level (Institutes that generates wastes) The micro level (Point & activities within the institution)
2) *Segregation:* Separation of different types of waste as per treatment & disposal options. It is the key to active process of scientific waste management.
3) *Collection & Storage:* Storage of waste refers to storage within wards or collection points within the department. Collection centers are planned between 2-3 wards. No untreated biomedical waste shall be stored beyond a period of 48 hours. If in any case it is necessary, then permission of the prescribed authority is essential.

4) *Transport:* Transportation system should be secured with special containers and well-defined route with minimum patient reflux. The containers should have non-washable and prominently visible label showing the type of waste it contains – Cytotoxic or Biohazards**.**
5) *Treatment & Disposal:* The main objective of treatment is disinfecting & decontaminating the waste and volume reduction.

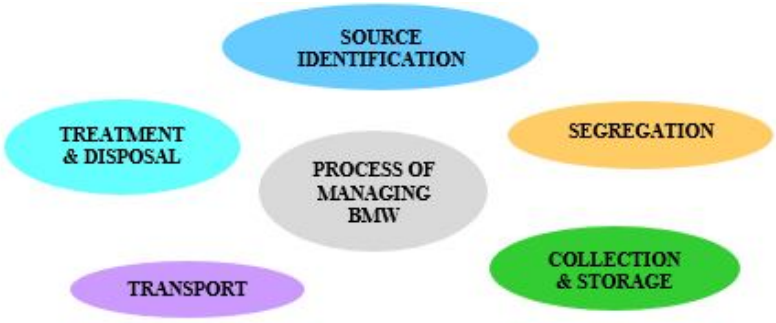


Fig. 3 Process of Managing Bio-Medical waste

There is a lot of biomedical waste which gets disposed in India. There are various categories of disposing waste in containers such as Yellow, Red, White (translucent) & Blue.

Class	Type of waste	Type of bag / container to be used
Yellow container 	It contains waste from Human anatomical, animal anatomical & soiled waste. Expired or discarded medical wastes Chemical waste Microbiology, biotechnology & other clinical laboratory wastes	Yellow-colored, non-chlorinated plastic bags, Autoclave safe plastic bags or containers
Red Container 	It contains contaminated waste that are recyclable. Wastes generated from disposable items such as tubing, bottles, and vaccinators with their needles cut, and gloves.	Red-colored, non-chlorinated plastic bags or containers
White Container 	Waste sharps including metals: Needles, syringes with fixed needles, needles from needle tip cutter or burner, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts.	Puncture proof, leak-proof, tamperproof containers
Blue Container 	Glassware: Broken or discarded and contaminated glass including medicine vials and ampoules (except those contaminated with cytotoxic wastes) Metallic body implants	Cardboard boxes or bags with blue-coloured marking

Table I
Classification Of Waste In Coloured Bins

Improper disposal increases risk of infection; encourages recycling of prohibited disposables and disposed drugs; and develops resistant microorganisms.

The new bio-medical waste management rules have hence been notified to efficiently manage the generated bio waste in the country.

- The ambit of the rules has been expanded to include vaccination camps, blood donation camps, surgical camps or any other healthcare activity
- Provide training to all its health care workers and immunize them regularly
- Establish a Bar-Code System for bags or containers containing bio-medical waste for disposal
- Bio-medical waste has been classified in to 4 categories instead 10 to improve the segregation of waste at source
- Procedure to get authorization simplified. Automatic authorization for bedded hospitals. The validity of authorization synchronized with validity of consent orders for Bedded HCFs. One time Authorization for Non-bedded HCFs
- The new rules prescribe more stringent standards for incinerator to reduce the emission of pollutants in environment
- Inclusion of emissions limits Dioxin and furans
- No occupier shall establish on-site treatment and disposal facility, if a service of common bio-medical waste treatment facility is available at a distance of seventy-five kilometre

Operator of a common bio-medical waste treatment and disposal facility to ensure the timely collection of bio-medical waste from the HCFs and assist the HCFs in conduct of training.

VI. STORAGE AND TRANSPORT

A separate storage site should be designated for health-related waste inside the establishment or facility, which should be big enough to contain the waste generated by the hospital depending upon the frequency of collection. The waste should be stored in sealed bags or galvanized containers to prevent risk of infection spreading to the workers. A refrigerated storage room, if available can hold waste for much longer period of time, whereas standard storage time shouldn't exceed 72 hours in winter and 48 hours in summer. Cytotoxic waste (any material contaminated with residues that are toxic to cells) should be stored separately in a storage facility, away from other general waste. Radioactive waste should be stored in labelled containers with lead shielding that prevent dispersion. The containers must be durable and leak-proof; and should have labels as warnings to employees and the public about the type of waste in the container and the nature of the hazard. Labels like the medical waste symbol or the hazardous waste symbol are particularly used. This kind of labelling helps for tracking purpose and also in inventory management system.

Fig. 4 Labelling for external use

The bags in which the waste is filled could be labelled or the health care can use red colour bags as a sign for medical waste. Intermediate bulk containers that can hold up to 700 gallons of waste are approved by the Department of Transport for handling of hazardous and non-hazardous waste. The storage facility should have a good drainage access and disinfecting equipment. The containers in which the waste is held should be cleaned and disinfected with sodium hypochlorite frequently. The floor of the storage facility should be hard and impregnable. The storage space should be inaccessible to unauthorized persons, animals, insects and birds.

Fig. 5 Medical waste transportation truck

A transport company is hired by the hospitals which is only in the business of transporting medical waste to the treatment or disposal sites. Sometimes the waste bags are directly placed into the transport trucks but it's advisable to pack them in further containers made out of carboard, stainless steel or lidded plastic. The vehicle for transportation should be of adequate size to hold in the waste containers and should have a bulkhead between the driver's cabin and the vehicle body so as to retain the load of the vehicle if involved in a collision. The vehicle should be locked at all times except when loading and un-loading. It should be disinfected repeatedly to avoid risk of infection to workers; and should not be used for any other purposes. The international hazard sign must be displayed on the container or the vehicle as well as an emergency number. The workers transporting hazardous waste must be wearing PPE kits, masks, gloves and respirators if necessary. Waste tracking is done through documentation such as manifests or consignment notes which is a part of cradle-to-grave approach.

VII. METHODOLOGY OF DISPOSAL

The treatment and disposal of bio medical waste generated by health care establishments has become a growing concern in the recent times due to COVID-19. In the past, medical waste produced in the hospitals was treated on site through shredding but due to the increase in the dependency on medical care, the clinics and medical personnel are prompted to switch to treatment and disposal off-site. On-site treatment usually requires heavy and expensive equipment with extra labour and space whereas off-site treatment involves collection of waste in special containers, transportation to disposal sites and then the treatment through various methods. The process of managing medical waste includes segregation of waste depending on the quantity, composition and disposal; separation of waste into different containers; packaging in uniform colour codes; storage and transportation to final disposal site; and lastly the treatment of this waste. The biomedical waste treatment aims to eliminate hazards of waste and make it untraceable in the environment. There are several methods of treatment of bio waste such as mentioned below:

A. Incineration

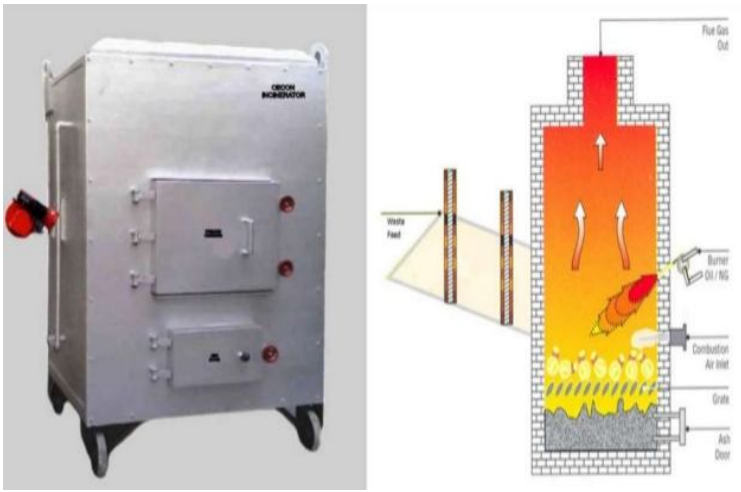


Fig. 6 Hospital Incinerators

Incineration is the high temperature dry oxidation process ranging from 982°C to 1093°C. It reduces organic and combustible waste into inorganic matter which results in significant reduction of waste volume and weight. This process is usually adopted to treat waste that cannot be recycled or disposed in a landsite. An incinerator is a furnace which operates at high temperatures to burn waste.

The basic process involves the waste to be fed into a primary chamber where it is heated to a high temperature to burn it down. The harmful gases released are sent to the secondary chamber and later passed on to various pollution control equipment to clean the flue gas before releasing into the environment.

The wastewater released is treated before discharged and leftover ashes are disposed or stabilized. This is by far the most effective method used for disposal of pathological waste such as body parts and recognizable tissues. The major advantages of Incineration are that it is quick, effective and simple. The various types of incinerators are burn barrel, rotary kiln, moving grate, fixed grate, fluidized bed, drum incinerator, specialized incinerator. Human anatomical waste, animal waste, microbiological waste, solid waste and discarded medicine can be disposed of through this method.

B. Autoclaving

The method of autoclaving uses closed chambers that apply heat, pressure and steam over some period of time to sterilize medical equipment. Autoclaves are of two types depending upon the method for removal of air packets; vacuum autoclave and gravity flow autoclave. It is an efficient process used majorly for sterilization of reusable medical equipment like gauges, bandages, plastic and metal waste contaminated with blood; and highly infectious waste such as microbial cultures; sharps such as surgical knives or clamps. Most autoclaves are cylindrical vessels which are better suited for high pressures. Vacuum autoclaves use a pump to evacuate air before heating after the chamber is sealed whereas gravity autoclaves work by injecting steam into the chamber and driving out the air that was present. This process is favourable since is less costly and doesn't present any major health risks. However, autoclaves are not suitable for pathological, cytotoxic and other harmful chemical waste.

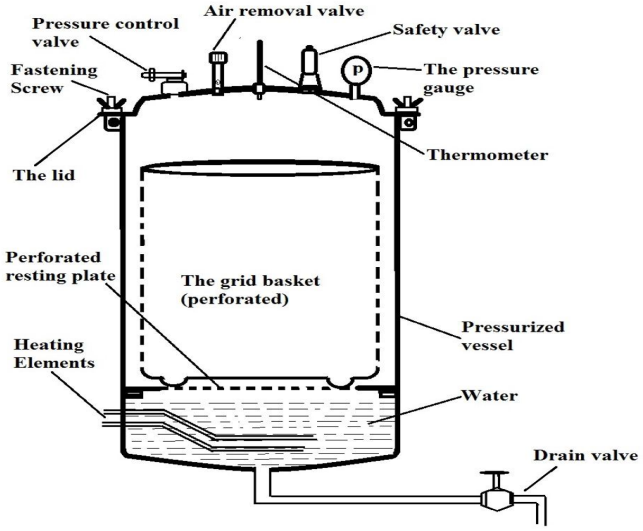


Fig. 7 Autoclave construction

C. Chemical Disinfection

Most liquid waste and some shredded solid waste can be disinfected by use of chemicals like sodium hypochlorite, dissolved chlorine dioxide, peracetic acid, hydrogen peroxide, and ozone. These chemicals are water-intensive and need neutralising agents as they kill micro-organisms in medical waste and can oxidise hazardous chemical constituents. This method is most suitable for liquid wastes like blood samples, urine, stool, sewage or some solid waste like microbial cultures and sharps but with some limitations. The important parameters considered for effective usage are type of disinfectant, concentration, quantity, contact time and mixing requirement. Chlorine disinfection through bleaching is the most common method of disinfection as it also reduces the risk of disease transmission.

D. Microwave Disinfection

Waste is shredded, mixed with water and then heated internally for treatment. By this method, most micro-organisms are destroyed when operated at 2450 MHz frequency and 12.2 cm of wavelength. Microwave units transmit this energy as micro-waves to heat the wet waste. The process time for each batch is about 20 minutes. The infectious components of the waste are destroyed by heat conduction while the water is heated rapidly by the microwave. Microbial waste, sharps, solid waste, plastic disposables are handled through microwave disinfection. This method is sometimes used as a pre-treatment for landfills or incineration.

E. Irradiation

Irradiation involves wastes being exposed to gamma rays of ultraviolet radiation in an enclosed chamber. This method uses a radioactive isotope of Cobalt that destroys all microbes and pathogens in the waste. For this method, the waste need not be removed from plastic garbage bags since the UV rays penetrate the plastic bags too, but is not recommended for pathological waste. Due to the high cost of Cobalt and the equipment used, this method is discouraged in commercial ventures. These systems require post-shredding to leave the waste unrecognizable.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VII July 2021- Available at www.ijraset.com

F. Landfills

A landfill is a facility designed to dispose solid waste into the ground. Landfills can be classified on the basis of their design as open dumps, basic landfills, sanitary landfills and bioreactor landfills. A landfill is sometimes referred to as a deep burial when the disposal is done in rural areas without engineered design. A 2m deep pit is dug out which is half filled with waste and covered up with lime and soil layer of 10 cm. Galvanized iron/wire meshes are used as covers. A volumetric ratio of waste to cover 4:1 is followed in all landfill sites. Mid-sized landfills can take up to 16-40 tons of waste whereas mechanized landfills can dispose around 40 tons of waste. Landfills can take in any kind of waste keeping in mind some measures for environment protection.

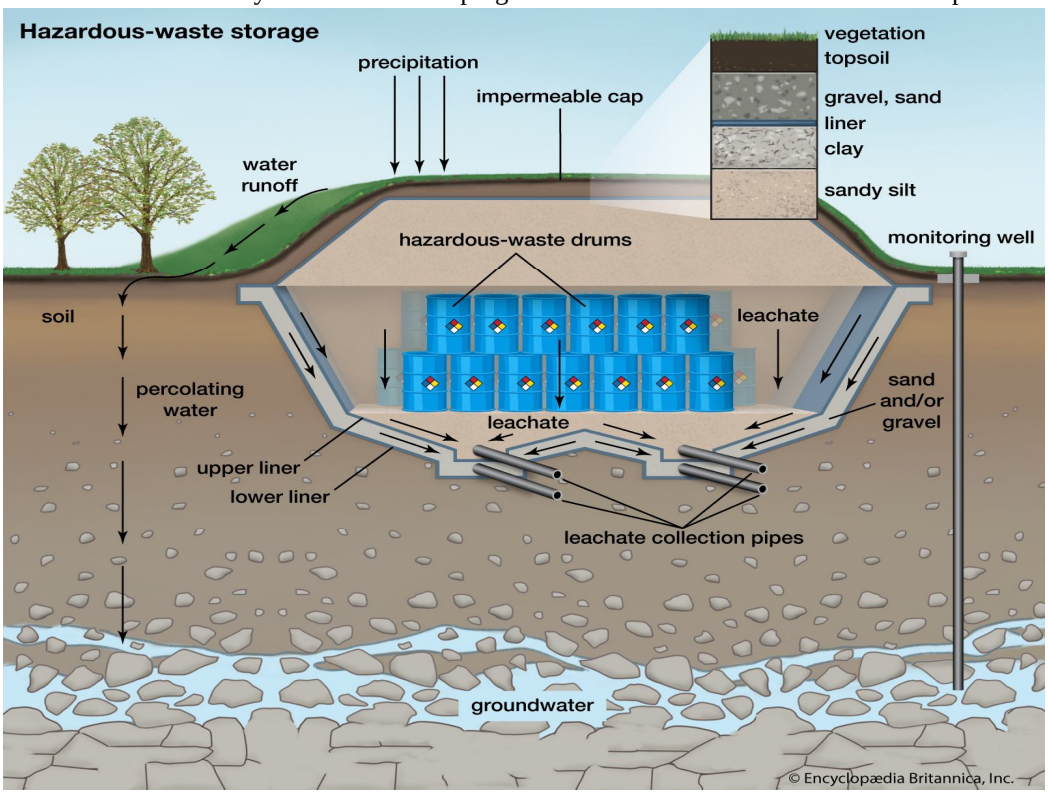


Fig. 8 Sanitary Landfill for biomedical waste

VIII. MEASURES OF WASTE MINIMSATION

Waste minimisation is the process of preventing or reducing the generation of waste through various techniques. It includes a set of practices intended to reduce the amount of waste produced. Waste minimisation involves redesigning products and processes; and changing patterns of civil consumption and manufacturing.

There are numerous benefits of Waste minimisation which help protect the environment and have positive economic values. It reduces the cost of waste disposal and hence the environmental impact of waste is reduced. It also makes it easier to fulfil the targets of environmental regulations, policies and standards. It enhances public and workers' health by reducing the hazards of waste disposal. More efficient use of products leads to reduced costs of buying new materials thus improving financial and economic performance of health care facilities. Significant reduction in waste generated by these health care facilities, research and pathology labs can be encouraged by implementation of certain practices that include 1. Source reduction, 2. Reuse and Recycle, 3. Green Purchasing

A. Source Reduction

Measures such as purchasing restrictions in health care organizations to ensure the selection of methods and supplies that are less wasteful; should be implemented. It includes procedures like maintaining inventory control in pharmacy and stockroom. This method also ensures unnecessary wastage of products in nursing and cleaning activities by using steam disinfection rather than chemical disinfection. The health care facilities can redistribute excess chemicals that are still in good condition for beneficial use. This technique minimizes waste generation and reduces cost of both buying and selling parties.

B. Reuse & Recycle

This operation conserves the most value, requires the least amount of energy and generates less secondary waste. Some equipment like tableware can be reused by washing and sterilizing, instead of disposable tableware. Other products that can be reused are washable gowns, sterilizable metal bed pans and reusable containers. A large number of materials and supplies used in health cares can be recycled and reused. Waste solvents from bio-medical labs like formaldehyde, formalin, ethanol, xylene, and toluene can be recovered by factional distillation units. The traditional X-ray films can be replaced with digital radiography wherever possible. Electrolytic recovery, ion exchange process or chemical precipitation units should be employed to recover silver from bio waste. Bio-digestion of health care waste such as kitchen leftovers, food waste, and leaves can be decomposed into methane in anaerobic conditions. This recovered methane can then be used for cooking and the sludge from the bio digester as rich organic manure. Sterilized waste like syringes, plastic tubs, containers, plastic parts of machine can be ground and remelted in an extruder to make new simple products.

C. Green Purchasing

Health care facilities should look at options for purchasing plastics that can be recycled or supplies with less packaging material. This outlook is also known as Environmentally Preferred Purchasing (EPP). EPP products are generally less toxic, minimal polluting, more energy efficient and easier to recycle.

Fig. 9 Green Purchasing/Recycling

Complex chemicals like Mercury that persist in the environment should be aimed to be eliminated and mercury-free devices should be purchased. Safer plastics such as Polyvinyl chloride should be targeted to phase out the “worst in class” plastics from health supply chains.

IX. CHALLENGES OF BIOMEDICAL WASTE MANAGEMENT

Amidst the growing Corona virus pandemic, bio medical waste management has raised serious concerns due to a number of factors. The absence of a solid strategy for disposing of COVID-19 related waste is still a huge threat. Major problems have escalated regarding economic and environmental effects of BMW in developing countries. About 10-20% of the health care facility’s budget is spent on waste disposal every year. While non-hazardous medical waste poses less problems, the challenges of hazardous waste must be considered carefully. Many cities are facing the issues of disposal of bulk waste like PPE kits, masks, gloves, shoe covers; generated due to COVID-19, in addition to the already existing medical waste. Despite restricting these safety kits to only medical professionals, these wastes are presenting an immense menace to the eco-system. Few of the challenges faced by the health care authorities in recent times are listed below.

Lack of segregation practices poses a significant harm to waste management system. If the infectious waste is mixed with the non-infectious waste, it makes the entire mass potentially infectious. Value of segregation isn’t understood among workers and hence is a major threat to them and the environment. Awareness about these practices and the adverse effects of not following them should be spread among all workers and hospital officials.

Many rules and regulations are formulated for the hospitals and clinics to follow but the inspection of these rules is a demanding task. Due to the lack of commitment and power of the agencies responsible for the enforcement of rules, the system isn’t fool proof. As a result, many hospitals and health care facilities don’t take these laws seriously and don’t comply with these rules even after amendment. The regulatory authorities are to be blamed for not taking enough measures for implementation of the rules. There is no coordination between authorities of pollution control and Department of health. Moreover, all the guidelines of waste collection and disposal have not been publicised enough, and hence smaller facilities would not be fully aware of the rules. With the powers like Central Pollution Control Board and State Pollution Control Board, inspection and strict uninformed checking of hospitals should be carried out occasionally.

Facilities and arrangements for storage, collection, treatment and disposal of bio-medical waste as well as appropriate technologies have been limited in India. On-site treatment of waste maybe feasible for large healthcare facilities but impractical or non-viable for smaller hospitals and clinics. Furthermore, current disposal techniques that are available, neither meet disposal requirements completely nor bring in new innovation in existing technology. In India, management of waste is carried out by ward attendees and other supporting staff whereas a separate committee consisting of head of the establishment, all departmental heads, superintendents, nurses along with a waste management officer should be formed and executed.

X. GOVERNMENT RULES AND POLICIES

A set of specific Guidelines for the proper management of waste generated during the treatment and diagnosis of COVID-19 suspects/confirmed patients are required to be followed by all isolation wards, laboratories, ULBs, other disposal centers following the existing practices of rules under BMW Management, 2016. ICMR, CDC, WHO, and other concerned agencies guidelines were regularly referred for understanding various aspects of COVID-19.

Handling, treatment, and proper disposal of COVID-19 waste Guidelines for isolation wards, laboratories, quarantine centers, quarantine homes, SPCBs/PCCs, CBWTFs are listed below.

A. From Isolation Wards for COVID-19 (Wards where positive patient is being kept for treatment)

Maintaining separate records of waste received from the wards.

The particular trolley should be dedicated in this ward with a label “COVID-19 WASTE” pasted on them and this trolley should be disinfected with sodium hypochlorite solution (1%) daily.

Updating the waste generation by registering in CPCB Mobile application “COVIDBWM”

Allot separate sanitation workers for these isolation wards to collect the biomedical waste and transfer it to the waste storage area.

Used tissue, PPE kit, mask, gloves should be segregated in yellow bags and toiletries of COVID patient shall be treated as biomedical waste

Segregation should be an on-point process inward. For occupational safety, segregation should not be practiced in temporary waste collection.

B. From Laboratories And Sample Collection Centers

Reporting of cases from the samples collected from COVID-19 centers and Labs to respective SPCB/PCC. For More Guidelines regarding the sanitation and disposal section (1) is applied suitably to all the Laboratories and test centers. Pipette Tips, Pre-Treat Viral transport media, Plastic Vials should be collected in red bags, as per the standard rules laid down by BMW Policies 2016.

C. Responsibility Associated With The Individuals Handling The Isolations Wards/Centers/Quarantine Homes

General solid waste such as household waste generated from isolation wards, quarantine centers, or camps should be collected in bags and should be handled with care and handed over to municipal solid waste collectors that are allotted by Urban Local Bodies.

The waste that is generated from waste food material, cleaning dust, household hazardous waste, kitchen, disposal utensils, water bottles are considered to be general solid waste, that is used by detected COVID-19 patient at home quarantine or center.

Mask, tissues, gloves that are found to be contaminated with body fluid or blood of patients affected by COVID-19, should be disposed of properly.

D. SPCBs/PCCs Duties

Maintaining records of COVID-19 Treatment centers and wards of quarantine.

To ensure the segregation, handling, and disposal of Waste generated according to the BMW rules 2016.

Allowing CBWTFs for operating for extra hours and to collect the biomedical waste as and when required.

Coordinating with ULBs and CBWTFs for the establishment of adequate facilities for the processing of COVID-19 waste.

Ensuring separate arrangements for handling and waste feeding in case volume of yellow color-coded (incinerable) has exceeded the limit of captive BMW incinerators.

Using the COVID19BWM portal by SPCBs/PCCs, must be compulsory to verify the biomedical waste of COVID-19 and to update data to CPCB through the same Portal.

E. Duties of Urban Local Bodies

ULB should ensure the safe and secure disposal of biomedical waste generated from various COVID isolation wards and Quarantine centers. Information on each of these centers and ward should be passed to SPCBs/PCCs.

Biomedical waste and general solid waste should not be mixed and should be collected separately, and handed over to authorized waste collector of ULBs.

Biomedical waste from quarantine centers is collected directly by CBWTFs identified by ULB. When the waste is collected at quarantine centers it is lifted by CBTWFs operator.

F. Wastewater Management from HCFs/Isolation Wards

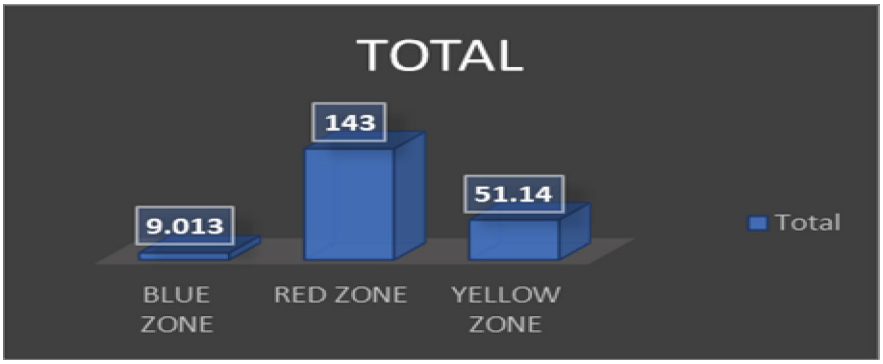
Transmission risk of virus causing COVID-19 through sewage system is found to be minimum as per the information by CDC. Although the risk of transmission to operators of sewage is possible none evident to date. Following guidelines was recommended for HCFs and operators of STPs. Agencies responsible are Isolation wards/sewage treatment plant operators (PHED, Jal board, etc.), they should ensure that the wastewater is disinfected properly using practices of making coronavirus inactive ETPs/STPs operator of discharge from healthcare facilities and Isolation centers must adopt hygiene precautions, operational practices, and wear PPE and if Prescribed for the particular operation of STPs, ETPs must include repellant, gloves, face mask, rubber boots.

Also, the reuse of treated wastewater during the COVID-19 pandemic must be avoided in HCFs.

XI. STATISTICS OF WASTE GENERATED DURING COVID-19

The below presented table and graphs show the collection of waste in a state wise manner. The table is verified from the data available from official site of State Pollution Control Board/Pollution control committees as well as daily data received from COVID19BWM tracking app, column of percentage BMW is further divided into the extent of Waste generated during treatment of COVID as ZONES:

1) Blue Zone (0%-1%)
2) Yellow Zone (1%-5%)
3) Red Zone (Greater than 5%)



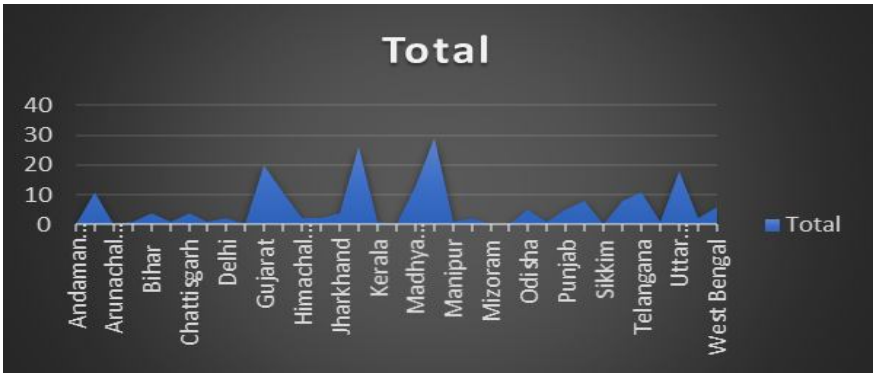


Fig. 10 Graph - Zone wise and State wise

Name Of States	COVID-19 BMW(Tons/day)	No of CBWTFs engaged	Percentage of BMW
Andaman And Nicobar	0.014	0	0.01%
Andhra Pradesh	9.99	11	4.92%
Arunachal Pradesh	0.112	0	0.06%
Assam	0.52	1	0.26%
Bihar	1.06	4	0.52%
Chandigarh	1.91	1	0.94%
Chhattisgarh	2.76	4	1.36%
DD and DNH	0.065	1	0.03%
Delhi	18.79	2	9.26%
Goa	0.45	0	0.22%
Gujarat	21.98	20	10.83%
Haryana	13.11	11	6.46%
Himachal Pradesh	2.27	2	1.12%
Jammu and Kashmir	2.49	2	1.23%
Jharkhand	0.56	4	0.28%
Karnataka	16.91	26	8.33%
Kerala	23.71	1	11.68%
Lakshadweep	0.01	0	0.00%
Madhya Pradesh	7.32	13	3.61%
Maharashtra	19.02	29	9.37%
Manipur	0.13	1	0.06%
Meghalaya	0.25	2	0.12%
Mizoram	0.033	0	0.02%
Nagaland	0.074	0	0.04%
Odisha	6.65	5	3.28%
Puducherry	1.81	1	0.89%
Punjab	4	5	1.97%
Rajasthan	4.98	8	2.45%
Sikkim	0.015	0	0.01%
Tamil Nadu	13.57	8	6.68%
Telangana	4.96	11	2.44%
Tripura	0.02	1	0.01%
Uttarakhand	1.98	2	0.98%
Uttar Pradesh	15.91	18	7.84%
West Bengal	5.72	6	2.82%

TABLE II
STATE WISE LIST OF WASTE GENERATED DURING COVID-19

- Most sensitive states were Delhi, Gujarat, Karnataka and Maharashtra with more than 9% of waste.
- Tripura, Mizoram, Sikkim, Manipur, Nagaland recorded very limited generation of waste.
- States with major COVID-19 cases witnessed a major generation of biomedical waste.
- A Major Hike was observed in the state Madhya Pradesh, Kerala, Uttar Pradesh, Maharashtra and Gujarat.
- Graph represents the waste in Tons/Day from different states of India.
- Highest waste generated was in Kerala that is 23.71 Tons/Day.
- Lowest waste generated was in Tripura that is 0.02 Tons/Day.
- It was observed that the waste collected together from the states considered under red zone produced more waste than States considered as Blue and Yellow Zone Collectively. From Blue Zone around 9 Ton/Day, Yellow Zone-51.14 Ton/Day and Red Zone-143 Ton/Day waste was produced from the states of India.

XII. RESULTS AND DISCUSSION

A recent generic survey conducted by us gave the following results. As per the survey findings, we can clearly say that the number of bio-medical waste has increased due to COVID-19 therefore it is necessary to inform the Pollution Control Board of India to take the necessary actions on those institutions and organizations who are not following the guidelines. The infectious waste generated should be sterilized by autoclaving before shredding and disposing them, as Autoclaving is the method which uses closed chamber that apply heat, pressure and steam over specified period of time to sterilize medical equipment. Also, each garbage container should be labelled properly so that it becomes easier for people to recognize it. The survey suggest that waste treatment and disposal is the main challenge faced during BMW management, followed by waste segregation and risk of waste collectors and workers. We also analyzed that the 3R method could be the most effective method to improve the BMW management system followed by better administration of the hospitals and Environmental Preferred Purchasing as mentioned before. 44.6% of the general public agreed to allow the reuse of hospital day-to-day consumables if sterilized accurately, though some were uncertain. Recyclable items were suggested instead of disposable items. Materials other than plastic was suggested to be used for waste disposal by 72.7% of the sample. It was also proposed that all health workers and waste workers should be vaccinated with both the doses at the earliest. Firm administration to reduce the spread of COVID19 through strict rules and guidelines is necessary at this stage.

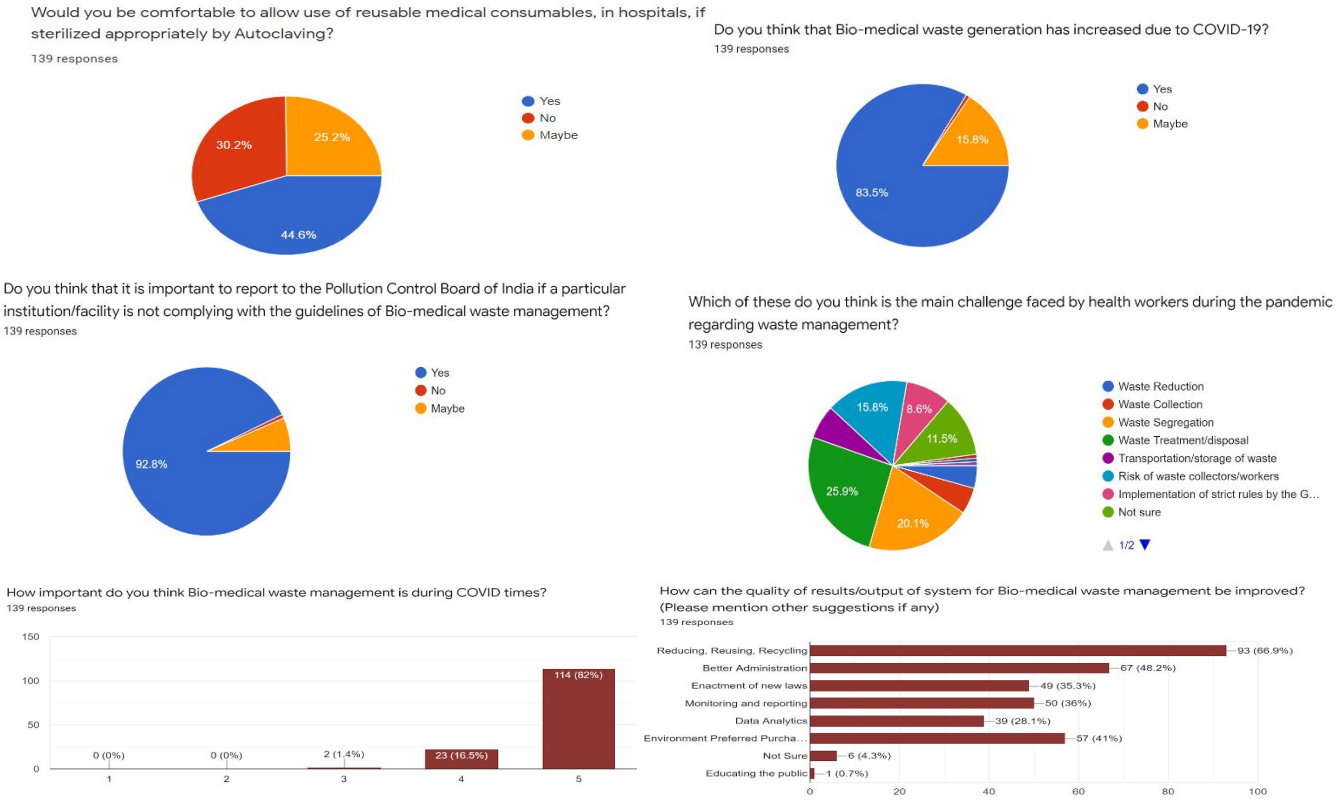


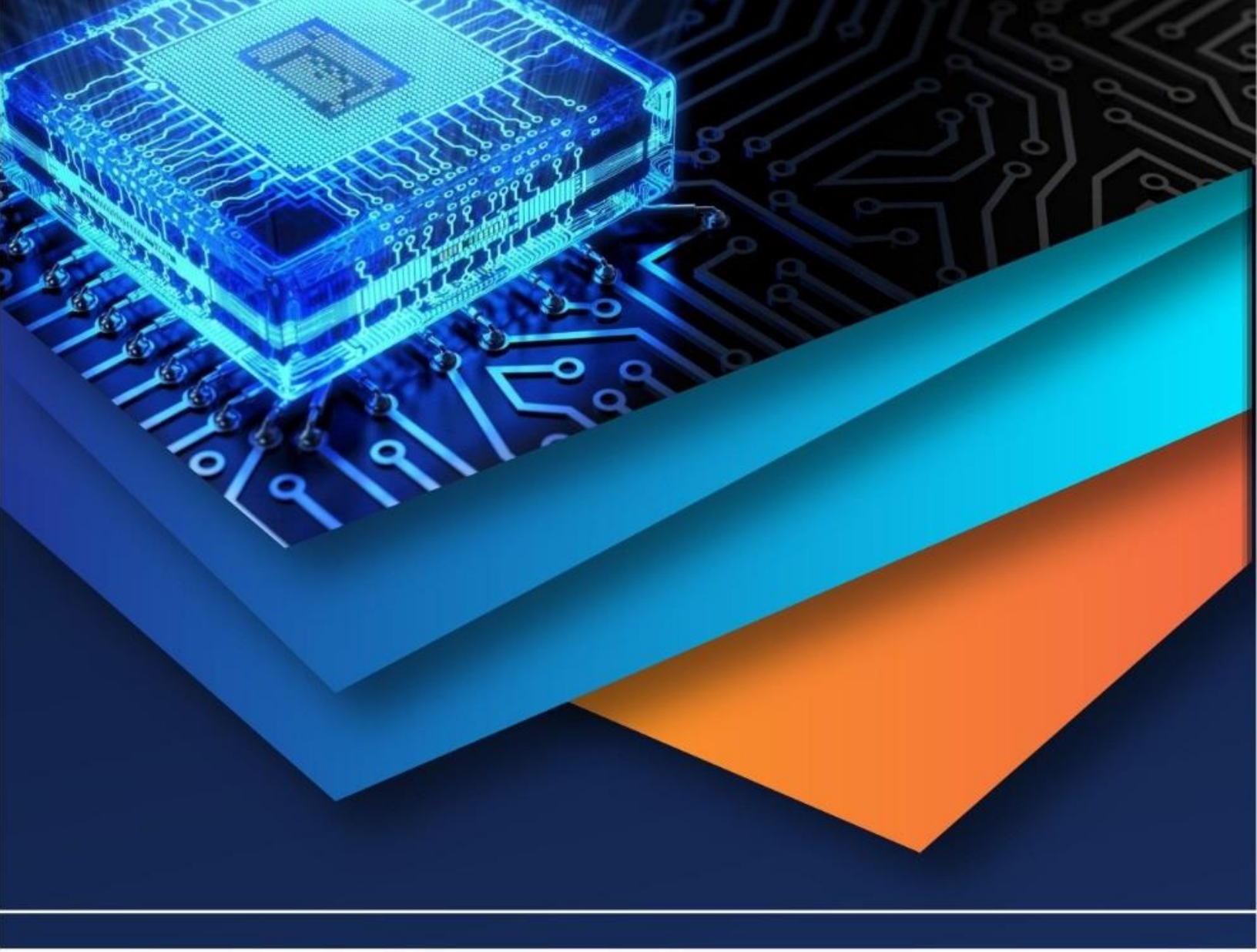
Fig. 11 Survey findings

XIII. CONCLUSION

Thus, it can be concluded that in the crisis of COVID-19, a large amount of waste will be generated but the waste can be minimized using various techniques such as green purchasing, proper segregation, and proper disposal. In the states with major number of cases, there is a high risk of transmission if the waste is not handled with proper care and precautions, operators involved in handling the waste should be trained well in order to ensure safety. Depending on different categories of authority, facilities should be provided with appropriate provisions and the existing BMW treating capacity should be increased for a safe and sound waste management system. This study can help various policymakers and regulatory bodies to design an efficient process for BMW waste management with a robust implementation strategy. Awareness about the dire need of mannerly control of biomedical waste should be spread among the health workers, waste workers and the general public too. Lastly, adequate funds should be provided to the health care facilities for on-site and off-site treatment of the large amount of waste generated in this pandemic.

REFERENCES

[1] Anupam Khajuria, "3R Approach towards bio-medical waste management", 7th Icon SWM Conference, Hyderabad, December 2017
[2] Dr. Navpreet, "Biomedical Waste Management", Chandigarh
[3] Surabhi Banerjee, Subhojoy Dasgupta, Subhadip Chowdhury, "Biomedical Waste Management: Issues and challenges in a new hospital", IOSR-JBM, India, pp 16-26, 2018
[4] Hemant Chhetri, "Biomedical waste management – Challenges in India", International conference, India, 2017
[5] Kamalakanta Muduli, Akhilesh Barve, "Challenges to waste management practices in Indian health care sector", IPCBEE, Singapore, vol. 32, 2012
[6] "Health Care waste", United Nations Environment Program, World Health Organization
[7] Edward H. Rau, Richard W. Gilpin, Larry E. Weaner, "Minimization and Management of Wastes from Biomedical research", Environment Health Perspectives, vol. 108, 2000
[8] Sutha Irin A, "An analytical study on medical waste management in selected hospitals located in Chennai city", Environ waste Management and Recycling, India, vol. 1 issue 1, 2018
[9] Pavithra Kumari, "Limitations of legal enforcement in bio-medical waste management in India", IJERME, India, vol. 2, issue 1, 2017
[10] Maryam Khadem Ghasemi, Rosnah Bt. Mohd. Yusuf, "Advantages and disadvantages of Healthcare waste treatment and disposal alternatives: Malaysian scenario", Pol. J. Environment Studies, Malaysia, vol. 25, 2016
[11] Preeti Gahlot, "Challenges of Biomedical waste management" Annals of Biology, India, vol. 35, 2019
[12] Central Pollution Control Board, "Guidelines for Handling, Treatment and Disposal Of Waste During Treatment/Diagnosis/Quarantine of COVID-19 patients", cpcb.nic.in, India, 2020
[13] Rahul Rajak, Ravi Kumar Mahto, Jitender Prasad, "Assessment of bio-medical waste before and during the emergency of novel coronavirus disease pandemic in India: A gap analysis", SAGE journal, India, 2021
[14] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7985622/
[15] https://www.iipsindia.ac.in/sites/default/files/Bio_waste_Paper_Published_rahul.pdf
[16] https://www.sciencedirect.com/science/article/pii/S2213398421000191
[17] https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0040-1716662
[18] https://www.researchgate.net/publication/336584260_Bio-medical_waste_disposal_in_India_From_paper_to_practice_what_has_been_effected
[19] https://www.academia.edu/Documents/in/Biomedical_Waste_Management
[20] https://www.jomfp.in/article.asp?issn=0973-029X;year=2007;volume=11;issue=1;spage=5;epage=9;aulast=Hegde



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