

An investigatory project on

ENVIRONMENTAL HAZARDS DUE TO UNPRECEDENTED INCREASE IN BIO-MEDICAL WASTE IN COVID-19 SCENARIO



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LIST OF ABBREVIATIONS

COVID	Corona Virus Disease 2019
BMW	Biomedical Waste
BMWM	Biomedical Waste Management
CPCB	Central Pollution Control Board
SPCB	State Pollution Control Board
CBWTF	Central Biomedical Waste Treatment Facility
WHO	World Health Organisation
HCF	Health Care Facilities
EMP	Environment Management Plan
PPE	Personal Protective Equipment
SARS-CoV-2	Severe Acute Respiratory Syndrome Corona Virus 2
MTP	Medical Termination of Pregnancy
MT	Metric Ton

1.0 INTRODUCTION

The Novel Corona virus outbreak which led to an horrifying pandemic, has completely exposed the fragile and poor infrastructure of the healthcare system, the lack of preparedness and strategy to battle an emergency and most importantly the loopholes and gaps in the biomedical waste management process world-wide. As per a report by the Central Pollution Control Board (CPCB), India generates 101Metric Tonnes of COVID 19 related biomedical waste per day. This is in addition to regular amount of waste that is produced per day, that is, 609 MT/day. Due to such large amount of waste which is almost surpassing the incineration capacity, unsafe incineration on roadside, dumping of waste in landfills, improper handling of infectious and hazardous wastes are taking place leading to more spread of infection and rise in COVID positive cases and also adversely impacting the environment.

WHO had set the principles for achieving safe and sustainable management of health-care wastes through correct investment of resources and full commitment. Along with the continuous surge of COVID-19 cases, there has been significant increase in generation of BMW. Due to lockdown, along with Health Care Facilities (HCF), Households are also generating high amount of BMW called domestic hazardous wastes. PPE kits, infected masks, microbiological cultures, body fluid, diagnostic kits, disposal bags etc. These wastes contain plastic products which are neither biodegradable nor fit for recycling. Unscientific disposal of BMW, along with the contagious nature of the corona virus, can result in biohazards with significantly detrimental impacts on health and environment. It is the social and legal duty for all people to ensure safe and sustainable management of BMW. There should be a collective teamwork with government support on finance and infrastructure development along with dedicated healthcare workers and facilities, continuous monitoring of BMW practises and strong legislature and regulatory board.



INFECTION AMONG HEALTH
CARE PROVIDERS



Infection of Patients



Poor aesthetics, stray dogs,
rodent menace



Infection and injuries to
waste handlers

**HAZARDS OF
HEALTH CARE
WASTE**



Air pollution



Water pollution



Infection to rag pickers
and injuries

(Source: <http://moef.gov.in>)

2.0 BIOMEDICAL WASTES

2.1 WHAT IS BIOMEDICAL WASTE?

Biomedical waste is the kind of waste containing infectious materials, which may also include wastes linked with medical or laboratory origin containing organisms or biomolecules that may be restricted from environmental releasing. Disposed sharp objects are also considered BMW due to their potential to cause injury. BMW may be solid or liquid. Examples of such *infectious biomedical waste* include:



2.2 CATEGORIES OF BIOMEDICAL WASTES

COVID 19 has caused a havoc as the amount of biomedical waste has surged in an unprecedented manner and we still donot have a solution to this problem. But there are several Biomedical waste management rules and regulations that has come up with time. One of the most important aspect of proper biomedical waste management is effective categorization followed by proper segregation of the waste to avoid mixing up of hazardous, infectious wastes with other wastes and creating a large volume of infectious waste. Hence it is important to understand the overall categorization of Biomedical waste.

The BMWs, generated from the health care facility is categorized by the Bio Medical Waste Management Rules, 2016 into four categories based on the segregation pathway and colour code. Several types of bio medical waste are categorised to each colour code category:

- Yellow Category
- Red Category
- White Category
- Blue Category

These categories are further divided as per the type of waste under each category as follows:

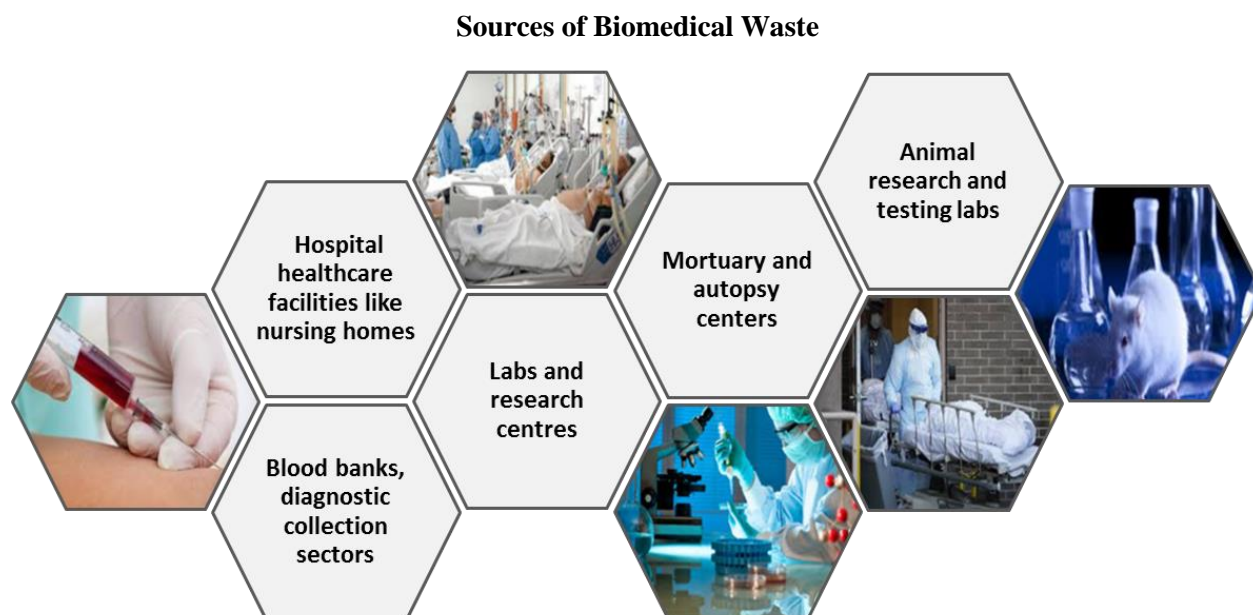
Table 1: Categories of Biomedical Waste

Category	Type of waste	
YELLOW	Human Anatomical Wastes	Human organ, tissue, body parts and foetus under viability period (as per the MTP Act, 1971)
	Animal Anatomical Waste	Experimented animals carcasses, organs, tissues, body parts, waste generated during experiment/ testing in veterinary hospital/college/animal house
	Soiled Waste	Things infected with, body fluids/blood dressings, cotton, plaster and bags having residual or discarded blood or components.
	Discarded or Expired Medicine	Wastes e.g. antibiotics, cytotoxic drugs including pharmaceutical items and items contaminated with such drugs with glass/plastic ampoules, vials etc
	Chemical Waste	Chemicals that are used in producing discarded biological disinfectants
	Chemical Liquid Waste	Generated liquid waste due to use of chemicals in producing biological disinfectants, discarded Formalin, silver X – ray film, aspirated body fluid, infected secretion, lab, house- keeping
	Discarded routine mask, beddings, linen, mattress contaminated with blood or body fluid and gown.	
	Microbiology, Biotechnology and other clinical laboratory waste (Pre-treated)	Live vaccines, Blood bags, Laboratory cultures, microorganisms, animal cell cultures used in research, industrial laboratories, production of biological, residual toxins, dishes and devices, used for cultures
RED	Disposable items such as intravenous tubes, bottles, catheters, urine bags, sets tubing, syringes without needles, gloves fixed needle syringes with their needles cut, vacutainers	
WHITE	Sharps Waste and metals like needles, syringes with fixed needles, cutter or burner, needles from needle tip, blades, or any other contaminated, scalpels, sharp object that may cause puncture and cuts both used, discarded and contaminated metal sharps	
BLUE	Broken or discarded and contaminated glass including medicine vials and ampoules, body implants except those contaminated with cytotoxic waste	

2.3 SOURCES OF BIOMEDICAL WASTES

Sources of biomedical wastes are of two types, primary and secondary. Primary sources include BMW from Hospitals, clinics, veterinary, nursing homes, dispensaries, blood banks etc and secondary sources include educational institutes, research centres, households and industries. It is generated in many locations. These include: Hospitals, Nursing homes, Doctor & dentist chambers, Emergency care facilities,

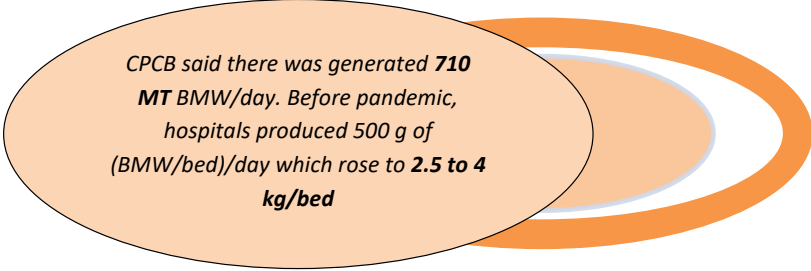
Research laboratories, transfusion centres, blood banks, dialysis centres, Clinical laboratories, Mortuaries, death care facilities and Veterinarians.



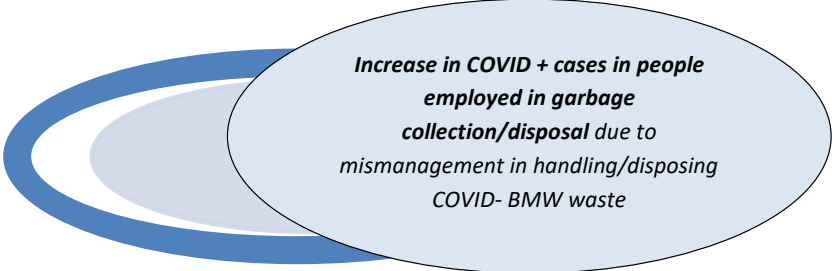
(Sources: <http://www.animalprotectionparty.ca>, <https://investindk.com>,
<https://abcnews.go.com>, <https://www.dreamstime.com>, <https://news.yahoo.com>)

3.0 CHALLENGES DURING COVID 19

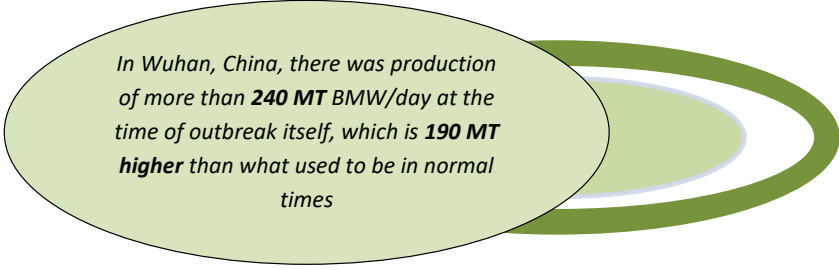
We never imagined even in our worst dreams that this pandemic could grow so worse and horrible. It seems like, mother earth will be drowning in biomedical wastes after few months due to this pandemic situation giving rise to thousands of tonnes of biomedical wastes every day and it seems that its repercussions will create a prolong impact on the environment, human, animal and plant health and sustainable biomedical waste management practices for years to come. The crucial need for proper management of biomedical waste is a global challenge now. During the COVID 19 pandemic scenario, it has become a huge challenge to effectively manage and dispose biomedical wastes including PPE kits worn by health workers and public, due to the huge unprecedented surge in the amount of BMW and high infectivity of this waste. The used PPE kits, masks, shields, goggles, shoe-cover, head cover from healthcare wards should be segregated and sent for disposal. But such wastes generated at the households or commercial centres or institutions, are required to be stored separately for 72 hours before disposal. Production of huge amount of such waste from sample collection of patient, diagnosis and treatment and disinfection purposes is taking place daily from every hospital and nursing homes and even from many domestic households. For example, in Ahmedabad of India the amount of biomedical waste that was getting generated increased from 550 to 1000kg/day in the first phase of lockdown itself. In Wuhan in China, there was a production of more than 240 metric tonnes of biomedical waste/day at the time of outbreak which is 190 metric tonnes higher than normal. About 206 metric tonnes of biomedical waste were generated /day in Dhaka, Bangladesh, related to COVID-19. Other places in the world like Bangkok, Kuala Lumpur, Manila etc also experienced around 150-300 metric tonnes more medical waste /day than normal. This huge surge in medical waste has caused significant pressure and challenge for the local biomedical waste management authorities.




CPCB said there was generated **710 MT** BMW/day. Before pandemic, hospitals produced 500 g of (BMW/bed)/day which rose to **2.5 to 4 kg/bed**



Increase in COVID + cases in people employed in garbage collection/disposal due to mismanagement in handling/disposing COVID- BMW waste



In Wuhan, China, there was production of more than **240 MT** BMW/day at the time of outbreak itself, which is **190 MT higher** than what used to be in normal times



206 MT COVID waste generated /day in Dhaka. Other places in the world like Bangkok, Kuala Lumpur, Manila experienced around **150-300 MT more** medical waste/day than normal.

4.0 ENVIRONMENTAL HAZARDS DUE TO BMW IN COVID 19

4.1 EFFECTS ON THE ENVIRONMENT:

The COVID 19 pandemic has caused a huge surge in BMW. Though this pandemic situation has highly improved air quality by reducing vehicular emissions, water pollution, noise pollution, reduced pressure in tourist spots which may assist significantly in ecological restoration process, but the negative impacts on the environment and health is even more significant and dangerous caused by unprecedented increase in biomedical wastes, improper management of such hazardous and infectious waste, haphazard usage and disposal of PPE kits, masks, disinfectants, gloves etc. This burden of untreated dangerously toxic waste is continuously endangering the environment. This sudden rise in the hazardous and infectious wastes and their effective management has become a significant challenge. It is also reported that SARS-CoV-2 virus can survive a day on cardboard and for up to 3 days on plastic and steel. So the wastes from the hospitals, like syringes, needles, mask, glove, PPE kit, bandage, tissue, medicines etc needs to be managed very carefully to reduce further infection and pollution. This BMW surge has highly impacted the environment. It is a huge matter of concern and needs care.

There is also lack of proper knowledge about infectious waste management among people and hence mostly these are dumped in open places and sometimes also with household wastes. Such haphazard disposal of these waste, clogs the water ways and **increases pollution**. The **PPE kits, masks etc, are source of micro-plastic fibres** in the environment. Polypropylene used to make N-95 masks, Tyvek for PPEs, remain for long time and **release dioxins and toxic elements**.



BMW dumped near roadside

(Source: <https://www.deccanchronicle.co>
[March 30, 2019])



Biomedical wastes handled unsafely

(Source: <https://zeenews.india.com>[Oct 14, 2020])

Mixing of household, municipal and BMWs result in increase in risk of disease transmission and exposure to virus. Many countries due to pandemic situations, postponed the waste recycling activities as well. Extensive use of **disinfectants is killing non-targeted beneficial species creating ecological imbalance**. Even municipal wastes are having viruses from the faeces of covid patients. The municipal wastes may be **disposed off into the water bodies without treatment causing water pollution** in many places especially in developing countries.

When **untreated BMW are dumped into landfills** that are poorly managed, can result in **contamination of surface, fresh, drinking and ground water**, due to improper construction. Along with this, **treatment of BMW with chemicals and disinfectants may lead to release of chemical substances into the environment if those wastes are improperly handled**, not segregated, improperly stored and disposed off in an environmentally unsound manner.



Poorly maintained biomedical waste landfill
(Source: <https://vishvatimes.com>
[October 21 2020])

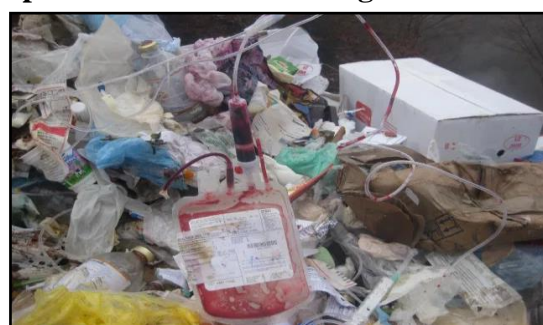


Excessive use of disinfectants and chemicals hampering air
(Source: <https://qz.com/india> [March 26, 2020])



BMW openly burned
(Source: <https://www.thehindu.com>
[SEPTEMBER 20, 2020])

Inadequate incineration and burning in open air or incineration of unsuitable wastes may lead to **release of toxic and harmful gases and pollutants into the atmosphere and may produce ash residues that may be highly toxic**. Incineration of heavy metals like **mercury and lead may cause spread of toxic metals in environment**. Wastes that are treated with chlorine, may give rise to **furans or dioxins which are human carcinogens** and can cause cancer. There is high level of **air pollution** caused by the incinerators which accelerates **ozone depletion and climate change**.



Hazardous BMW
(Source: <https://www.bioenergyconsult.com>
[October 24, 2020])

BMW includes PPE kits, masks, gloves, shields, medicines, drugs, oxygen cylinders, laboratory wastes, used testing kits, research laboratory wastes, materials used for patient care and all such things, and even more wastes are generated due to the high infectious rate and large number of people being affected in a short span of time due to this COVID 19 pandemic. The people carelessly handle these and infection rate increases and furthermore the careless dumping of these hazardous wastes badly affects the environment and human health.



PPE kits and other covid BMW disposed carelessly in a graveyard ground
(Source: <https://www.hindustantimes.com> [Jun 25, 2020])



Tonnes of used infectious masks and other BMW
(Source: <https://www.nationalheraldindia.com> [12 Oct 2020])



Cattle feeding on hazardous openly dumped BMW
(Source: <https://timesofindia.indiatimes.com> [Dec 27, 2017])

Dumping of BMW into land or waters can result in discharge of poisonous substances that could be consumed by the terrestrial or aquatic life and get injected into the food web reaching humans as well hence giving rise to several diseases and disorders. High volume of plastic substances in the BMW also poses serious threat to the environment especially due to macro and micro-plastics. This causes acid rain, damage to crops, water, soil and animals causing their extinction due to long periods of exposure to these toxins. These toxins are getting embedded into our food chain and impacting the ecosystem.

4.2 EFFECTS ON THE HUMAN HEALTH:

BMW contains potentially harmful microorganisms that have the capability to infect large number of people like the hospital patients, health-care workers or the general public. These organisms may also prove to be drug resistant and hence, may cause a havoc. Other effects may be sharps-inflicted injuries, exposure to toxic medicinal or pharmaceutical products like antibiotics and cytotoxic drugs which may get released into the environment.



Hazardous and infectious BMW that can pose serious threat to humans
(Source: <https://www.inciner8.com> [January 31, 2019])



COVID BMW being disposed by the health-care workers
(Source: <https://timesofindia.indiatimes.com> [May 19, 2020])

The pathogens that are present in the biomedical wastes may enter the human body through various ways like a cut or puncture or abrasion or mucous, respiration (inhaling) or ingestion. This may cause several gastric, respiratory, skin infections or bacteraemia, viral hepatitis, influenza, haemorrhagic fevers. The way hospitals, nursing homes and pathological labs are disposing of toxic waste; this has exposed many people to infection and water contamination. In many places, infectious waste is being packed in ordinary plastic bags, transported in open trucks and dumped in lands. This causes littering and also increases risk of spreading of infection. Heavy rains in few places of India has increased the fear of water contamination and leaching as well. Incinerators also pose serious threats to human health like exposure to incinerated ashes which may contain mercury or dioxins and the harmful gases released may cause lung cancer, bronchitis, asthma etc. Radiation or chemical burns may also take place while handling, disinfecting and sterilizing or treatment of wastes.

5.0 EXISTING SOLUTIONS

Solutions to this problem are addressed through –

- A. Technological Solutions**
- B. Administrative Solution**

A. Technological Solutions

Researchers are constantly working on numerous technological solutions to these problems. Some of the solutions initiated so far are –

i) **Microwave technology** uses heat technology to remove infection, germs and is of non-contact nature. It generates high frequency short waves which caused the waste to vibrate and generate heat up to 2000C and also reduces the volume of waste by up to 80%.



Sterilwave product using Microwave technology (this device is for small amount of waste)

(Source: <https://www.bertin-medical-waste.com>)



Sterilwave product using Microwave technology (this device is for huge amount of waste)

(Source: <https://www.bertin-medical-waste.com>)

ii) **Waste to Energy Technology** helps in complete removal of waste instead of reuse or processing. Usually they used incineration but turning towards more eco-friendly solutions they are using gasification, pyrolysis, thermal depolymerisation and plasma arc gasification to convert waste to minimal substance and resulting heat into energy.



Aries Clean Energy Lebanon Tennessee Gasification Plant

(Source: <https://www.globalsyngas.org>)



Bio Medical Waste Incinerator
(Source: <https://www.exportersindia.com>)

iii) **Anaerobic digestion** involves degradation of waste by microorganisms in the absence of oxygen and is an in-vessel treatment. It can treat organic solid and waste water of any kind and is best way for hospital wastes. It is quick and remainder can be used as fertilizers while biogas produced can be used as energy.

iv) **Autoclaving, electro-pyrolysis, chemical and mechanical grinding and shredding** systems ensure medical wastes are non-infectious so that they can be disposed off in landfills or incinerators.



Medical Waste Autoclaves
(Source: <https://www.mark-costello.com>)



Medical waste pyrolysis plant
(Source: <https://plasticpyrolysisplants.com>)

v) **Smart management methods** to handle these operations such as global positioning systems (**GPS**), radio frequency identification (**RFID**) help in enabling tracing, routing, pneumatic tubes, fuel switching etc. Mechanical and biological treatments along with new **advanced recovery and refuse-driven fuel production facilities**, are also gaining popularity. Also, **bioremediation** is a choice and is cost-effective as well.

B. Administrative Solution

Wide range of Administrative solutions is initiated by WHO, Governments, Pollution Control Boards, Local authorities, Municipal authorities etc. All the administrative/management solutions were trying address the following reasons for failure of Biomedical Waste Management -

- Lack of awareness about the health hazards linked to BMW.
- Inadequate training regarding efficient waste management.
- Lack of proper waste management and disposal systems.
- Insufficient finances
- Insufficient human resources
- Low priority given to this topic
- Many countries do not proper regulations and legislature or they are unable to enforce those.

Key steps towards improved Biomedical Waste Management:

- BMW Management should be given increased attention and diligence which will help avoid adverse health outcomes related to improper practise and exposure to infectious organisms and toxic items.
- Developing strategies and systems and regulations to dynamically improve waste segregation, destruction, treatment and disposal practices with the common motive to meet the national and international set standards.
- Promoting the methods and practises that reduce significantly the volume of waste generated at source to ensure proper waste segregation
- Raising awareness about the risks associated to BMW and safe practices to avoid these risks
- Always promoting safe and environmentally sound treatment of hazardous BMW; for example steam treatment with internal mixing, chemical treatment, autoclaving, microwaving etc; can be preferred over incineration.
- Preparing safe and eco-friendly management system to protect people and environment from the hazards while collecting, handling, segregating, storing, transporting, treating or disposing.
- Government should be committed and supportive for overall long-term development. Immediate actions can be taken at the local level.
- To build a comprehensive system while addressing responsibility and resource allocation, handling and disposal of BMW. This will result in gradual improvement.

Mitigations suggested by WHO:

WHO developed the first global and comprehensive guidance document for safe management of wastes from health-care activities. The guide by WHO addresses:

Aspects:

- Regulatory framework
- Planning issues
- Waste minimization and recycling handling, storage and transportation, treatment and disposal
- Training

Aimed at:

- Managers of hospitals
- Policy makers
- Public health professionals
- Managers involved in waste management

Tools:

- A monitoring tool
- A cost assessment tool
- A rapid assessment tool
- A policy paper
- Guidance to develop national plans
- Management of waste from injection activities
- Management of waste at primary health care centres
- Management of waste from mass immunization activities
- Management of waste in emergencies

Mitigations initiated By Central Pollution Control Board

Guidelines issued by CPCB of India during COVID-19 to ensure safe biomedical waste management and disposal during isolation, treatment, diagnosis and quarantine of patients, generated in isolation wards, sample collection centres and laboratories for suspected patients, quarantine camps and homecare facilities as well as outlining the duties of Common Biomedical Waste Treatment Facilities and State Pollution Control Boards and Urban Local Bodies.

The key points in the CPCB guidelines are:

COVID-19 Isolation Wards:

- Proper Segregation of waste- Separate colour coded bins/bags/containers, as per BMWM Rules 2016.
- No Leaks- Double layered bags for adequate safety/no leaks
- Dedicated/marked as 'COVID-19' collection bin and temporary storage area of biomedical waste prior to handing over the same to authorized staff at Common Bio-medical Waste Treatment Facility (CBWTF) for priority treatment and immediate disposal.
- Identify COVID-19 wastes- Proper labelling of bags with COVID-19 wastes
- General waste that is not contaminated can be disposed as solid waste as per SWM rules, 2016
- Record maintain- Maintaining separate records of COVID19 waste generated from isolation wards
- Use of dedicated trolleys and collection bins labelled a sCOVID-19
- Disinfection- Daily disinfection of inner and outer surface of containers/bins/trolleys used for storage of COVID-19 waste with 1 per cent sodium hypochlorite solution
- Reporting opening and operation of COVID wards to State Pollution Control Boards
- Dedicated sanitation workers for biomedical waste so that COVID-19 waste can be collected and transferred timely to temporary waste storage area

Sample Collection centres and laboratories for COVID -19 suspected patients:

- Reporting opening and operation of COVID-19 test centres and laboratories to State Pollution Control Boards. All guidelines in part (a) are applicable here as well.

Quarantine camps/Homecare facilities for COVID-19 suspected patients:

- Routine wastes generated from these places can be treated as solid waste as per SWM Rules, 2016. If any biomedical waste generated then that can be collected separately in yellow coloured bins/bags.
- Inform CBWTF in case of such waste collected for proper disposal and treatment.
- In case of such waste from home-care facilities, they should be collected in yellow bags and handed over to local collection bodies which can be further handed over to CBWTFs

Duties of SPCBs/PCCs:

- Shall maintain records of all above mentioned sources of COVID biomedical wastes
- Ensure proper disposal and treatment of biomedical wastes as per BMWM Rules, 2016
- Allow CBWTFs to operate for extra-hours when required

6.0 EFFECTIVE SOLUTIONS FOR THIS ISSUE

–My Proposal

In my point of view the identification of the problem is the biggest issue and is extremely difficult but if identified correctly, can redefine the biomedical waste management system and improve the condition to a large extent

1. **Solution for Municipal waste getting contaminated with Covid infected biomedical waste:**

As majority of the people affected by the corona virus are asymptomatic and amount of testing done is very less, in a country like India, with huge population of 1.38 billion, the biomedical wastes (e.g., masks, gloves, tissues, clothes etc used by infected individuals) that are produced from the households, are being disposed off with the municipal waste due to **lack of awareness** and **unavailability of a segregated collection system**. When these infected hazardous biomedical wastes are mixed with the non-hazardous municipal waste, the whole volume of waste becomes hazardous and infected. From several research, it has been observed that the corona virus can remain alive for more than three days on plastic or cardboard surfaces. Hence when these are also disposed off with other wastes, it contaminates the whole volume of waste producing huge amount of hazardous infectious waste.

SOLUTIONS:

- i) **Awareness campaign** through Social Media platforms, Youtube, TV, Radio, Educational Institution etc.
- ii) **Segregation of waste and segregated collection system** should be arranged by all the municipal corporations. Special arrangements to be made for safe collection, handling and treatment.
- iii) **Policy Making** should be a priority for the government for appropriate segregation of biomedical waste from municipal waste.
- iv) **Monitoring system** to be established by Municipal Corporations, Pollution Control Boards, Police and local authorities to ensure proper segregation and disposal of biomedical wastes at household level. Irresponsible behaviour should be penalized.
- v) **Training of workmen** involved in of collection, treatment and disposal of municipal waste, to ensure safe handling of potentially covid-19 contaminated waste.
- vi) **Infrastructure** necessary for handling covid-19 related wastes need to be developed by all municipalities.
- vii) **PPEs** required for handling of Covid-19 waste must be provided to all relevant municipal workmen.

viii) **Collection Vans or hand carts** used by most of the municipalities are open type of collection vans. These need to be designed as a closed van/ hand cart in which for inserting waste, even the lid/ door need not to be opened. A separate compartment to be designed for Biomedical Waste.



Existing collection vans



Suggested type of collection vans

(Source: <https://timesofindia.indiatimes.com> (Aug 4, 2017),
<https://www.open.edu>, <https://dailyasianage.com>)

2. Solution for Waste coming out from small hospitals, nursing homes small clinics etc.

PROBLEMS:

- i) **Lack of proper imposing of guidelines and rules laid down by the CPCB, by the authorities-** In spite of opportunity for segregation of waste, the hospitals *do not segregate the waste at source*. This is mainly due to *callous attitude of the workers and lack of adequate knowledge and awareness* about the issues related to COVID-19 wastes and rules laid down by the government. All workers handling these wastes are *not given proper PPE*.
- ii) **Labour shortage-** Many corporations hire temporary workers for the waste handling job. But during COVID-19, almost all temporary workers have left job. Hence existing members are under pressure and corporations are stretched.
- iii) **Non-clearance of COVID waste on time leading to dumping-** It has also been observed that in few hospitals, the government notified medical waste lifting agency was at fault as it did not clear the COVID waste within stipulated time and which led to dumping.

SOLUTIONS:

- i) **Medical waste capacity assessment:** This will help hospitals, nursing homes and other clinics in assessing the quantity of infected waste that is potentially produced, and the available technologies that they could use to treat the waste manner to avoid mismanagement and haphazardness.
- ii) **Sustainability Assessment of Technologies:** Along with the above, adoption of Sustainability Assessment of these Technologies will help in choosing the most eco-friendly solution.
- iii) **Knowledge of Guidelines and policies:** Proper awareness to be created among the workers about the various guidelines and policies of the government regarding COVID waste.
- iv) **Monitoring system:** monitoring agency should be appointed for strict monitoring to ensure that the hospitals and other clinics are following the rules laid by government. These agency should also monitor an ensure collection of COVID waste in the stipulated time and hence avoid dumping.
- v) **Labours should be incentivised and appointed as permanent workers:** Corporations should *incentivise* the labours *to encourage* them, *train* them to make them *aware* of the issue, *appoint them as permanent* workers to *secure employment* and ensure their *safety* by providing *PPEs*.

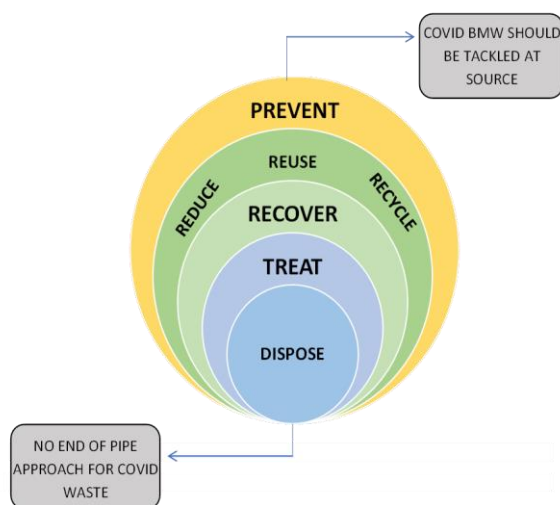
3. Solution for waste handling and storage facilities:

The major problem around handling of COVID waste is human contact and spread of infection. In storage, the covid waste are seen to be littered here and there on the road. Animals feeding on these hazardous waste. With time, small light particles (which may have living corona virus on its surface) may get blown by air and contaminate the air as well with the virus.

SOLUTIONS:

- i) **Robotics Technology:** Robotic technology can be employed in handling the wastes to almost eliminate human contact. Robots can be employed to collect the waste from the individual sources (like from individual beds in the hospital) and store it in the storage facility. Artificial intelligence and machine learning can be used in Robots so they can also be used for inspection, monitoring and sensing covid waste to isolate them. Robots can also keep records of amount of waste from each source (like from each bed in a hospital).
- ii) **Closed storage area:** The storage area should be isolated and closed to minimise contact with the surrounding environment. Continuous disinfection should be done in that area to maintain safety.

iii) COVID waste should be tackled at source itself. This principle should be followed:



4. Solution for Ineffective awareness campaign

In spite of some awareness campaigns being conducted regarding COVID-19 waste management, the required impact is not being created among the masses. Major reasons for this are -

- Inappropriate audience
- Inappropriate medium
- Inappropriate content
- Contents are not attractive enough to catch audience
- Complicated content, difficult to remember etc.

SOLUTIONS:

- i) **Organise various Competitions** encouraging youth to come up with innovative ideas.
- ii) **Increase in technical training sessions** focused towards waste collectors and municipal staffs, health workers, etc.
- iii) **Social Media** remains a very effective medium for public awareness. Effective use of social media, youtube channel etc will definitely help to enhance the effectiveness of the awareness programmes.

7.0 CONCLUSION

I personally feel that there needs to be a behavioural change among the workers and common people. The sense of safety has to come from within. Mere imposing of rules on people will not create the impact that needs to be created in this crisis scenario. People have to realise from within the destructive effects of improper biomedical waste management. Adequate Knowledge, Attitudes and Practices (KAP) with respect to biomedical waste management and proper awareness among all health professionals and workers as well as the common people is essential. The youth need to come up with innovative ideas to redefine the biomedical waste disposal and management system to protect the environment.

Mr. Basak, who works in the Disaster Management Department Dhubri, Assam, often used to visit the medicine store as a part of his daily duty during COVID-19. He observed that there were stacks of unused wasted medicines and syringes that were improperly disposed. That was when his creative mind decided to utilise these wastes to create something that gives hope- Idol of Goddess Durga. He invested months to make the idol which was the centre of attraction during the festival and a like a ray of hope during the pandemic.



***Goddess Durga Idol created by Mr. Basak
with expired capsules, medicines and syringes
(Source: <https://indianexpress.com> [October 22, 2020])***

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