

Technical review paper: Biomedical Waste Management during COVID-19

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Abstract

COVID-19, the disease caused by SARS-CoV-2, is a pandemic that has disrupted many facets of life. With number of cases of affected people increasing globally and in India, health and safety of mankind is in jeopardy. Whilst there is research being conducted across health care institutions and academia, the immediate solution to prevent the spread is to utilize proper PPE's like masks, gloves etc., as well as adopt practices like maintaining social distance, disinfection and sanitization more rigorously. Self-isolation and quarantining have quickly become the accepted norm to COVID prevent the spread. Number of people being tested for COVID-19 is also increasing on a daily basis. Due to enhanced healthcare needs, such as using PPE's to conducting numerous tests everyday as well as hospitals running at full capacity, the amount of biomedical waste generated has also increased manifold across the globe. Efficient biomedical waste management is an essential aspect to prevent the spread of COVID-19. This technical paper aims to analyse the biomedical waste scenario due to the onset of COVID-19, piece together guidelines and best practices given by national and international bodies as well as to give an insight into technological developments that have surfaced to manage biomedical waste more effectively.

Keywords: *Biomedical waste, waste management, COVID-19, Coronavirus, guidelines, technologies*

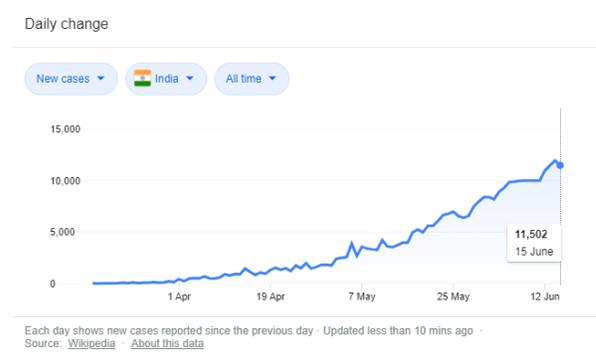
1 Overview of the impact of COVID-19 on biomedical waste

With the onset of the COVID-19 pandemic, the amount of biomedical waste generated has also been increasing with the increase in number of people tested and affected all over the world. Whilst there is research being done to develop a vaccine for the virus, as of now, the accepted means to prevent the spread is by using PPE such as respiratory masks, gloves, etc. and be practicing social distancing, self-isolation as well as quarantining. Due to the increase in number of people being tested, number of patients being treated in hospitals, as well as increase in usage of masks and other PPEs, the amount of biomedical waste generated is also increasing at a very rapid rate.

Wuhan, China one of the first places to get affected by the SARS-CoV-2 virus saw a peak of 240 tons of medical waste generated per day¹. In United States, around 2.5 million

tons of biomedical waste was generated per month during the peak outbreak.²

In India, from April till Mid-June 2020 the number of new corona virus affected cases added everyday is rapidly increasing.



Daily change in new cases added in India

Source: Graph using data from MoHFW

There are around 200 Common Biomedical Waste Treatment Facilities (CBMWTF) spread across the country. However, due to the corona virus pandemic, these CBMWTF are inadequate even while running at full a capacity³. For example, in the state of Tamil Nadu in India, around 47 tons of medical waste is being produced daily, while there are only 11 CBMWTF in the state with a capacity of 34 tons.⁴ Karnataka state has produced

¹Pandemic COVID-19 and Biomedical Waste Handling: A Review Study, Dr Irin Hossain et al JMSCR Volume 08 Issue 05 May 2020

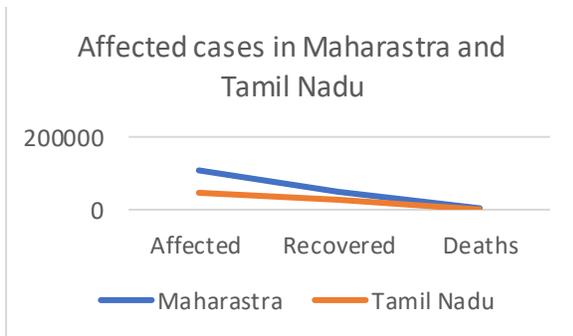
² <https://ww2.frost.com/frost-perspectives/managing-the-growing-threat-of-COVID-19-generated-medical-waste/>

³ The Hindu Business Line, April 28th 2020 – COVID 19 medical waste

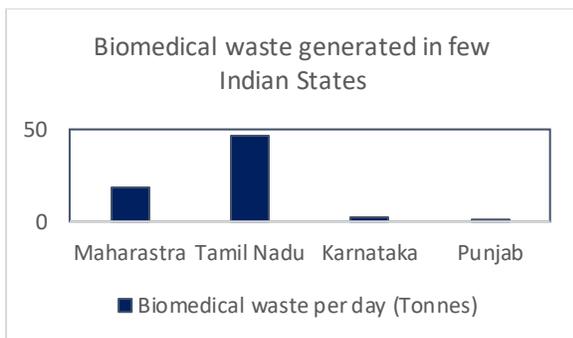
⁴ The Hindu, Chennai based environmental group seeks more norms for disposal of -19 medical waste

around 135 tons of medical waste during COVID-19 from March to mid-June 2020⁵. The State of Maharashtra has recorded around 19 tons of biomedical waste per day in the month of May 2020⁶.

Maharashtra and Tamil Nadu are the two most affected states in India with respect to COVID-19. While Tamil Nadu is recording higher levels of biomedical waste generation per day, the number of affected cases in Maharashtra is higher than the number of affected people in Tamil Nadu.



Source: MOHFW data as on 15.06.2020



⁵ Times of India, Bangalore Urban produces 15% of Karnataka's COVID-19 biomedical waste

This could indicate that in some states, the biomedical waste is not being properly and efficiently segregated at source and a fraction of biomedical waste could be disposed of with general solid wastes and not as biomedical waste.

2 Types of Biomedical Waste generated during COVID-19

Several types of biomedical wastes that are being generated due to this pandemic. Personal protective equipment including face mask, caps, gloves, protective overalls etc., items contaminated with blood, cotton swabs, lab chemicals, discarded disinfectants, floor washings, articles used for housekeeping & disinfection in health care facilities and hospitals, metallic sharps etc.

3 Types of Biomedical Waste generators during COVID-19

Biomedical waste is being generated in massive quantities in isolation wards, COVID-19 test centers, hospitals, common centers that have been converted to serve as make-shift hospitals, community and household level, travel industry, as well as other manufacturing industries. As per the report put out by Stericycle, most hospitals,

⁶ Times of India, Mumbai: Daily biomedical waste rises 68% to over 19,000 kg since outbreak

health care facilities, quarantining zones, as well as travel industry are over classifying all types of solid wastes as biomedical wastes⁷.

The Central Pollution Control Board (CPCB), India has classified COVID-19 biomedical waste generators into the following categories⁸ –

- a) COVID-19 isolation wards which comprise of health care facilities that have a provision for isolating and treating COVID-19 affected patients.
- b) Sample collection centers and laboratories for COVID-19 suspected patients.
- c) Quarantining camps/ home quarantine/ home-care facilities
- d) Urban bodies and communities

4 Rules for Biomedical Waste Management in India

The ministry of Environment and Forest (MoEF) has notified the Biomedical Waste Management Rules, 2016 and its amendments in 2018 under the

Environmental (Protection) Act, 1986 to replace earlier rules and its amendments.

Bio-medical waste means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or research activities pertaining thereto or in the production or testing of biological samples or in health camps, including the categories mentioned in Schedule I appended to these rules.

4.1 Salient features of rules for occupiers

4.1.1 Segregation

Occupiers including healthcare facilities that generate waste shall make a provision within the premises for a safe, ventilated and secured location for storage of segregated biomedical waste in colored bags or containers in the manner as specified in Schedule I. No untreated bio-medical waste shall be mixed with other wastes.

Yellow bags/bins: Human & animal anatomical waste, soiled waste, expired or discarded medicines, chemical wastes and laboratory wastes.

⁷ Novel coronavirus – COVID 19 waste , a report by Stericycle

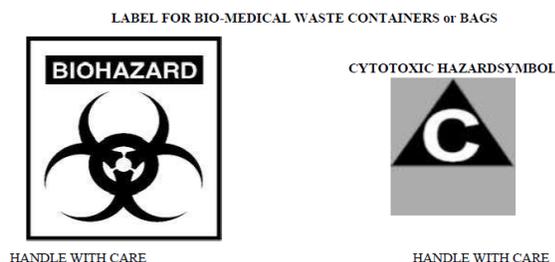
⁸ Guidelines for Handling, Treatment and Disposal of Waste Generated during Treatment/Diagnosis/Quarantine of COVID-19 Patients, March 2020

Red bags/bins: Contaminated recyclable wastes

White bins/bags: Waste sharps and metals

Blue bins/bags: glassware and metallic body implants.

Occupiers shall establish a Bar- Code System for bags or containers containing bio-medical waste to be sent out of the premises or place for any purpose. Waste Bins and bags are to be labeled as per these rules.



4.1.2 Pre-treatment

Laboratory waste, microbiological waste, blood samples and blood bags shall be pre-treated through disinfection or sterilization on-site in the manner as prescribed by the World Health Organization (WHO) or National AIDS Control Organization (NACO) guidelines and then sent to the common bio-medical waste treatment facility for final disposal.

4.2 Salient features for rules for common biomedical waste treatment facilities

CBMWTF shall establish bar coding and global positioning system for handling of bio- medical waste. Untreated human anatomical waste, animal anatomical waste, soiled waste and, biotechnology waste shall not be stored beyond a period of forty –eight hours.

After ensuring treatment by autoclaving or microwaving followed by mutilation or shredding, whichever is applicable, the recyclables from the treated bio-medical wastes such as plastics and glass, shall be given to recyclers having valid consent or authorization or registration from the respective State Pollution Control Board or Pollution Control Committee.

5 Guidelines for management of COVID-19 biomedical wastes by Indian Regulatory Authorities

5.1 Guidelines given by Central Pollution Control Board (CPCB)

The CPCB has published a set of specific guidelines⁹ for the management of wastes

⁹ https://tnpcb.gov.in/pdf_2020/BMW-GUIDELINES-COVID_Revised_April2020.pdf

generated from treatment of COVID-19 suspected/confirmed patients in the categories as mentioned above.

COVID-19 Isolation wards: The biomedical wastes shall be collected in separate color-coded bins (with double layered bags) as per the BMWM Rules, 2016 and label it as 'COVID-19 waste'. The inner and outer surface of containers/bins and trolleys used for storage should be disinfected with 1% sodium hypochlorite solution daily. The wastes shall be stored separately before transporting to CBMWTF through collection van. General wastes shall be disposed as per Solid waste management rules, 2016. Dedicated sanitary workers shall be provided with PPE to separately handle biomedical waste and solid waste. Used PPEs should be disposed in red bags and gloves, masks, head covers in yellow bags. The faeces collected in diapers should be disposed as biomedical wastes and the feces from bedpans should be disposed in toilets after which it should be disinfected with 0.5% chlorine solution and rinsed with clean water.

Sample collection Centers and Laboratories: The opening or operating of isolation wards/laboratories/sample collection centers should be intimated to

SPCB. The wastes such as pre-treatment viral transport media, plastic vials, pipette tips etc. shall be collected in red bins as per BMWM Rules, 2016.

Quarantine Camps/ Homes: General Solid waste should be disposed to Municipal Corporation as per SWM Rules, 2016. The biomedical wastes should be collected in yellow bags in separate bins. Authorities at quarantine camps should dispose the biomedical wastes as and when it gets generated to the CBMWTF and should contact ULBs in case of any difficulty in disposing the wastes.

Common Biomedical Waste Treatment Facility (CBMWTF): Regular sanitization and use of adequate PPEs by all the workers should be ensured by the operator of CBMWTF who should also inform about receiving of wastes from various facilities to SPCB/PCC. Dedicated vehicles sanitized with sodium hypochlorite for every trip should be deployed for collecting wastes. COVID-19 waste should be discarded immediately upon arrival and separate record to be maintained for collection, treatment and disposal of COVID-19 wastes.

SPCB/PCC: The records of COVID-19 treatment facilities and quarantine homes in respective states should be maintained. The

biomedical wastes shall be collected and disposed as per BMWM Rules, 2016. The CBMWTF should be allowed to operate extra hours and in the absence of CBMWTF, deep burial pits shall be used for disposal of yellow category wastes as per BMWM Rules, 2016. Existing HW incinerators at TSDF shall be used for incinerating large quantities of yellow color coded (incinerable) wastes. Adequate treatment facilities for COVID-19 wastes should be established in coordination with CBMWTF and ULB.

Urban Local Bodies (ULB): ULB should update the SPCB on the information of quarantine camps/homes/homecare. Biomedical wastes from quarantine camps should be disposed to CBMWTF. Necessary support should be provided to all quarantine camps/homes by providing yellow color bags for safe collection and disposal of biomedical wastes including authorization of staff at CBMWTF. The biomedical wastes should be collected only by designated authorized trained team of workers of CBMWTF who should be donned with PPE throughout the process of collection of waste and disposal. Adequate availability of SWM and BMWM facilities should be ensured by ULBs.

Management of Wastewater: Though the transmission of COVID-19 risk through

sewerage systems is low, the guidance for the HCFs and the operators of STPs are provided. The existing practices should be followed to disinfect the treated wastewater which would inactivate coronavirus. PPE should be worn by all the workers involved in the process of STP and basic hygiene precautions be followed. The utilization of wastewater within the HCF during COVID-19 pandemic is to be avoided.

5.2 Guidelines given by Ministry of Health and Family Welfare (MoHFW)

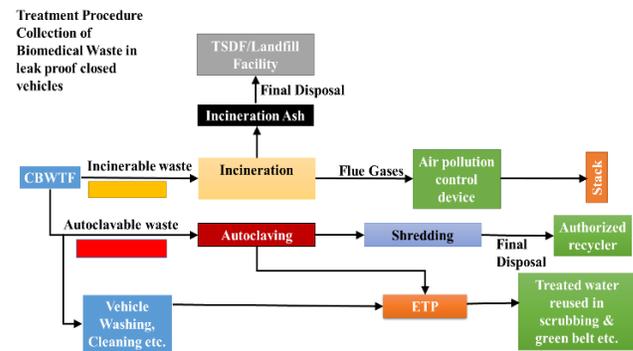
The personnel at quarantine facility who are involved in the process cycle of generation to disposal of biomedical wastes must follow the Biomedical Waste Management Rules, 2016. The wastes shall be segregated at source in the color-coded bins according to the type of waste.

Effective implementation of biomedical

Category	Type of Bags	Type of waste
Yellow	Non-chlorinated plastic, autoclavable bags	1. Donned off PPE 2. PPE with spill 3. Gloves 4. Shoe covers 5. Head covers 6. Disposable bed sheets
Red	Non-chlorinated plastic, autoclavable bags	1. Eye protection goggles 2. Recyclable materials like pens 3. Plastic water bottles used by quarantined people 4. Bed sheets
White	Puncture/leak/tamper proof containers	1. Sharp waste including metals
Blue	Cardboard boxes with blue coloured marking	Glassware/tube light/CFL bulbs/LED used in Quarantine facility

waste management involves continuous training, monitoring and supervision. The **duties of the healthcare authorities** is to give proper training to healthcare workers involved in handling biomedical wastes, identify a safe and secure location for storage of biomedical wastes within the facility and provide the waste collecting van/vehicle with legal authorization. The **duties of the biomedical waste management facilities** is to ensure timely collection of biomedical wastes from the facilities, to handover recyclable wastes to Government authorized agencies, to assist healthcare facilities in providing training, provide PPE kits to all the people involved, issue ID card to all people visiting quarantine facility.

All the wastes from quarantine facility should be considered as biomedical wastes which shall be loaded to special Biomedical waste trucks/vans and transported to offsite facility where they are treated and disposed as per the BMW regulations. The untreated wastes should not be stored more than 48 hours. The records of generation, handling, storage, transportation, treatment and disposal shall be maintained for 5 years as per rules. Any accidents shall be reported to Quarantine Facility In-Charge within 24 hours.



Treatment Options
Source: MoHFW

6 International Guidelines for management of biomedical Waste

6.1 Guidelines given by World Health Organization (WHO)

Guidelines on water, sanitation, hygiene and waste for the management of COVID-19 by

World Health Organization¹⁰ are the internationally accepted guiding document for effective management of biomedical waste generated during COVID-19. As per the guidelines, though there is no evidence that the healthcare wastes would spread the infection, the wastes which are produced during treating patients including those who were infected with COVID-19 shall be considered as infectious (infectious, sharps and pathological waste).

Separate lined containers and sharp safe boxes shall be used to collect the wastes. Strong black bags shall be used to collect non-hazardous wastes from the waiting areas and sealed properly which can be disposed as municipal solid wastes. The excreta from the suspected or confirmed COVID-19 patients shall be disposed once they reach the capacity (higher capacity designs to be preferred). The regular cleaning of latrines and holding tanks shall be adopted based on the volume of wastewater generated.

The appropriate PPEs (boots, long-sleeved gown, heavy-duty gloves, mask, and goggles or a face shield) are must for those who handle healthcare wastes (inclusive of

pumping out tanks & unloading pumper trucks for excreta), which can be later removed and hygiene be performed after removal. The soiled PPE shall be put in sealed bag for laundering. The wastes can be either treated onsite or offsite before final disposal. The on-site treatment of excreta is preferred where off-site treatment can be practiced which involves using a 10% lime slurry added at 1-part lime slurry per 10 parts of waste. To treat the increasing healthcare wastes, additional treatment facilities shall be developed and alternative technologies like autoclaving or high temperature burn incinerators may be installed for sustainable operations.

The COVID-19 infected patients at home quarantine should collect the wastes in strong black bags and seal completely before disposing as municipal solid wastes. The tissues and other materials used during sneezing or coughing shall be thrown into waste bin immediately to avoid infection and hand hygiene be performed.

¹⁰ <https://www.who.int/publications-detail-redirect/water-sanitation-hygiene-and-waste-management-for-the-covid-19-virus-interim-guidance>

6.2 Guidelines given by European commission

The EU law on waste (Directive 2008/98/EC on waste and articles 17, 23, 24 and 25 pertaining to hazardous waste and permitting requirements) shall be followed along with the updated guidance provided by ECDC¹¹ and national health authorities to handle and treat the healthcare wastes from the activities involving coronavirus infected patients. Specific ECDC guidance¹² applies to the handling of coronavirus contaminated wastes, Category B (UN3291) applies to the treatment of infectious clinical wastes, whereas non-healthcare facility wastes should be disposed in separate bags and wastes from general setting to be discarded as residual wastes.

Proper planning of treatment and storage capacities of wastes to be ensured by Member states. Temporary storage of medical wastes to be preferred if there is lack of dedicated disposal or incineration capacity. Inner and outer surfaces of containers to be disinfected, sealed containers to be used and secured in areas where only authorized personnel are allowed. The practice of alternative treatment

process as per the EU law and applicable national rules by Member states shall be limited to address shortage in storage and treatment capacity if they provide less benefit to the environment than the normal practices.

6.3 Recommendations given by International Solid Waste Management for COVID-19

The priorities of ISWA for waste management during the COVID-19 pandemic are: proper waste management with recycling services, treatment and disposal with safeguarding the waste management workers, avoiding cross-contamination in recycling activities and evading risks of infections from the increased quantity of medical wastes.

Special care is to be given in collection, treatment and disposal of medical wastes by all countries, states and local authorities, especially when it exceeds the local capacity. Infection of coronavirus spreads through cough and touch of face after touching a common infected surface and thus the healthcare wastes cannot be completely categorized as hazardous wastes.

¹¹ <https://www.ecdc.europa.eu/en/publications-data/infection-prevention-and-control-and-preparedness-covid-19-healthcare-settings>

¹² <https://www.ecdc.europa.eu/en/publications-data/disinfection-environments-covid-19>

The healthcare wastes from the COVID-19 patients should be treated as infectious wastes which should be segregated at source and disposed on-site preferably. The wastes contaminated with TB, Hepatitis, HIV, anthrax, norovirus, salmonella, etc are handled separately and the same be followed. Off-site disposal will require details of the treatment, location, method of disposal. Wearing of PPE and performing hand hygiene after removal is must for all those who handle healthcare waste.

When there is lack of infrastructure for treating healthcare wastes, sanitary landfills isolated from other wastes shall be used for storage. The objective of such disposal is that the wastes wouldn't be exposed, wouldn't mix with non-infectious waste and does not affect human and animal during disposal and thereafter. PPE should be worn by disposal site workers and a safe distancing from direct contact of wastes to be practiced.

Direct unloading of healthcare wastes into the selected area is more preferable than

piling of wastes temporally before dumping. Sanitary landfills are a better source of safe disposal of the increasing healthcare wastes, in the absence of thermal treatment.

7 Technological advancement for facilitating efficient management of COVID-19 biomedical waste

7.1 COVID-19 Biomedical Waste tracking App and Web portal by Central Pollution Control Board

CPCB, India has released an app and associated web-based portal for easy tracking of biomedical waste generated from different types of users and for efficient data management¹³.

The free-to-download and use mobile app is available across all application stores such as Google Play Store, Apple Store etc.

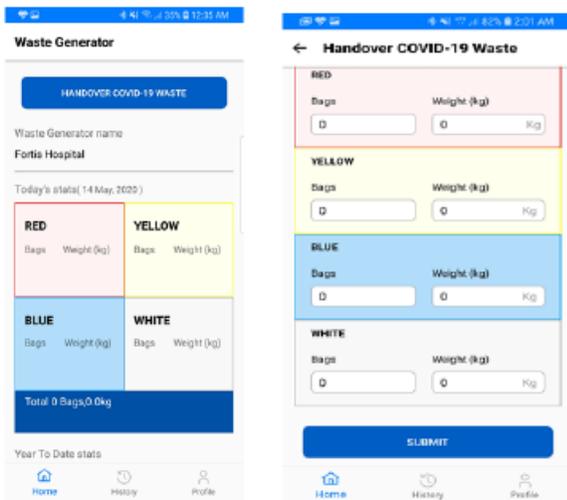
Waste Generators can create their own login credentials while waste handlers and managers such as collectors, CBMWTFs will be assigned login credentials from CPCB.

¹³ User Manual for Android Mobile & Web Applications - COVID-19 BMW Tracking App, CPCB Delhi, May 2020

7.1.1 Functionality for Waste Generators and Waste Handlers

Waste generators can add details about type of biomedical waste generated (based on categorization as per Biomedical Waste Management Rules, 2016) into the mobile app. The waste generator can also request a waste pick-up schedule using the app. Real time data is also available to the waste generators to analyse waste generation statistics.

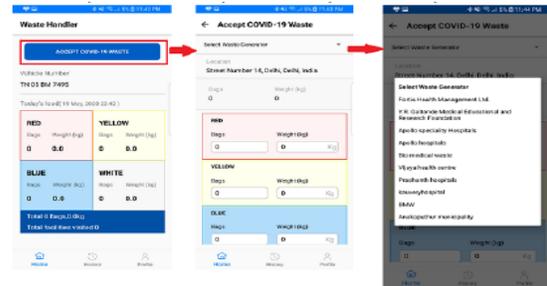
When the waste collector arrives to pick up the waste, a handover option is embedded in the app which will indicate how much waste the generator has handed over to the waste collector.



Waste generator and handover interface
Source: COVID-19 BMW Tracking app

Once the waste handler collects biomedical waste from the waste generator, the data shall be indicated in the dashboard with list of

generators quantity of waste per generator etc.



Waste handler interface

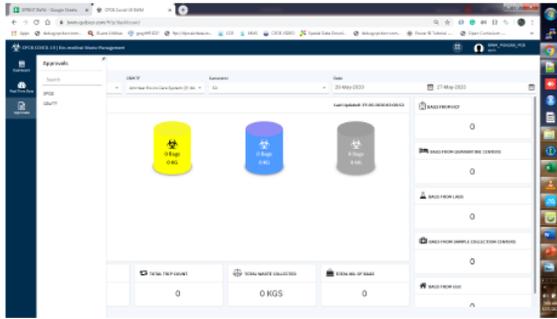
Source: COVID-19 BMW Tracking app

7.1.2 Functionality for CBMWTF

The common biomedical waste treatment facility can accept dispatch schedule request from waste handler. The handover details from the waste handler to the CBMWTF is recorded through the app. The app provides functionality for CBMWTFs to analyse amount of waste collected per day per category. Each CBMWTF can analyse and submit data to SPCB everyday.

7.1.3 Functionality for State Pollution Control Boards

The State pollution control boards can access and analyse real time data of biomedical waste being generated and treated across the state using the web portal for data analysis.

A screenshot of a web portal for data analysis showing a table with columns for date, time, and various data points. The table is titled 'SPCR Data Verification' and includes a search bar and a date range selector. The data is organized into two main sections: 'NO. OF BAYS OBSERVATION' and 'NO. OF WASTE OBSERVATION'.

NO. IN	NO. OF BAYS OBSERVATION	NO. OF WASTE OBSERVATION
1	21-05-2020	15
2	22-05-2020	10
3	23-05-2020	10
4	24-05-2020	12
5	25-05-2020	1

Web portal for Data Analysis

Source: COVID-19 BMW Tracking app

7.2 Mobile Biomedical Waste Treatment facilities

In Wuhan, China around 240 tonnes of biomedical waste was generated per day during the peak outbreak of the COVID-19 crisis. Prior to the corona virus pandemic, around 40 tonnes of biomedical waste was generated in Wuhan. To cater to the demands of the sudden increase in biomedical waste generation, the central government deployed 46 mobile bio medical waste treatment facilities.¹⁴

‘Sterilwave solution’ developed by Bertin Technologies with assistance from CNIM Industrial Systems China for on-site treatment of waste contaminated was used by hospitals in Wuhan region. Sterilwave SW440 machines have a treatment capacity of 80 kg/hour. These machines make it possible to grind down and sterilize all types of hospital waste that may potentially have been contaminated by the coronavirus using microwave treatment, and therefore remove the need to take this waste outside the hospital, which poses a significant risk of external contamination.

The Sterilwave *in-situ* process is fully automated: the waste is ground down and heated in the same container to over 100°C for twenty minutes. When the waste exits the machine, it is dry, inert and completely unrecognizable, with a volume reduction of 85% and a weight reduction of 25%. After the Sterilwave process, all the treated waste can be managed as a regular municipal waste without biological risk and hazard for the Public Health

¹⁴ Pandemic COVID-19 and Biomedical Waste Handling: A Review Study, Dr Irin Hossain et al JMSCR Volume 08 Issue 05 May 2020

8 Conclusion

COVID-19 pandemic has disrupted many aspects of life across the globe and posed a serious threat to health and safety of human beings all around the world. Biomedical waste is being generated in humongous amounts due to the prolonged outbreak of the pandemic. Efficient biomedical waste management is the need of the hour and an immediate mandate that requires to be addressed. Various stakeholders such as international organizations, government bodies, academia, biomedical waste treatment facilities and innovation providers are working hand-in-hand to manage the high quantities of biomedical waste generated across the world. This review paper presented by Cholamandalam MS Risk Services Ltd is to aid in bringing together various technical guidelines, practices and innovations in managing the biomedical waste generated during the COVID crisis and is a public document aimed to assist in providing a common and credible platform to showcase the plethora of data and practices available at this hour.

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