



## STATUS AND CHALLENGES OF COVID-19 WASTE MANAGEMENT IN THANE CITY, INDIA

### Environmental Science

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### ABSTRACT

Due to enhanced healthcare needs brought upon by the COVID-19 pandemic, the amount of biomedical waste generated has also increased manifold across the globe. With the world in global crisis due to the recent outbreak of the COVID-19 pandemic, it has put great pressure on the biomedical waste management system in India and around the world. To control the spread of the COVID-19 virus, proper disposal of the waste is essential to reduce any risk of secondary transmission. This paper investigates the situation of biomedical waste management in the city of Thane in Maharashtra due to the onset of COVID-19 and suggests some key recommendations to the policymakers to help handle biomedical waste from possible future pandemics. The study found that there was an 81% increase in the total biomedical waste (BMW) generation in 2020, when compared to 2019 and the yellow category waste from COVID-19 centres was the highest contributor to this waste. It was also found that though there was a slight increase in yellow category waste, the total biomedical waste from non- COVID healthcare facilities (HCFs) was comparable to that of the waste generated in HCFs during 2019, revealing that there was conscious reduction in the usage of single use PPEs at non- COVID HCFs. The city, despite owning a Central Biomedical Waste Treatment Facility (CBWTF), was dependent on another incinerator at the Hazardous Waste Management Treatment facility (HWTF) for treatment of the additional waste generated. Unforeseen situation like these, expose the vulnerability of our existing biomedical waste management system and reinforces the need for investing and improving them for strengthening preparedness in the future. The situation also demands periodic education on importance of source segregation and waste reduction through rational use, disinfection and disposal of PPEs.

### KEYWORDS

COVID-19, Biomedical waste, Thane city, COVID-19 Centres

### INTRODUCTION

The coronavirus or COVID-19 has brought life to a near standstill in almost every part of the world. The disease from novel coronavirus which originated in central China's Hubei Province in December 2019 was declared as a pandemic by The World Health Organization (WHO) on 11th March 2020. [1] The disease has affected more than 172 million people and has claimed more than 3.7 million lives globally at the time of writing this paper.

India reported its first confirmed case of the coronavirus infection on 30th January 2020 in the state of Kerala and the country announced national lockdown from 24th March, 2020 onwards for 68 days. [2]

With rise in COVID-19 cases, there is a proportional increase in the generation of contaminated medical waste, which if mismanaged, could lead to transmission risk, pilferage and environmental pollution [3]. Many types of medical and hazardous waste including infected masks, gloves, and other protective equipment, along with a higher volume of non-infected items of the same nature are generated during an outbreak [4]. Mixing of COVID-19 virus-laden waste with the regular solid waste would adversely impact the health and safety of sanitation workers and escalate the spread of COVID-19 via secondary transmission [5]. Thus, safe handling and disposal of this waste is a crucial component of an effective emergency response.

"Bio-medical waste" (BMW) has been defined as "any waste, which is generated during the diagnosis, treatment or immunisation of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps" [6]. In India, biomedical waste generated from healthcare establishments or diagnostics is managed under Biomedical Waste Management Rules, 2016. The main objective of this rule is to mitigate environmental pollution while safeguarding the health of patients, healthcare workers and community at large. The typical BMW generation in India ranges from 0.5kg to 2kg per bed per day among various hospitals. [7]. The Biomedical Waste Management Rules specifies source segregation of waste followed by treatment of the waste using adequate technology for safe management. Currently, there are four separate colour-coded

bins designated for segregation with clearly defined treatment and disposal options for waste in each colour coded bin (Table-1). The rules also include a provision for a third party to setup and operate a facility, commonly termed as CBWTF (Common Bio Medical Waste Treatment Facility), responsible for collection, transportation and treatment of this waste as per the standards prescribed.

**Table 1: Treatment and disposal options for various categories of waste should be as per Biomedical Waste Management Rules, 2016 [6] (Source: MoEFCC, 2016)**

| Category      | Type of Waste                                                                                                                                                                                                                                              | Treatment or Disposal Options                                                                                                                                                                                                                                                                                                                      |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Yellow</b> | Soiled Waste: Items contaminated with blood, body fluids like dressings, plaster casts, cotton swabs and bags containing residual or discarded blood and blood components.                                                                                 | Incineration or Plasma Pyrolysis or Deep Burial                                                                                                                                                                                                                                                                                                    |
| <b>Red</b>    | Contaminated Waste (Recyclable) Wastes generated from disposable items such as tubing, bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles and fixed needle syringes) and vacutainers with their needles cut) and gloves | Autoclaving or micro-waving/ hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent to registered or authorized recyclers or for energy recovery or plastics to diesel or fuel oil or for road making, whichever is possible. Plastic waste should not be sent to landfill sites |
| <b>White</b>  | Waste sharps including Metals: Needles, syringes with fixed needles, needles from                                                                                                                                                                          | Autoclaving or Dry Heat Sterilization followed by shredding or mutilation or encapsulation in metal                                                                                                                                                                                                                                                |

|                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                        |             |                                                                                                                                                                     |                                                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| needle tip cutter or burner, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts. This includes both used, discarded and contaminated metal sharps | container or cement concrete; combination of shredding cum autoclaving; and sent for final disposal to iron foundries (having consent to operate from the State Pollution Control Boards or Pollution Control Committees) or sanitary landfill or designated concrete waste sharp pit. | <b>Blue</b> | Glassware: Broken or discarded and contaminated glass including medicine vials and ampoules except those contaminated with cytotoxic wastes. Metallic Body Implants | Disinfection (by soaking the washed glass waste after cleaning with detergent and Sodium Hypochlorite treatment) or through autoclaving or microwaving or hydroclaving and then sent for recycling |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

**Table 2: Waste Generators and Type of waste during diagnostics & treatment of COVID-19 patients, as on 17<sup>th</sup> July, 2020 [9]**

| Areas of Operation                                                                                   | Definition                                                                                                                                                                                                                                                                                                           | Segregation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Handling                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Treatment                                                                                                                                                                                                 |
|------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| COVID-19 Isolation Wards and Sample Collection Centres/ Laboratories for COVID-19 Suspected Patients | Isolation Ward in Healthcare Facility are those area where COVID-19 positive patients are being kept for treatment / diagnosis.<br><br>Sample Collection Centres are places where individuals suspected of COVID-19 are tested for the infection.                                                                    | - Double layered bags (using 2 bags) should be used for collection of waste from COVID-19 isolation wards so as to ensure adequate strength and no-leaks<br><br>-Separate colour coded bins (with foot operated lids)/bags/containers as per BMW Rules, 2016<br><br>Yellow Bags<br>-Used mask (including Triple layer mask, N95 mask etc.), head cover/cap, shoe-cover, disposable linen Gown, non-plastic or semi-plastic coverall<br>-Faeces from COVID-19 confirmed patient, who is unable to use toilets and excreta collected in diaper<br><br>Red Bag<br>-Used PPEs such as goggles, face-shield, splash proof apron, Plastic Coverall, Hazmat suit, nitrile gloves<br>-Used gloves and plastic bottle from patients<br><br>General solid waste like wrappers of medicine/syringes etc., fruit peel offs, empty juice bottles or tetra packs, empty water bottles, discarded papers, carton boxes of medicines, empty bottles for of disinfectants and any other items which were not contaminated by the patients secretions, body fluids should be collected separately as per SWM Rules, 2016. | -Use a dedicated collection bin labelled as "COVID-19" to store COVID-19 waste and keep separately in temporary storage room prior to handing over to authorized staff of CBWTF<br>-In addition to mandatory labelling, bags/containers used for collecting biomedical waste from COVID-19 wards, should be labelled as "COVID-19 Waste". This marking would enable CBWTFs to identify the waste easily for priority treatment and disposal immediately upon the receipt<br>- Dedicated and labelled trolleys and collection bins in COVID-19 isolation wards to be disinfected with 1% sodium hypochlorite solution daily.<br>- No segregation of biomedical waste and solid waste at temporary waste collection / storage area of Healthcare Facility.<br><br>-Operator of CBWTF shall ensure regular sanitization of workers involved in handling and collection of biomedical waste. Workers shall be provided with adequate PPEs including three layer masks, splash proof aprons/gowns, nitrile gloves, gum boots and safety goggles;<br><br>Vehicle should be sanitized with sodium hypochlorite or any appropriate chemical disinfectant after every trip. | COVID-19 waste should be disposed-off immediately upon receipt at facility.<br><br>Treatment of waste contained in red or yellow bags should be undertaken as per Biomedical Waste Management Rules, 2016 |
| Quarantine Centres/Camps/ Home Quarantine or Home- Care facilities                                   | Places where suspected people or the contacts of suspected / confirmed cases who have been directed by local authorities to stay for at least 14 days or more for observation for any symptom of COVID-19, if any. Home care facility is a home where care is to be provided to a COVID-19 positive patient at home. | Bio medical waste - (Used masks, gloves and tissues or swabs contaminated with blood / body fluids of COVID-19 patients, including used syringes, medicines, etc.) –to be collected separately in yellow bags.<br><br>General waste may comprise of the waste generated from kitchen, packaging material for groceries, food material, waste papers, waste plastics, floor cleaning dust, etc. generated and handled by patient care-takers or the suspected quarantined persons.<br><br>General solid waste should be handed-over to municipal solid waste collector identified by Urban Local Bodies or as per the prevailing local method of disposing general solid waste.                                                                                                                                                                                                                                                                                                                                                                                                                          | Biomedical waste - Hand over the yellow bags to authorized waste collectors at doorsteps engaged by local bodies; or<br>-Deposit biomedical waste in yellow bags at designated deposition Centres established by ULBs; or<br>- Handover the biomedical waste to waste collector engaged by CBWTF operator at the doorstep.<br><br>Masks and gloves used by persons other than COVID-19 patients - kept in paper bag for a minimum of 72 hours prior to disposal as general waste<br><br>General solid waste - segregated separately and disposed as per provisions under SWM Rules, 2016.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                           |

In addition to the existing rules and guidelines on BMW management, the Central Pollution Control Board issued fresh guidelines in the month of March 2020 for effective management of COVID waste [8]. The guidelines have been revised from time to time adapting to the evolving situation, and its key features are highlighted in Table 2. While India has guidelines and necessary infrastructure to manage infectious waste, it is critical to study the impact of COVID-19 pandemic on waste management, especially biomedical waste management system of a city. The study by Hossain et al., 2020 [10] involved systemic review of 26 articles and newsletters published

across the world to establish relationship between COVID-19 and biomedical waste management. A few studies have also mathematically estimated the biomedical waste generation based on the caseload in the respective country [11, 12, 13]. Efficient biomedical waste management is an essential aspect to prevent the spread of COVID-19. Bhakta et al., 2020 [3] have put together guidelines and best practices given by national and international bodies as well as to manage biomedical waste more effectively. In a study undertaken by INOPOL (India Norway Cooperation Project on Capacity Building for reducing Plastic and Chemical Pollution in

India), actual biomedical waste generation in two cities of India- Delhi and Surat was assessed. The findings of the research exhibited a rise in biomedical waste generation from March 2020 onwards, which was managed by the existing CBWTF facilities. The study was however undertaken till the month of June 2020 only [14]. The literature thus highlighted that there are limited studies on the actual biomedical waste generation and performance of a city in managing the biomedical waste during the COVID-19 pandemic.

#### Hence, a study was planned in Thane city of Maharashtra with following objectives:

- To analyse the status of BMW generated due to the ongoing pandemic in the city
- To evaluate the capacity of a CBWTF to handle COVID-19 waste
- To assess the ability of the Urban Local Body in managing biomedical waste during a pandemic

#### Study Area:

Thane city falls under the jurisdiction of Thane Municipal Corporation, spread over 147 square kilometer area with population of 1.8 million. Thane city is defined as a Class B Corporation, with 1 CBWTF (Central Biomedical Waste Treatment Facility) allotted, which is outsourced to the vendor M/S Envirovigil by Maharashtra Pollution Control Board managing 1200kg/ day of biomedical waste generated from 1416 registered Health Care Facilities (HCFs).

The city reported its first confirmed case of COVID-19 in the month of March 2020 and by April 2021; the city had over 1, 20,000 COVID-19 cases. For managing COVID-19 patients, the city had dedicated healthcare facilities (HCFs) for COVID-19 treatment and quarantine centres, isolation centres and home quarantining for COVID-19 suspected or asymptomatic patients.

In the current study; dedicated healthcare facilities for COVID-19 treatment, quarantine camps/homes, COVID-19 sample collection centre and laboratories will be together referred to as "COVID-19 centres"

#### METHODS:

A retrospective study was undertaken to achieve the above stated objectives. For the purpose of this study, the following data was collected from M/S Envirovigil and Pollution Control Cell, Thane Municipal Corporation.

1. Month-wise routine biomedical waste generated from healthcare facilities (HCFs) from January-December 2019 (Pre-COVID)
2. Month-wise biomedical waste generated from non-COVID healthcare facilities (HCFs) from January 2020-April 2021.
3. Month-wise biomedical waste generated from COVID-19 centres from March 2020-April 2021
4. COVID-19 case load from March 2020- April 2021.

SPSS version 22.0 statistical software package for Microsoft Windows (SPSS Inc., Chicago, IL) and MS-Excel were used for data analysis.

#### RESULTS AND DISCUSSION

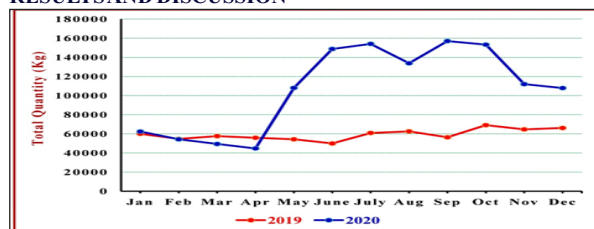


Figure-1: Month-wise quantity of all Biomedical Waste (kg) during 2019 and 2020

#### (a) Biomedical waste comparison - 2019 & 2020

A comparison of the biomedical waste generated in 2019 and 2020 revealed that the total BMW increased from 712 tons in 2019 to 1286 tons in 2020 respectively. This increase can be attributed to the ongoing pandemic which has led to additional generation of COVID-19 waste in the city. Literature suggests that many other cities (Manila, Kuala Lumpur, Hanoi and Bangkok) also experienced a similar increase, ranging from 154 MT to 280 MT of biomedical waste generation per day as compared to pre-pandemic levels [15]. In certain cities like Wuhan, China, the city experienced an increase in the biomedical waste generation by almost 400% in March 2020 [16] (You, Sonne, & Ok, 2020).

#### (b) Category wise comparison of 2019 and 2020

In order to understand which category of waste contributed maximum to the total biomedical waste generation, a year-wise comparison of BMW (kg) during 2019 and 2020 in various colour-coded containers was done. The diagrammatic depiction in Figure-2 indicates that there was a substantial increase in yellow bag waste, with marginal differences in the quantities of biomedical waste in red, blue and white categories respectively. As COVID-19 waste would mostly include masks, coveralls and other waste contaminated with blood / body fluids of COVID-19 confirmed or suspected patients, which is categorised as yellow waste, an increase in yellow waste was expected.

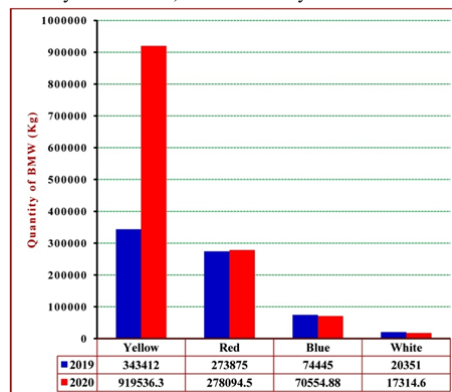


Figure-2: Quantity of BMW (Kg) in various bags/containers during 2019 and 2020

#### (c) Month-wise COVID-19 case load versus biomedical waste generation from COVID Centres and non COVID HCFs. (January 2020 –April 2021)

In an effort to understand any correlation between COVID-19 case load and biomedical waste generation, a month wise data was plotted. The waste stream from COVID-19 centres and routine biomedical waste from non-COVID HCFs were separately depicted.

The data revealed that the waste generation from COVID centres was proportional to the monthly caseload. From April 2020 onwards, there was a rise in the number of cases as well as waste generation from COVID centres, followed by a decline from October 2020 onwards. With the onset of second wave, as the cases started rising from March 2021, the waste generation from COVID centres too increased. It was further observed that the waste generation did not increase at the same rate, as it did during the first wave. In fact, despite COVID-19 cases in April 2021 being almost four times that of first wave's peak in July 2020, the waste generation in April 2021 was less than 60% of the waste generated in July 2020.

In case of non-COVID HCFs, there was a drop in the waste generation in the months from April-June 2020 followed by a rise and steady rate of waste generation from July 2020 onwards. This could be attributed to the advisory released by Ministry of Health and Family Welfare in the month of March for postponement of elective surgeries and minimising routine visits to OPD. [17]. In addition to this, in the months of April and May, many private hospitals were either closed or had reduced their OPD time, while opting for teleconsultation, which too could have caused a decline in biomedical waste generation [18]. Since the beginning of 2021, the waste generation has been low in non-COVID HCFs. Close-down of many private medical practices, especially dentists and conversion of many non-COVID healthcare facilities into COVID HCF were some of the reasons cited by the CBWTF owner for the downward trend of waste generation.

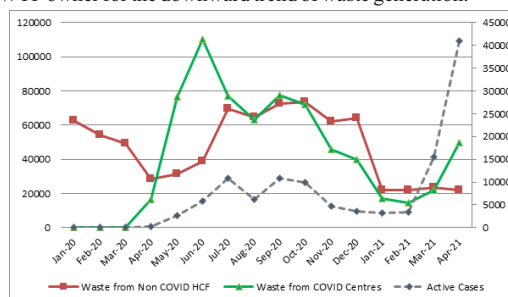
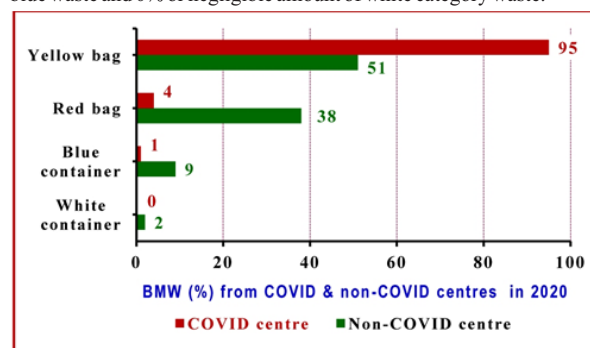


Figure 3: Month wise COVID-19 cases and waste generation from COVID & non-COVID centres (January 2020 –April 2021)

#### (d) Biomedical Waste from COVID-19 Centres & Non- COVID HCFs in 2020

In order to further investigate the quantity of various categories of waste generated from each facility, a comparison of biomedical waste from COVID-19 centres and non- COVID HCFs was undertaken. It was observed that the proportion of yellow waste from COVID centres was higher than that from the non-COVID HCFs. On the other hand, the proportion of BMW in white, blue and red categories were higher in non-COVID HCFs, as compared to that from COVID centres. The waste generated from the COVID centres in 2020 were in the following proportions: 95% yellow category waste, 4% red waste, 1% blue waste and 0% or negligible amount of white category waste.



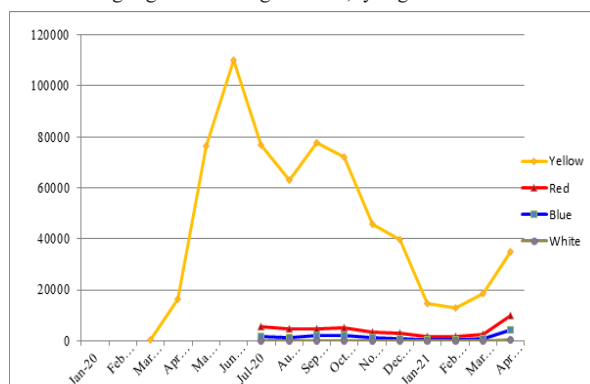
**Figure-4: Percentage of BMW from COVID and Non-COVID centres in 2020**

#### (e) Category wise and month wise waste from COVID-19 centres (March 2020-April 2021)

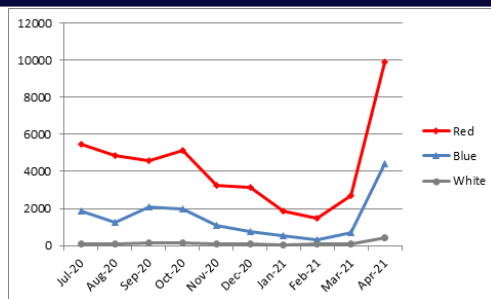
When a month-wise comparison was done to analyse the waste generation across the four categories, it was found that during March 2020 to June 2020 (4 months), BMW was only collected in yellow bags and not in other three categories.

While the initial guidelines released by Central Pollution Control Board suggested that all biomedical waste generated during the treatment of COVID-19 patients is to be disposed in yellow bags [8]. It was only in the revised guidelines released in April, followed by June and July that the red bag was recommended for disposal of used PPEs such as goggles, face-shield, splash proof apron, plastic coverall, hazmat suit and nitrile gloves, generated from COVID-19 Isolation wards [9]. This suggests why the other three category wastes were generated from July onwards only. Moreover, even general solid waste including food, medicine wrappers, fruit peels etc, which were not contaminated by patient fluids, were also disposed in yellow bag before the revised guidelines were released in June. [9]

From March 2021 onwards, with rise in COVID-19 cases, an increase in yellow category waste was observed. A sudden rise in waste generation was also observed for the other three categories of waste from March 2021 onwards (Figure-6). The increase could be postulated to the vaccination drive for 45+ age category adults initiated from March onwards [19] along with increased requirement for injections to patients with complications related to COVID-19 [20], thus resulting in generation of glass vials, syringes and needles.



**Figure 5: Month-wise biomedical waste (kg) from COVID-19 centres (March 2020-April 2021)**

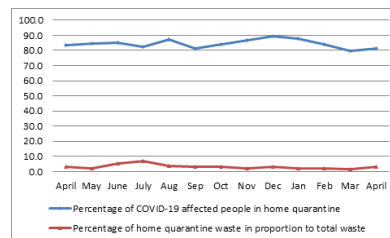


**Figure 6: Month-wise Red, Blue & White category waste (kg) from COVID-19 centres (July 2020-April 2021)**

#### (f) Contribution of COVID-19 waste from Quarantine Homes.

During the study period, on an average 84% of the monthly COVID-19 cases were managed by civic body through home quarantine. It was also observed that of the total monthly COVID-19 waste generated in the city, an average of 3% of the waste was from patients in home quarantine.

Thus the month wise proportion of patients in home quarantine versus the quantity of waste from home quarantine remained mostly the same. The low contribution of waste from quarantine homes could be attributed to the low quantity of waste generated per person, when compared to an institutional centre where besides the waste generated by the patient, it also includes the waste generated by healthcare staff during treatment.

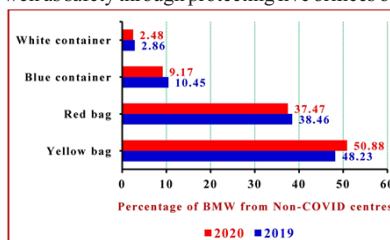


**Figure-7: Proportion of home quarantined patients and waste collection**

#### (g) Contribution of BMW from Non-COVID Centres in 2019 versus 2020

While it was clear that there was a significant increase in biomedical waste, especially yellow waste from COVID centres (Figure 4), in order to understand if pandemic has had any effect on biomedical waste generation from non- COVID HCFs, a comparative representation was done between routine waste contributions from non- COVID centres in 2019 and 2020.

While there has been a slight increase in yellow waste generation (%) in 2020, the proportion of other waste in 2019 and 2020 were observed to be similar (Figure-8). This suggests that, though use of disposable PPEs would have increased in routine functioning of healthcare centres, there may have been rational use of PPEs, based on guidelines released by Ministry of Health & Family Welfare, like choosing PPE based on exposure levels of the health care worker; use of reusable alternatives without compromising on the safety [21]. In the month of March, The Deenanath Mangeshkar Hospital (DMH) in Pune designed its special Personal Protective Equipment (PPE) policy advocating for use of plastic PPE only during aerosol generating procedures like swab collection or incubation, while using reusable PPEs along with N-95 masks. The hospital claims that not only did it help in reducing the generation of waste by avoiding unnecessary PPEs but ensured comfort as well as safety through protecting five orifices of face [22]



**Figure-8: Percentage of BMW from Non-COVID centres in 2019 and 2020**

(h) Dependence on external incinerators for COVID-19 Waste Management

While the city has a centralised biomedical waste treatment facility, from May 2020 onwards, the waste generated in the city exceeded beyond the CBWTF's incinerator capacity of 1200kg/day of yellow waste. Thus, in order to manage the increased waste due to COVID-19 pandemic, Thane Municipal Corporation (TMC) made arrangements with a hazardous waste treatment facility to accommodate this increase in yellow bag waste. There was a steady increase in the quantity of biomedical waste handled by the hazardous waste treatment facility, followed by decrease in dependence from October onwards, due to fall in COVID-19 cases in the city (Table 3). With the onset of the second wave, the waste had increased once again, thereby prolonging this dependence for safe handling and management of incinerable waste.

**Table-3: Treatment of BMW from Jan 2020-Mar 2021**

| Month     | Total yellow waste generated by the city (kg) | Percentage of waste exceeded by CBWTF's incinerator capacity |
|-----------|-----------------------------------------------|--------------------------------------------------------------|
| Jan 2020  | 29,685                                        | -                                                            |
| Feb 2020  | 23,501                                        | -                                                            |
| Mar 2020  | 20,492.6                                      | -                                                            |
| Apr 2020  | 29,090.4                                      | -                                                            |
| May 2020  | 91,279.04                                     | 145.4%                                                       |
| June 2020 | 1,28,076.4                                    | 255.8%                                                       |
| July 2020 | 1,16,717.4                                    | 213.8%                                                       |
| Aug 2020  | 1,00,409.8                                    | 169.9%                                                       |
| Sep 2020  | 1,17,303.5                                    | 225.8%                                                       |
| Oct 2020  | 1,11,238.2                                    | 199%                                                         |
| Nov 2020  | 78,495.6                                      | 118%                                                         |
| Dec 2020  | 73,247.3                                      | 96.9%                                                        |
| Jan 2021  | 26816.4                                       | -                                                            |
| Feb 2021  | 24914.4                                       | -                                                            |
| Mar 2021  | 31180.8                                       | -                                                            |
| Apr 2021  | 46835.7                                       | 30.1%                                                        |

## CONCLUSION:

This paper studied the biomedical waste management practice adopted in the city of Thane during the first and second wave respectively. The study indicated that there was an 81% increase in the total biomedical waste generation in 2020, when compared to 2019 and the yellow category waste from COVID centres, was the highest contributor to this waste. During the second wave, it was observed that the waste generation did not increase at the same rate, as it did during the first wave, despite the cases being four times at the peak of first wave (July 2020). This could be attributed to the revised guidelines from CPCB which suggested general waste to be not discarded in yellow waste category. Also, Ministry of Health and Family Welfare suggested appropriate use of PPEs for different levels of healthcare workers. As compared to first wave, the second wave showed an increase in the generation of red, blue and white categories of waste. This increase could be due to the start of vaccination drive along with increase in hospital management of COVID 19 cases

In case of non-COVID healthcare facilities (HCFs), it was found that though there was an increase in yellow category waste, the total biomedical waste generation was comparable to that of the waste generated in HCFs during 2019 (pre-COVID), revealing that there was judicious usage of single use PPEs at non- COVID HCFs. This highlights the best practices adopted, to reduce risk of disease spread, environmental hazard and financial burden.

At the onset of COVID-19 pandemic in the month of March 2020, the pollution control cell of Thane Municipal Corporation established a parallel system for collection and safe management of COVID-19 waste from the newly developed health care facilities (Quarantine centers, Dedicated COVID Care Centers) as well as from patients under home isolation. The city, despite having a Central Biomedical Waste Treatment Facility (CBWTF), was dependent on incineration facilities of the Hazardous Waste Management Treatment Facility (HWTF) for additional yellow waste generated. This helped reduce the burden on the existing CBWTF and ensured safe management of the incinerable category of. The city still continues to use the facilities of HWTF to match the gap in the capacity to handle incinerable waste.

The pandemic also posed a new challenge of managing COVID-19 related waste masks, gloves and PPEs from commercial

establishments like malls, salons, hospitality industry etc. Mismanagement of this COVID-19 related waste could prove hazardous to the environment and can put the health of waste handlers at risk. With support of local NGOs, Thane Municipal Corporation (TMC) initiated an awareness drive to manage this waste for the safety of human health and the environment.

## RECOMMENDATIONS:

1. Unforeseen situation like the COVID pandemic exposes the vulnerability of the existing biomedical waste management system. Hence there is a need to invest and improve them for future preparedness while keeping in account growth in population.
2. The situation has highlighted the importance of various stakeholders, like CBWTF operators, the ULB, healthcare providers, waste handlers and citizens to come together and work towards developing a system for safe and sustainable management of biomedical waste from healthcare facilities and homes.
3. ULB needs to set up incineration facility for management of domestic hazardous waste like sanitary pads, diapers, condoms, used medicines etc. and COVID-19 related waste. This category, while not a biomedical waste, needs to be managed safely to prevent health and environment risk.
4. The city should invest in regular training and education of healthcare workers to improve the segregation rates thereby help reduce incinerable waste and increase the quantity of waste being sent for recycling.
5. Lastly, there is also a need to devise policies towards waste created in healthcare sector, by taking into account Life Cycle Assessment and EPR for sustainable management of biomedical waste.

## ACKNOWLEDGEMENT:

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