International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 17, Issue 10 (October. 2021), PP. 23-30

Analysis of COVID-19 Bio-medical Waste Generation and Management Scenario in India

Rajbir Singh Rathee
Department of Applied Sciences, MSIT Jankapuri, New Delhi, India

Abstract: *The abrupt occurrence and swift spread of Coronavirus-2 (SARS-CoV-2) commonly called as Coronavirus disease (COVID-19) in early 2020 snowballed the waste generation globally. The pandemic has resulted in putting tremendous pressure on already scarce resources, especially in developing countries, for waste handling and management. Though India proactively formulated new guidelines for proper and scientific management of the COVID-19 related bio-medical waste; inadequate infrastructure for waste handling & treatment and the flouting of norms by waste generation & management facilities as well as the general public engendered continuing dismal state of waste management. In order to arrest this burgeoning problem, taking stock of the current situation and improving the waste management strategy accordingly is the need of hour. In this regard, this paper aims to critically examine and present statistical analysis on several aspects related to bio-medical waste in India such as its composition, generation, treatment and disposal. The paper also peruses the current regulatory framework and potential methodologies for effectual waste reduction.*

Keywords: *Biomedical Waste, COVID-19, India, Waste Generation, State-wise Distribution*

Date of Submission: 08-12-2021 Date of Acceptance: 23-12-2021

I. INTRODUCTION

Biomedical waste (BMW) is defined as "Any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals" [1]. As per World Health Organization (WHO), 85% of BMW is comparable to general household waste implying that it is non-hazardous in nature and only 15% is hazardous BMW which further comprises of 10% infectious waste and 5% chemical or radioactive BMW [2]. The BMW is mainly composed of [2]: **Infectious waste**: Materials contaminated with blood and other bodily fluids, cultures of infectious agents from autopsies and infected animals and waste generated by infected patients such as bandages, swabs and disposable medical devices; **Sharps waste**: needles, syringes, disposable blades and scalpels etc; **Pathological waste**: bodily fluids, human tissues and organs, contaminated animal remains; **Chemical waste**: disinfectants, reagents and solvents, heavy metals contained in medical devices to be disposed of such as mercury in damaged thermometers; **Cytotoxic waste**: highly hazardous substances such as cytotoxic drugs and their metabolites which are used for treating cancer; **Pharmaceutical waste**: unused, expired and contaminated vaccines and drugs; **Radioactive waste**: such as radioactive therapeutic and diagnostic materials; **General or Non-hazardous waste**: waste materials which do not pose any particular physical, chemical, biological or radioactive hazard such as kitchen waste from healthcare facilities.

Infectious and pathological BMW consists of potentially harmful pathogens. Untreated BMW poses great risk to human health as well as our environment. Careless handling and littering of BMW may lead to unfurling of infectious diseases and help the epidemics to turn into the pandemics. It is estimated that medical waste related diseases globally cause more than 5.2million deaths per year including 4million children [3]. Most of these deaths occur in developing countries with low per-capita income. Despite paying such a high price for not handling and disposing the BMW properly, the reasons for poor BMW management practices, especially in developing countries like India, mainly include practical, technical and financial constraints. As per "State of India's Environment 2021" report, the amount of BMW generated in India increased from 559 tonnes per day (TPD) in 2017 to 619 TPD in 2019, however the percentage of BMW treaded decreased from 92.8% in 2017 to 88% in 2019 [4]. This implies that amount of untreated BMW increased from 7.2% to 12% between 2017 and 2019. Growing at a rate of 7% per annum, the amount of BMW generated in India is expected to become 775.5 TPD by 2022 [5]. Without proportionate increase in BMW treatment capacity, it will lead to higher percentage of BMW being left untreated thereby worsening the waste management situation in India. As per the CPCB annual report on BMW management for the year 2019 [6], brief overview of BMW management scenario in India is presented in table 1:

Table 1: **Bio-Medical Waste Management Scenario in India**

Parameter	Number/Quantity
No. of Health Care Facilities(HCFs)	3,22,425
No. of bedded HCFs	1,06,796
No. of non-bedded HCFs	2,15,780
No. of beds	24,86,327
No. of Common Bio-Medical Waste Treatment Facilities (CBWTFs)	202* + 35**
No. of HCFs granted authorization	1,53,885
No. of HCFs having Captive Treatment Facilities	18,015
No. of Captive Incinerators Operated by HCFs	136
Quantity of bio-medical waste generated in Tonnes/day	619
Quantity of bio-medical waste treated in Tonnes/day	544
No. of HCFs violated BMW Rules	29,062
No. of Show-cause notices/Directions issued to defaulter HCFs	17,435

* - CBWTFs in operation ** - CBWTFs under installation
Source: CPCB (2019) [6].

From Table 1, it can be easily deduced that India is generating 619 tonnes of BMW per day but it can treat only 544 TPD leaving 75 tonnes of BMW untreated per day which, directly or indirectly, is dumped into landfills. This prevailing crisis of BMW has further been exacerbated by sudden surge in BMW generation due to ongoing Coronavirus disease (COVID-19). Due to unforeseen nature of pandemic like COVID-19 in recent past, arrangements were not in place to deal with huge quantities of BMW. COVID-19 pandemic has augmented the sources as well as the amount of BMW. Several precautions were taken to contain the spread of COVID-19 which comprised wearing face mask, face shields, personal protective equipment (PPE), gloves, shoe covers, frequent sanitization, using disposable items as far as possible so as to avoid the contact through surfaces and carrying out vaccination drives. As per the guidelines issued by Central Pollution Control Board (CPCB) for handling bio-medical waste in the wake of COVID-19, all these items used by a covid patient are to be treated as hazardous BMW [7]. Implementation of all these measures have resulted in generation of humongous amount of BMW. A fifteen-fold increase in the amount of BMW generated in India has been projected in comparison to pre-pandemic times [8]. Not only that amount is large but also the waste generated is highly infectious in nature. India being the second most populous country and the second worst-hit by the COVID-19 pandemic [9] is confronting the BMW management crisis.

II. COVID-19 INDUCED BMW MANAGEMENT CRISIS IN INDIA

The rapid spread and prolonged stay of COVID-19 has changed the face of litter all over the world. The effect is more pronounced in India due to the large population size, lack of awareness among general public and shortage of resources to handle the waste. Surgical masks, gloves, face shields, shoe covers and PPEs can be easily sighted lying discarded around the hospitals, by the roadsides, in landfills or disposed along with the household waste. This litter poses grave danger for human and environmental health as it can be a carrier for novel coronavirus. The survival ability of the virus fluctuates across different materials and media as depicted in Figure 1. Most of the protective gears used to stop the spread of COVID-19 are made from plastic. As seen from Figure 1, coronavirus can stay on plastic for around 72 hrs. Due to the inherent risk of COVID-19 litter, CPCB categorized it as hazardous BMW.

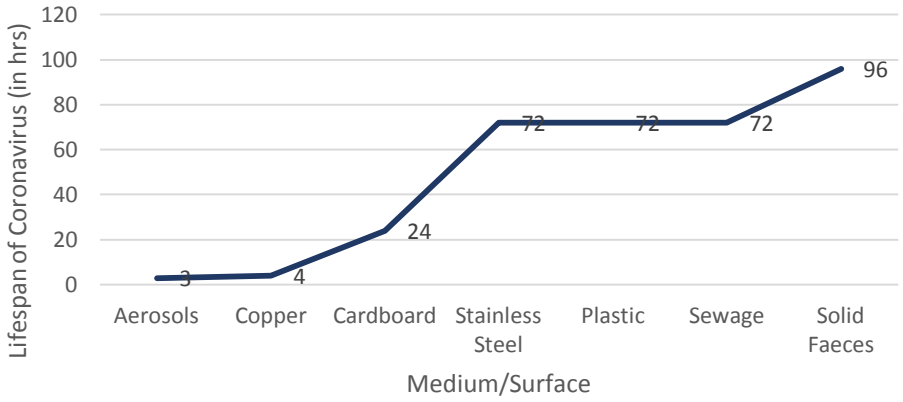

Figure 1: Lifespan of coronavirus on different surfaces or medium. [10]

Before the coronavirus pandemic, the major sources of BMW included hospitals, dispensaries, nursing homes, clinical establishments, blood banks and research institutions. The onset of pandemic led to exponential increase in the amount of BMW generated from these sources in addition to enumerating isolation wards, quarantine centers, covid-19 sample collection centers (SCCs) & testing labs, covid infected households and public places as the fresh sources of BMW. In India, 2907 hospitals, 1540 SCCs, 264 testing labs and 20707 quarantine centers have been designated to deal with COVID-19 [11]. The total amount of COVID-19 associated BMW (CBWM) generated each month from these facilities between June 2020 and June 2021 is shown in Figure 2.

The analysis of CPCB data [12-18] (as presented in Figure 1) shows that India generated a total of 56898 tonnes of CBWM between June 2020 and June 2021 i.e. India produced 155.88 tonnes of COVID-19 BMW per day. This is in addition to 619 tonnes of non-covid BMW generated by the country on any given day. Thus, around 25% of the total BMW generated in India was contributed by COVID-19. The large amount of CBMW generated during August, September and October 2021 was due to first wave of pandemic in India. November onwards there was a decrease till February 2021. March 2021 again witnessed rise in the generation of CBMW. During April 2021, CBMW generated was 139 TPD which increased to 203 TPD during May 2021; an increase of 46% in May as compared to April. This was due to peak of second wave of pandemic in India during May when large number of people were affected by COVID-19 thereby stretching the healthcare and waste management infrastructure to its limits.

The total amount of CBMW generated by high burden states during June 2020-June 2021 is shown in Figure 3. As seen from the figure, Maharashtra has emerged as the largest producer of CBMW followed by Kerala, Gujrat, Tamilnadu, Delhi, UP and Karnataka.

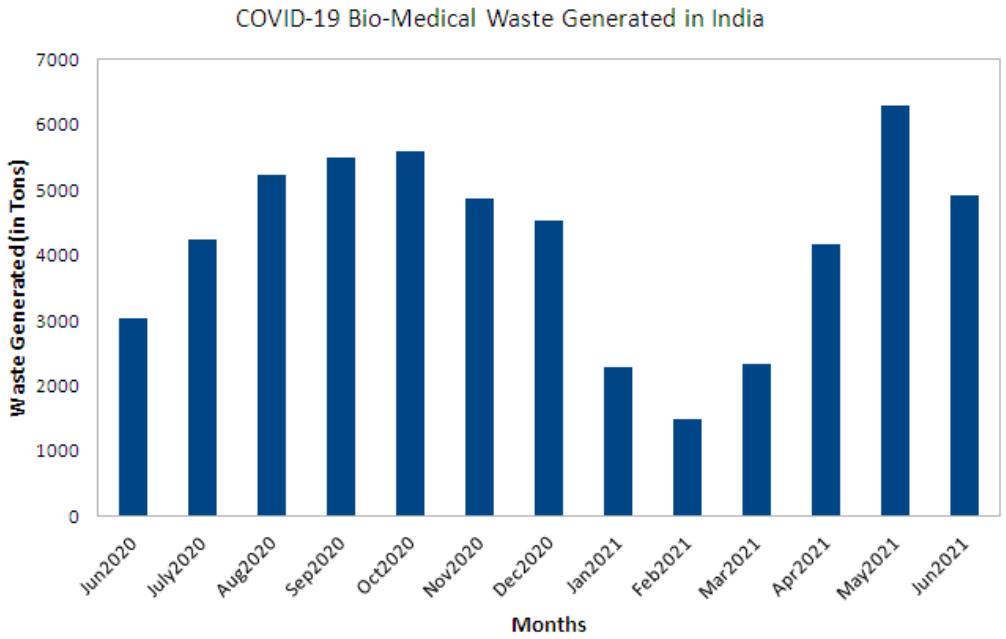

Figure 2: Month-wise COVID-19 associated BMW generated in India between June 2021 and June 2021 Source: CPCB [12-18]

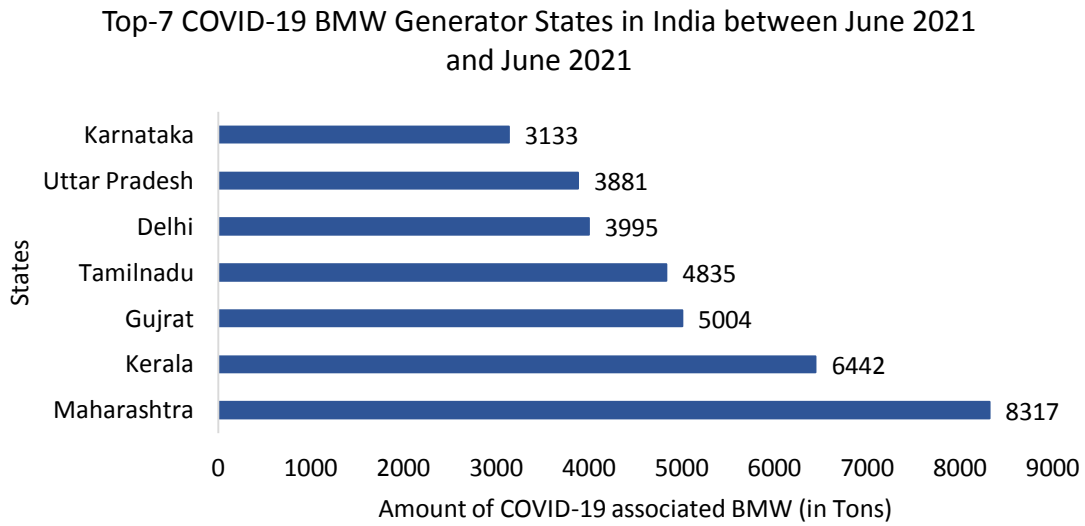

Figure 3: **Total COVID-19 associated BMW generated by top-7 states between June 2021 and June 2021 Source: CPCB [12-18]**

State-wise statistics for total BMW generated (in TPD), total treatment capacity (in TPD), amount of CBMW generated (as % of total BMW) and number of CBWTFs engaged in handling of BMW during second wave of pandemic are presented in Table 2.

Table 2: Bio-Medical Waste Generated and Treatment Capacity During peak of Pandemic's second wave

Sr No	Name of State/UT	BMW Generated (in Tonnes Per Day (TPD))	Total Treatment Capacity (TPD)	% Share of COVID-19 BMW in the total BMW	No. of CBWTFs engaged
1	Andaman & Nicobar	0.7	0.2	2	0
2	Andhra Pradesh	25	25.7	40	11
3	Arunachal Pradesh	0.5	1	22	0
4	Assam	9.3	8.6	6	1

5	Bihar	35.9	35.6	3	4
6	Chandigarh	5.8	5.6	33	1
7	Chhattisgarh	6.5	16.4	42	4
8	Daman & Diu	0.4	0.3	18	1
9	Delhi	47.6	37.2	39	2
10	Goa	1.9	2	23	0
11	Gujrat	58.4	50.5	38	20
12	Haryana	27.9	21	47	11
13	Himachal Pradesh	5.7	4.2	40	2
14	J&K	8.4	13.9	30	2
15	Jharkhand	7.8	4.9	7	4
16	Karnataka	94.5	72.6	18	26
17	Kerala	66.6	89.5	36	1
18	Lakshadweep	0.1	72	9	0
19	Madhya Pradesh	25.2	23.8	29	14
20	Maharashtra	81.3	82.7	23	29
21	Manipur	1.1	1.4	12	1
22	Meghalaya	1.5	1.7	17	2
23	Mizoram	1	0.9	3	0
24	Nagaland	0.7	0.2	11	0
25	odisha	24.6	18.7	27	5
26	Puducherry	7.7	4.9	23	1
27	Punjab	20.1	18.8	20	5
28	Rajasthan	25.7	25.7	19	8
29	Sikkim	0.5	0.5	3	0
30	Tamil Nadu	71.8	55.3	19	8
31	Telangana	25.4	18.4	20	11
32	Tripura	1.42	1.40	1	0
33	Uttarakhand	5.8	6.6	34	2
34	Uttar Pradesh	68.4	61.4	23	18
35	West Bengal	47.3	43.1	12	6
	Total	812.54	826.7	----------	198

Source: CPCB [12-18].

The % share of CBMW in total BMW generated in each state has been calculated by taking December 2020 data for BMW generated and May 2021 data for CBMW generated in each state. As seen from Table 2, India has a total of 198 CBWTFs and all are involved in treatment and disposal of CBMW in the country. As per the data provided by CPCB, India has a total treatment capacity of 826.7 TPD of BMW while the waste generated is 812.54TPD which is well below the nation's BMW treatment capacity. Thus, India looks to be well equipped to handle this COVID-induced waste crisis. However, this data given by CPCB defies itself as Lakshadweep has shown to be having treatment capacity of 72 TPD while there is no CBWTF in this union territory (UT). This brings down the India's effective treatment capacity to 754.7 TPD (826.7 – 72) which is highly insufficient to manage the BMW generated in the country. With the threat of third wave looming over, it can be inferenced that India is not currently prepared to handle any spike in BMW.

The situation is grimmer when BMW generated by individual state is compared against its waste processing capacity. A careful analysis of data in Table 2 reveals that the amount of BMW generated by 22 out of the 35 States/UTs exceeds their treatment capacity. Also the capacity of the available CBWTFs is nearly saturated in almost all of the states. Therefore, 23 states/UTs are disposing their BMW through deep burial methodology despite the government restrictions on the practice of deep burials for CBMW management [7].

In May 2021, when India generated 203TPD of CBMW [17], CBMW accounted for 33% of the total BMW generated across the nation thereby overwhelming the already strained BMW treatment and disposal infrastructure in India. The volume of CBMW was massive in several states in May 2021 reaching as high as 47% in case of Haryana which was closely followed by Chhattisgarh with a proportion of 42%, Himachal and Andhra both having 40% and Delhi with 39% of CBMW. This led to rapid increase in yellow category BMW thereby putting tremendous pressure on BMW incineration units in these states. As per the CPCB guidelines, CBMW is to be treated as hazardous and disposed of accordingly. The regulatory framework developed by CPCB in order to better handle the pandemic situation and the compliance statistics are discussed in next section.

III. REGULATORY FRAMEWORK AND COMPLIANCE STATISTICS FOR CBMW MANAGEMENT IN INDIA

India was one of the countries who recognized the COVID-19 crisis at the early stages and took proactive measures to handle the situation arising due to this pandemic. Prior to the occurrence of COVID-19 pandemic, India was following the Bio-Medical Waste Management (BMWM) Rules, 2016 [19] which required BMW to be treated and disposed of through CBWTFs. If no CBWTF is available in any state/UT, then BMW management was to be done through captive treatment facilities including deep burial pits. Though BMWM Rules 2016 could have been sufficient for safe handling of CBMW yet considering the nature of pandemic, CPCB issued new guidelines on 18th March 2020 for handling the CBMW generated by healthcare facilities, SCCs, testing labs, quarantine camps, individuals in home isolation, urban local bodies (ULBs), State Pollution Control Boards (SPCBs) and CBWTFs. These guidelines were revised continuously keeping in mind the prevailing situation at the ground and practical aspects of implementation. The fourth and final version of guidelines was released on 14th July 2020 [7]. The CPCB guidelines are shown in Figure 3(a) and 3(b). Monitoring the proper execution of these guidelines by various stakeholders involved in BMW management is a very challenging task due to innumerable sources of generation of CBMW which include healthcare facilities, makeshift quarantine camps, isolation centers, SCCs, testing laboratories etc. To overcome this challenge and to keep track of the BMW statistics in real-time, in May 2020 CPCB launched a mobile application named "COVID19BWM" which tracks the amount of BMW generated, collected and treated [20]. Apart from monitoring daily BMW collection and disposal, it also provides for tracking of vehicles carrying the BMW to treatment facilities. The app facilitates coordination among various stakeholders by exchanging the information between regulatory bodies and the waste generators, collectors & CBWTFs. However, reporting on the app has not been very encouraging. The usage statistics of "COVID19BWM" are presented in Table 3.

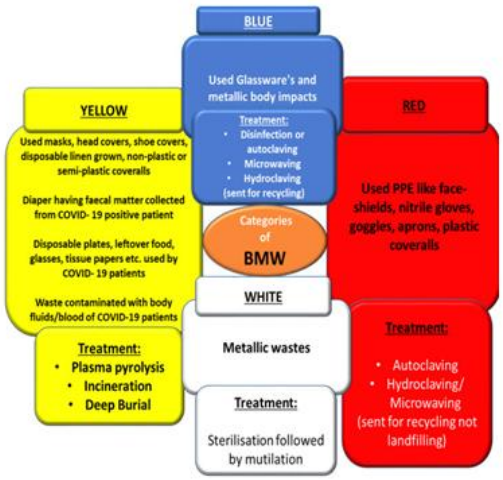

Figure 3 (a): BMW segregation guidelines by CPCB [7].

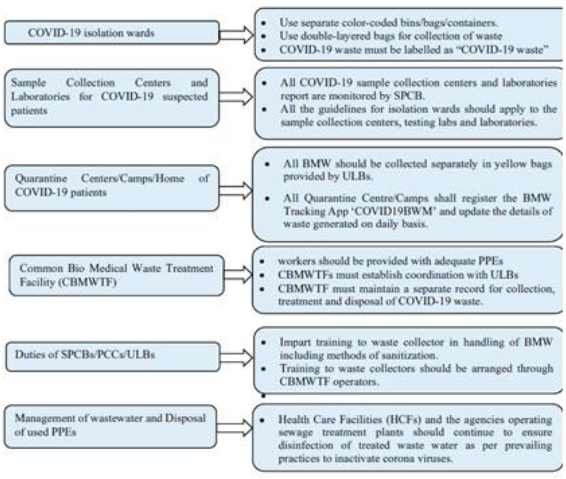

Figure 3 (a): CBMW management guidelines by CPCB [7, 21].

Table 3: COVID19BWM Application Usage Statistics

Month	Number of Treatment Facilities using the app	Number of generators using the app
August 2020	150	Over 5000
September 2020	174	6800
October 2020	181	6800
November 2020	184	100000 (approx)

December 2020	184	8000 (approx)
May 2021	186	5048
June 2021	193	13000

Source: CPCB [12-18].

As seen from Table 3, out of total 198 registered CBWTFs across the country, 193 are reporting the waste treatment activities on the app. The generators comprise of bedded HCFs and the individual households under quarantine. The household data is updated by municipal bodies governing that area. As evident, reporting by the generators is very poor. Maximum usage of app by the generators was during November 2020 when around one lakh generators shared their waste generation information on the app. However, during May 2021, when almost 50% of the world's new COVID-19 cases were reported in India, only 5048 generated updated their details on the app. In June 2021, this number increased to 13000 but is still very low as number of waste generators is very high in our country. This points to the conclusion that serious lacunas exit in waste reporting in the country which further leads to another conclusion that actual amount of BMW generated in India is much higher than projected by CPCB.

IV. DISCUSSION AND WAY FORWARD

It is clearly visible from the analysis carried out in previous section that large gaps exist in the infrastructural capacity, monitoring, treatment and disposal capability and the level of awareness required for effectual management of CBMW in India. Many of the states do not have resources and facilities to carry out the BMW management practices prescribed by the authorities. States like Maharashtra, Karnataka, Gujrat and Haryana are better equipped to handle the waste crisis in comparison to the other states.

Increase in BMW is inevitable in the face of ongoing pandemic. However, in order to minimize the environmental contamination through air, water and land, safe handling and disposal of CBMW should be prioritized. The analysis of facts and figures presented in previous section shows that there is gross under-reporting on CBMW. An increase of 234% was reported in the number of covid-infected patients between September 2020 (first peak of COVID-19 in India) and May 2021 (second peak) while the CBMW increased only by a meagre 11% during the same period. Although this disproportion has been attributed to proper segregation of BMW, under-reporting on CBMW is a matter of serious concern. While we are taking all the possible measure such as use of protective gears (e.g. masks, gloves, PPEs etc), frequent sanitization, social distancing and vaccination; the backdoor should not be left ajar for COVID-19 to spread through waste. As per a study [22], only 70% of BMW is disposed of in India and remaining 30% is either dumped illegally in the landfills or ends up as common garbage along the road-sides or it is burned openly. Open burning of BMW releases many harmful components in the environment and leads to public health risk. In a populous country with very limited healthcare facilities, scientific treatment and disposal of BMW will result in healthier population and reduced expenditure on healthcare services. For proper and scientific management of BMW, adequate infrastructure, technical knowledge, human and financial resources are required. So capacity building needs to be emphasized by providing necessary skills through training and acquiring modern equipments for safe and effective handling of hazardous waste. Also the regulations imposed by the authorities should be enforced strictly.

In addition to incorporating the above measures, attitudinal and behavioural changes should be promoted among citizens through awareness campaigns on adverse effects of untreated BMW and benefits of source-level segregation. Waste should not be considered as the headache of waste management authorities only. Instead the entire community should devote their time and effort to solve the problem of waste management. Infectious and non-infectious waste from households should be collected separately in order to prevent unauthorized dumping of the infectious BMW. Other potential measures to reduce the generation of BMW include promoting reusable masks and gloves, avoiding use of PPEs in non-COVID areas etc.

V. CONCLUSION

Comprehensive assessment of current scenario for BMW management in India has been carried out in this paper. It has been found that most of the states/UTs do not have sufficient resources for waste management and therefore average amount of untreated BMW on a daily basis is very high. There is an urgent requirement to invest in waste management infrastructure and skilled human resources in order to increase the capacity as well as the coverage so that India becomes future ready to face any COVID-19 like emergency. Innovation in the area of environment-friendly technologies for BMW management should be emphasized. Awareness campaigns should be at the heart of waste management practices so that the citizens improve upon their waste generating habits.

REFERENCES

[1]. Mathur P, Patan S and Shobhawat AS, Need of biomedical waste management system in hospitals-An emerging issue-a review. *Current World Environment* Vol. 7, pp. 117–124, 2012.

[2]. WHO (2014) Safe management of wastes from health-care activities. A summary, *The World Health Organization*. Available at: https://apps.who.int/iris/bitstream/handle/10665/259491/WHO-FWC-WSH-17.05-eng.pdf

[3]. Rahman MM, Bodrud-Doza M, Griffiths MD, et al. Biomedical waste amid COVID-19: perspectives from Bangladesh. *The Lancet Global Health*, Vol. 8, pp. 1262, 2020.

[4]. State of India's Environment Report, 2021.

[5]. ASSOCHAM India, Unearthing the Growth Curve and Necessities of Bio-Medical Waste Management in India-2018.

[6]. CPCB (2019) Annual Report on Biomedical Waste Management as per Biomedical Waste Management Rules, 2016 For the year 2019. Central Pollution Control Board. Available at: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/AR_BMWM_2019.pdf.

[7]. CPCB (2020a) Revision 4: Guidelines for handling, treatment and disposal of waste generated during treatment/diagnosis/quarantine of COVID-19 patients. Central Pollution Control Board. Available at: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/BMW-GUIDELINES-COVID_1.pdf

[8]. Anwer M and Faizan M, Solid waste management in India under COVID19 pandemic: Challenges and solutions. *International Journal of Research in Engineering and Technology*, Vol. 9, pp. 368–373, 2020.

[9]. Worldometer. https://worldometers.info/coronavirus.

[10]. Nghiem LD, Morgan B, Donner E, Short MD, The COVID-19 pandemic: considerations for the waste and wastewater services sector. *Case Studies in Chemical and Environmental Engineering*, Vol. 1, pp. 100006, 2020.

[11]. CPCB (2020b) Scientific Disposal of Bio-Medical Waste arising out of Covid-19 treatment - Compliance of BMWM Rules, 2016 before Hon'ble National Green Tribunal, Principle Bench, New Delhi. Central Pollution Control Board. Available at: https://greentribunal.gov.in/sites/default/files/news_updates/Status%20Report%20in%20O.A%20No.%2072%20of%202020.pdf

[12]. CPCB (Aug 2020) Generation of COVID19 related Biomedical Waste in States/UTs in August 2020. Available at: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/COVID19_Waste_Management_status_August2020.pdf

[13]. CPCB (Sep 2020) Generation of COVID19 related Biomedical Waste in States/UTs in September 2020. Available at: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/COVID19_Waste_Management_status_September2020.pdf

[14]. CPCB (Oct 2020) Generation of COVID19 related Biomedical Waste in States/UTs in October 2020. Available at: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/COVID19_Waste_Management_status_October2020.pdf

[15]. CPCB (Nov 2020) Generation of COVID19 related Biomedical Waste in States/UTs in November 2020. Available at: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/COVID19_Waste_Management_status_November2020.pdf

[16]. CPCB (Dec 2020) Generation of COVID19 related Biomedical Waste in States/UTs in December 2020. Available at: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/COVID19_Waste_Management_status_December2020.pdf

[17]. CPCB (Jan-May, 2021) Generation of COVID19 related Biomedical Waste in States/UTs in Jan-May 2021. Available at: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/COVID19_Waste_Management_status_Jan_May_2021.pdf

[18]. CPCB (June 2021) Generation of COVID19 related Biomedical Waste in States/UTs in June 2021. Available at: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/COVID19_Waste_Management_status_June_2021.pdf

[19]. CPCB Bio-medical Waste Management Rules, 2016 (Amended 2019). Available at: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/BMW_Amended_10.05.2019.pdf

[20]. Covid19BWM app. User manual available at: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/V1_COVID-19_BMW_Tracking_App.pdf

[21]. Rahul Rajak, Ravi Kumar Mahto, Jitender Prasad and Aparajita Chattopadhyay. Assessment of bio-medical waste before and during the emergency of novel Coronavirus disease pandemic in India: A gap analysis, *Waste Management & Research*, pp. 1-12, 2021.

[22]. Satviki Sanjay, WHERE DOES IT ALL GO: Every Day, India Produces Nearly 146 Tons of Covid19-Related Biomedical Waste, *The SWADDLE*, March 2021.