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Std : TY Bsc(Statistics)

Subject : Bio-Statistics

Topic : Management Of Bio – Medical Waste In India

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1.Introduction

Biomedical waste refers to any waste that includes anatomical waste, pathological waste, infectious waste, hazardous waste and other waste generated in health care facilities and medical laboratories that require special handling. Hospitals and other healthcare establishments have a ‘duty of care’ for the environment, public health and have particular responsibilities in relation to the waste they produce (i.e. biomedical waste). Negligence in terms of biomedical waste management significantly contributes to polluting the environment and affects the health of human beings. The waste

generated by any hospital/health care facilities consists of general waste like packaging material, eatables, paper, wrapper, etc. hazardous and infectious waste like outdated medicines, cytotoxic drugs, soiled dressing, swabs, cotton with blood and body fluid, dissected body organs and tissues, disposable syringes, intravenous fluid bottles, injectors, gloves, injection vials, needles, blades, scalpels, etc. Quantity wise around 70-80 per cent is general waste and 20-30 per cent is hazardous and infectious waste which poses risk to human health and environment. As per biomedical waste rules, 1998 and amendments, any waste, which is generated during the diagnosis, treatment or immunisation of human beings or animals or in research activities pertaining there to or in the production of testing of biological and including categories mentioned in schedule 1 of the Rule, is the biomedical waste. As per WHO norms the healthcare waste includes all the waste generated by healthcare establishments, research facilities, and laboratories. In addition, it includes the waste originating from minor or scattered sources such as that produced in the course of healthcare undertaken in the home (dialysis, insulin injections, etc.)

Biomedical Waste Management Rules, 2016

Govt. of India has notified Biomedical Waste Management Rules, 2016 (BMWM Rules, 2016) under the Environment (Protection) Act, 1986 in the year 2016. These Rules stipulate various provision for collection, segregation, processing, treatment and disposal of bio-medical wastes in an environmentally sound manner. As per the BMWM Rules, 2016 the biomedical waste generated in Healthcare Facilities should be collected, transported, treated and disposed-off through Common Biomedical Waste Treatment Facilities (CBWTFs). The Rules defines duties for Occupier which include hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories, etc.), duties of the operator of CBWTFs and duties for authorities like Ministry of Environment Forest & Climate Change (MoEF & CC), Ministry of Health & Family Welfare (MoH & FW), Ministry of Defence (MoD), Central Pollution Control Board (CPCB), State Government of Health (GoH), State Pollution Control Boards (SPCBs)/Pollution Control Committees (PCCs) and Municipalities or Urban Local Bodies (ULBs).

Annual Report on Biomedical Waste Management

As per BMWM Rules, 2016 every occupier or operator of common bio-medical waste treatment facility (CBWTF) shall submit an annual report to the prescribed authority i.e. SPCBs/PCCs on or before the 30th June of every year. Thereafter, the prescribed authority shall compile, review and analyse the information received and send to Central Pollution Control Board on or before the 31st July of every year. The BMWM Rules, 2016 Annual Reports shall also be available online on the websites of Occupiers, SPCB/PCC and CPCB. The occupier or operator of CBWTF through this report provide

the information regarding the waste generated, collected in the facility, amount of biomedical waste treated, disposal facilities utilised, amount of treated biomedical waste sent to recyclers, number of vehicles used in collection of biomedical waste, trainings, accidents, violations of BMWM Rules, 2016, etc. These details help in analysing status of the biomedical waste across the country, identifying the gaps in the biomedical waste management and addressing the shortcoming in the upcoming year for effective management of biomedical waste and implementation of BMWM Rules, 2016.

States and UTs namely Andaman & Nicobar, Arunachal Pradesh, Bihar, Chhattisgarh, Chandigarh, Delhi, DD & DNH, Goa, Gujarat, Himachal Pradesh, J&K, Karnataka, Kerala, Ladakh, Lakshadweep, Madhya Pradesh, Mizoram, Meghalaya, Nagaland, Odisha, Puducherry, Punjab, Sikkim, Telangana, Tamil Nadu, Rajasthan, Tripura, Uttarakhand and West Bengal & DGAFMS submitted the annual report information before July, 2023. However, SPCBs namely Andhra Pradesh, Assam, Jharkhand, Manipur, Maharashtra, Haryana, Uttar Pradesh submitted the annual report information after July, 2023.

The following common gaps/discrepancies were observed in the annual report information received from SPCBs/PCCs and communicated to respective States/UTs for clarification and rectification.

i) 11,093 HCFs are using the deep burial for disposal of biomedical waste.

ii) 24,705 HCFs are operational without authorisation. **iii)** 17,490 HCFs are still using captive treatment facility.

Brief Summary of Bio-medical Waste Management in India

In year 2022, about 705 tonnes/day of biomedical waste was generated in the country, out of which 645 tonnes/day BMW was treated and disposed-off through CBWTFs and Captive treatment facilities. There are 3,93,939 no. of HCFs in the country, out of which 1,25,259 no. of HCFs are bedded with a total of 24,65,063 number of beds and 2,67,155 no. of HCFs are non-bedded. 3,10,809 no. of HCFs that is around 79% of HCFs utilise the facilities of CBWTFs for the collection, treatment, & disposal of biomedical waste, while 17,490 no. that is around 4.4 % of HCFs have captive treatment facilities for the treatment and disposal of biomedical waste. A gap of 16% of HCF is reported that are neither using CBWTF nor CTF.

A gap of around 8.5% is reported between the generation and disposal of the BMW in the country, as per response received from SPCBs/PCCs the gap is due for information not received from CBWTFs or deep burials. There are 218 no. of CBWTFs in operation and 34 no. of CBWTFs are under construction.

No. of HCFs	3,93,939
No. of bedded HCFs	1,25,259
No. of non-bedded HCFs	2,67,155
No. of beds	24,65,063
No. of CBWTFs	218* + 34**
No. of HCFs granted authorization	1,56,637
No. of HCFs utilizing CBWTFs	3,10,809
No. of HCFs having Captive Treatment Facilities	17,490
No. of Captive Incinerators Operated by HCFs	153
Quantity of BMW generated in tons/day	705
Quantity of BMW treated in tons/day	645
No. of HCFs/CBWTFs violated BMW Rules	22,306
No. of Show-Cause notices/Directions issued to defaulter HCFs/CBWTFs	8291

Note: (i) * - CBWTFs in operation (ii) ** - CBWTFs under construction

Comparison of BMWM in 2021 and 2022

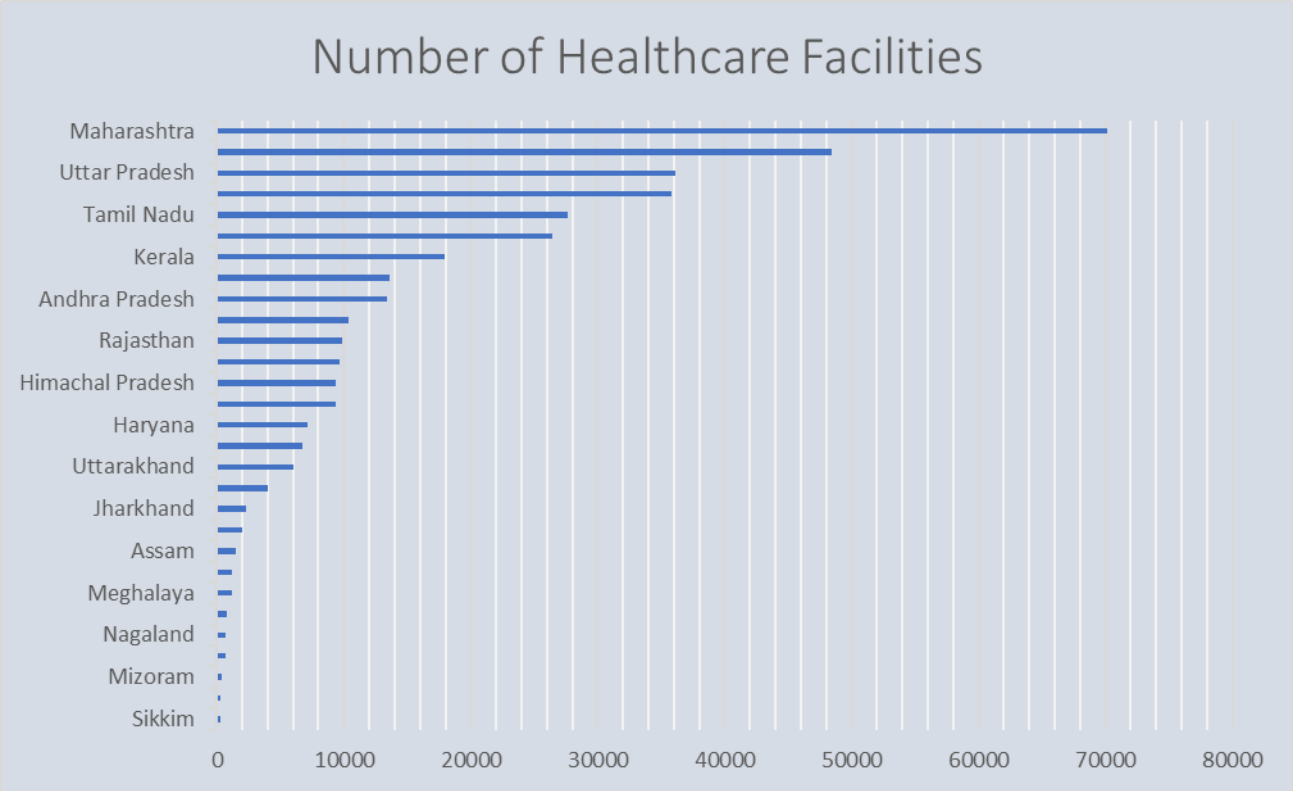
As per the annual report information for year 2022, 705 tons of BMW waste was generated in the country per day which is less than the generation of biomedical waste (764 tons per day) in year 2021. 59 tons (about 8%) of biomedical waste was generated less per day in 2022 in comparison to 2021 which may be due to increased quantity of biomedical waste during COVID-19 pandemic. Around 5% of increase in the total number of healthcare facilities have been reported in year 2022 as compared to 2021. Annual report information shows that 3 new CBWTF were added in 2022 for the treatment & disposal of generated biomedical waste. Also, increase in number of HCFs utilising CBWTFs was observed to be increased from 2,62,786 to 3,10,809 from year 2021 and 2022, respectively. The captive treatment facilities are majorly operational in regions where CBWTFs is not accessible. Detailed comparison of biomedical waste management BMWM scenario during 2021 and 2022 is mentioned in Table below:

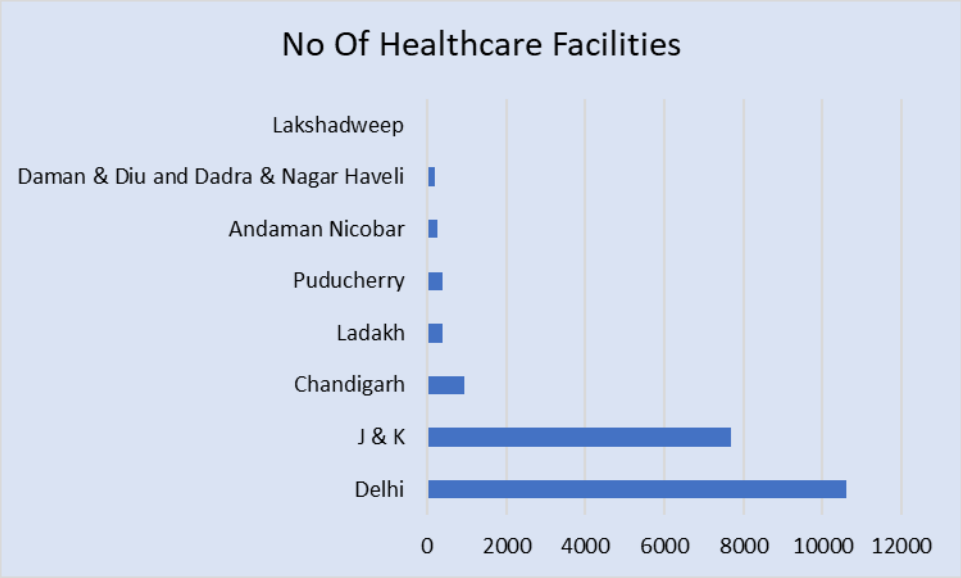
Particulars	Year 2021	Year 2022
No. of HCFs	3,75,256	3,93,939
No. of bedded HCFs	1,21,396	1,25,259
No. of non-bedded HCFs	2,53,860	2,67,155
No. of beds	25,61,295	24,65,063
No. of CBWTFs	215* + 35**	218* + 34**
No. of HCFs utilizing CBWTF	2,62,786	3,10,809
No. of HCFs granted Authorization	3,20,751	1,56,637
No. of HCFs having Captive Treatment Facilities	13,605	17,490
No. of Captive Incinerators Operated by HCFs	102	153
Quantity of BMW generated (Tonnes/day)	764 (684 Non COVID BMW+80 COVID BMW)	705
Quantity of BMW treated (Tonnes/day)	721	645
No. of HCFs violated BMW Rules	23,199	22,306
No. of Show-cause notices/Directions issued todefaulter HCFs	15,355	8291

1.Availability of Healthcare Facilities

As per BMWM Rules, 2016, health care facility means a place where diagnosis, treatment or immunisation of human beings or animals is provided irrespective of type and size of health treatment system, and research activity pertaining thereto. It includes bedded and non-bedded

HCFs.





As per the annual report information received from SPCBs and PCCs for the year 2022, there are 3,93,939 no. of HCFs, out of which 1,25,259 no. of HCFs are bedded and 2,67,155 no. of HCFs are non-bedded. Detail of number of HCFs in states/UTs and DGAFMS are given in figures .

In case of states

and Uttar Pradesh. Sikkim has the lowest number of health care facilities followed by Arunachal Pradesh and Mizoram.

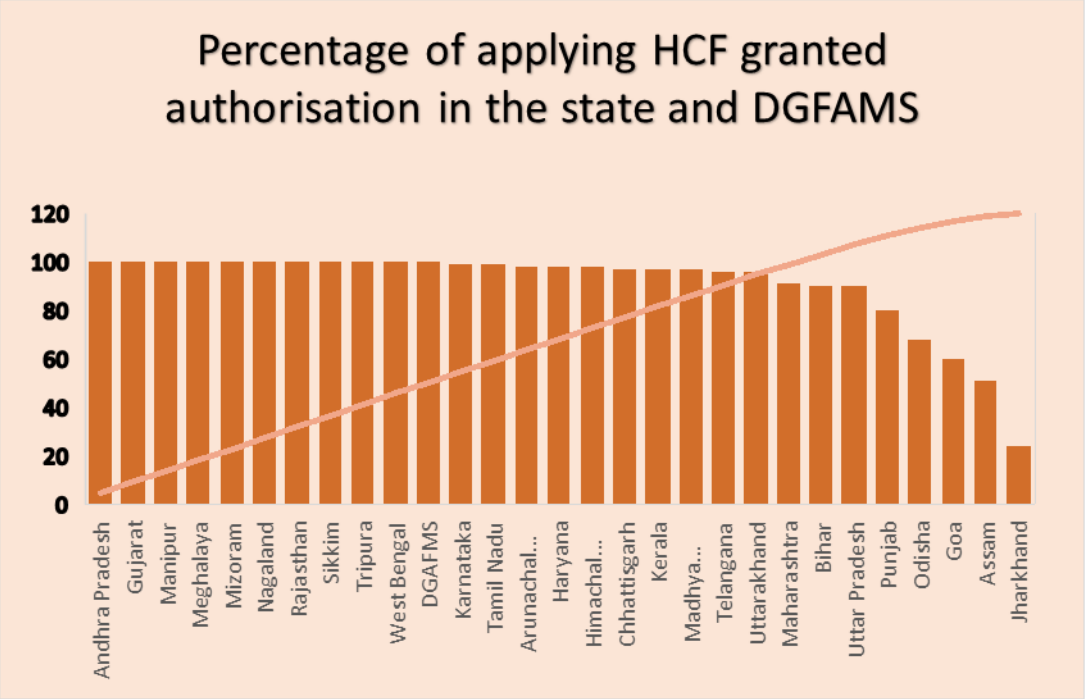
In case of Union territories

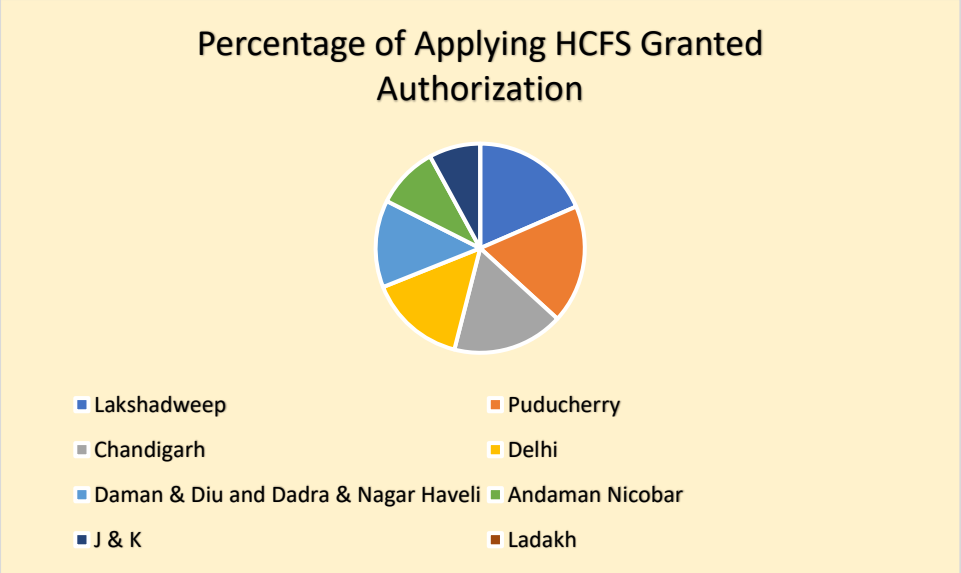
Delhi has the highest number of health care facilities and the lowest healthcare facilities are present in Lakshadweep. Number of healthcare facilities generally depends on the geographical area of the state/UT, population density, availability of the health workers, financial restrains of state, workload of healthcare facility, etc.

2.Authorisation of Healthcare Facilities

Authorization is a process which brings HCFs and CBWTFs under the purview of BMWM Rules, 2016. BMWM Rules, 2016 stipulate that every healthcare facility (bedded & non bedded) require to obtain authorization from concerned SPCB/PCC. It has been observed that there are HCFs not yet authorized which is a violation of BMWM Rules, 2016. SPCB/PCC should ensure authorization of every HCFs under BMWM Rules, 2016

Percentage of applying HCF granted authorisation in the state and DGFAMS





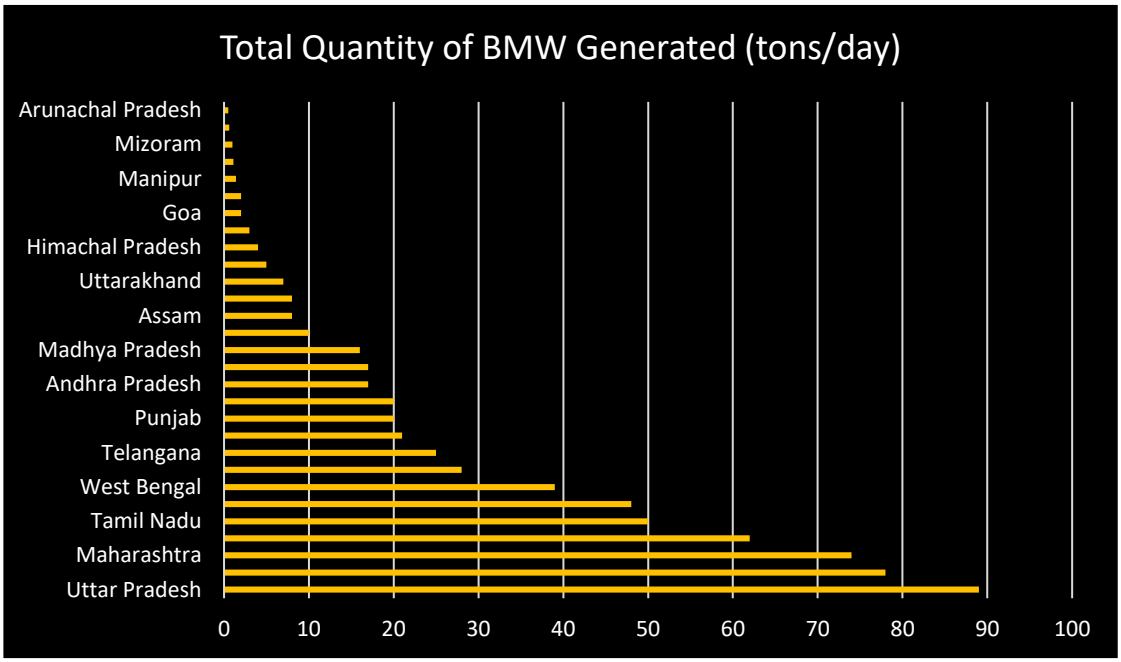
Percentage of applying HCFs granted authorisation in UTs

HCFs of States/UTs namely Andhra Pradesh, Gujarat, Kerala, Lakshadweep, Manipur, Meghalaya, Mizoram, Nagaland, Rajasthan, Sikkim, Tripura and West Bengal have reported no HCF operating without authorisation. The States/UTs which has no HCF operating without authorisation are Delhi, Lakshadweep, Manipur, Mizoram, Nagaland and Puducherry, Tripura and West Bengal.

3.Status of Biomedical Waste Generation

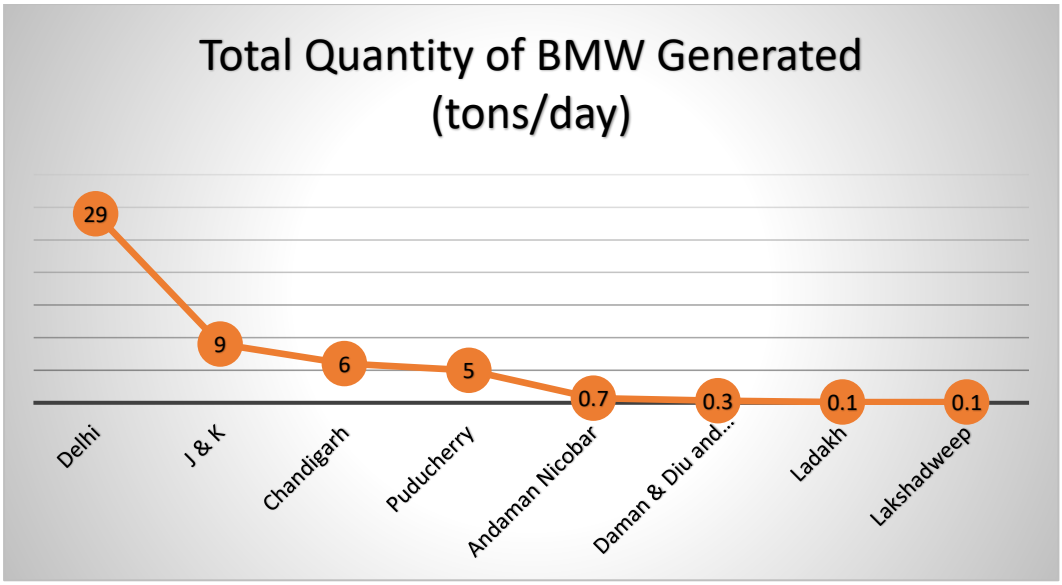
. Biomedical Waste Generation Bio-medical waste means any waste, which is generated during the diagnosis, treatment or immunisation of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps, including the categories mentioned in BMWM Rules, 2016. As reported by SPCBs/PCCs, about 705 tonnes/day of BMW were generated during the year 2022 by 3,93,939 numbers of HCFs. The biomedical waste production generally depends on the number of healthcare facilities present in the state, population density, type of healthcare facility, etc. the quantity of biomedical waste

produced in the states and UT in 2022 given in figure.



Total Quantity of BMW generated (tons/day) in different states and DGFAMS

- Uttar Pradesh has the highest BMW generation with 89 tons/day.
- West Bengal and Karnataka are next in line with 39 and 78 tons/day respectively.
- Tamil Nadu and Gujarat are also noteworthy with 50 and 48 tons/day respectively.
- Several states have very low BMW generation, less than 10 tons/day.
- The majority of states generate between 10 and 50 tons/day.
- The data shows a wide variation in BMW generation across different states, indicating potential differences in waste management practices and industrial activity

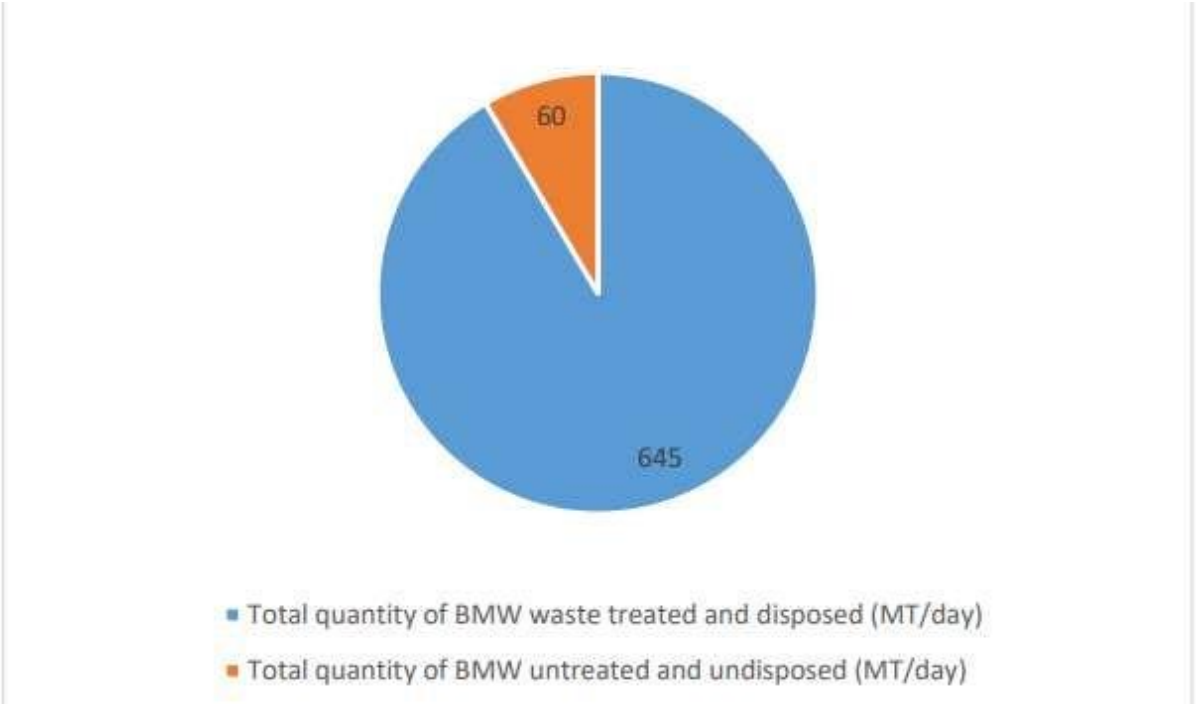
- 

Total Quantity of BMW generated (tons/day) in different UT

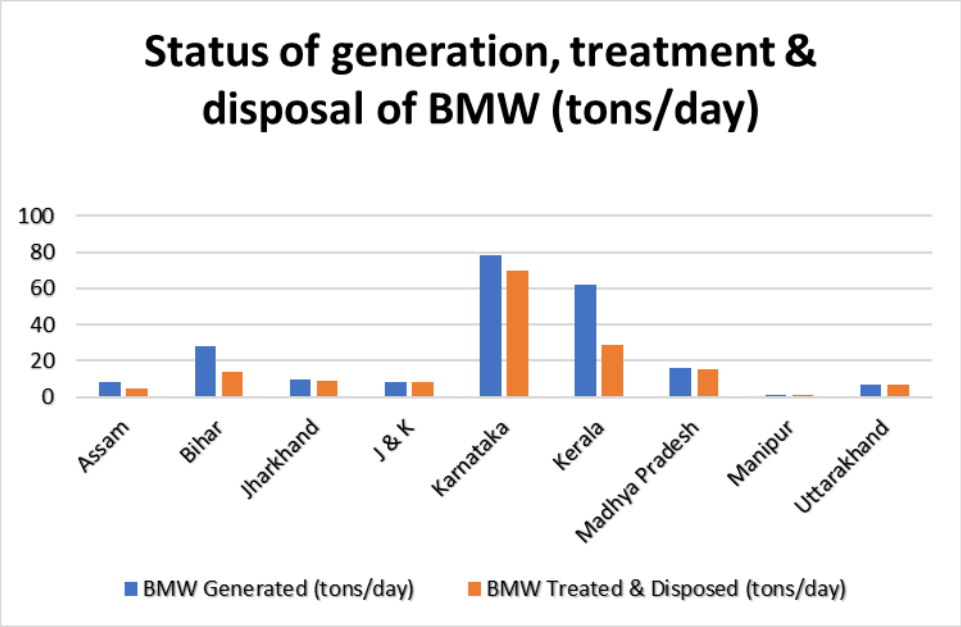
- Delhi generated 29 tons of BMW per day, which is significantly higher than any other state or union territory.
- Chandigarh generated the second-highest quantity of BMW at 6 tons per day.
- The remaining states and union territories generated a significantly lower amount of BMW, with most generating less than 1 ton per day

4.Treatment of Biomedical waste

Bio-medical waste shall be treated and disposed of in accordance. Out of 705 tonnes/day of BMW generated in the country in 2022, 645 tonnes/day of BMW is treated and disposed of by CBWTFs and captive treatment facilities (CTFs) installed by Healthcare Facilities.



As per Annual report information for year 2022, there is a gap between biomedical waste generation and its treatment & disposal. Figure depicts the amount of BMW treated and disposed of, as well as the gap between treatment and disposal. For environment friendly disposal of BMW there should be no gap between generation and treatment & disposal of biomedical waste. However, the gap in generation, treatment & disposal has been observed in States namely Assam, Bihar, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Meghalaya and Uttarakhand .Among the above States, the gap in generation, treatment, and disposal has also been observed in 2021 for Assam, Bihar, Karnataka, Jharkhand, Karnataka, Madhya Pradesh while the states of Himachal Pradesh, Nagaland and Tripura has overcome the gap in 2022 for the generation and treatment of BMW. CPCB has communicated the gaps observed to the respective SPCB/PCC to rectify the issue and ensure the disposal of all BMW generated in accordance with the BMWM Rules, 2016.



Status of generation, treatment & disposal of BMW (tons/day)

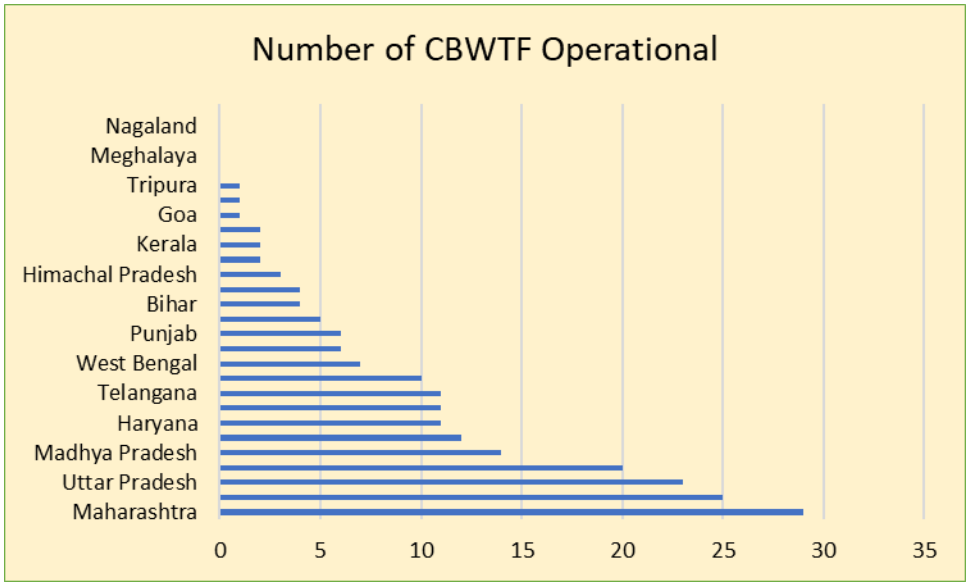
(The data for the rest was not supplied to the Government)

5.Status of Common Biomedical Waste Treatment Facilities (CBWTF)

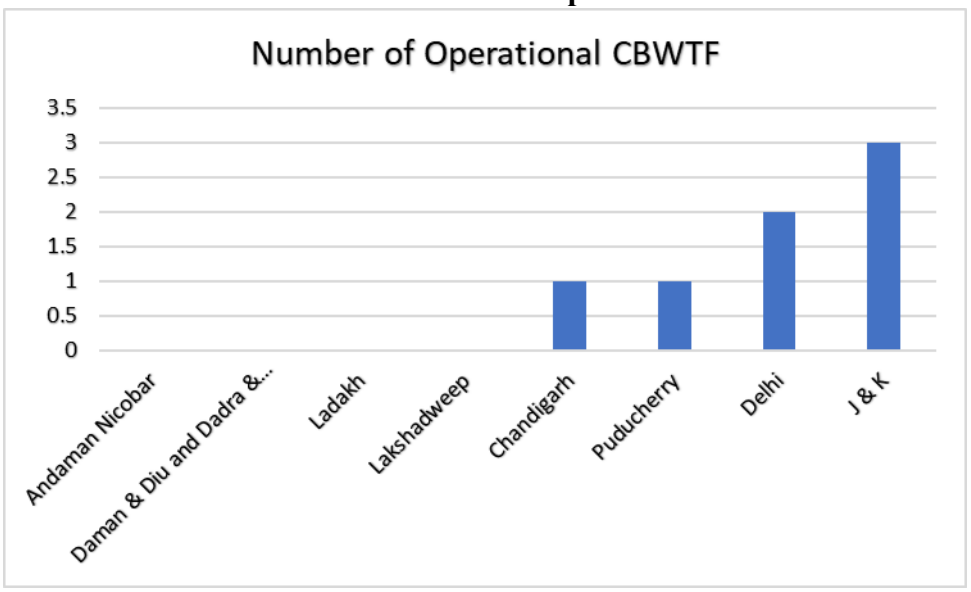
Availability of CBWTF

CBWTF means any facility which is involved in collection, treatment and disposal of biomedical waste. As per BMWM Rules, 2016, it is the duty of CBWTF operator to take all necessary steps to ensure that the BMW collected from the occupier is transported, handled, stored, treated and disposed of, without any adverse effect to the human health and the environment, in accordance with BMWM Rules, 2016 and guidelines issued by the CPCB.

As per the Annual Report Information submitted by SPCBs/PCCs for the year 2022, currently there are 218 numbers of CBWTFs operated in the Country and 34 CBWTFs are under construction. In year 2022, there is increase in number of CBWTFs in Assam, Chhattisgarh, Punjab, Tripura and West Bengal as compared to year 2021. Andaman and Nicobar, Arunachal Pradesh, Laddakh, Lakshadweep, Mizoram, Nagaland and Sikkim have reported that no CBWTF is present in the State/UTs. Daman & Diu and Dadra & Nagar Haveli utilises the CBWTF of Gujarat state for treatment of biomedical waste. Similarly, Lakshadweep is utilising the facility of CBWTF situated in Kerala. In rest reported states the disposal of Biomedical waste is undertaken using the Captive treatment facility or deep burials. In this regard, CPCB requested such SPCBs/PCCs for submitting the proposal for setting up of
CBWTFs for which they may avail financial assistance from Ministry of Environment Forests & Climate Change. No. of CBWTF present in state and UTs is represented in fig.



No. of CBWTFs operational in the States



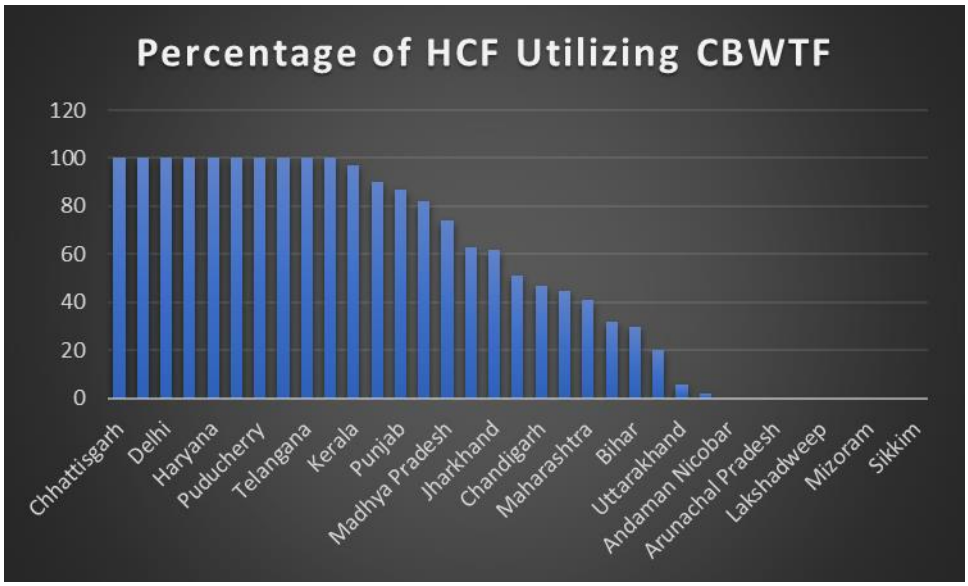
No. of CBWTFs operational in the UTs

The availability of CBWTFs operated in States varies based on the area of the State, population density, number of HCFs in the states/UT, capacity of the CBWTF, accessibility of CBWTF, etc. New CBWTF are under currently reported to be under construction in the states of Andhra Pradesh, Chhattisgarh, Gujarat, Himachal Pradesh, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal.

Utilisation of CBWTF

As per Rule f the BMWN rules, 2016, "no occupier shall establish on-site treatment and disposal facility, if a service of common biomedical waste treatment facility is available at a distance of seventy-five kilometre". As per Annual Report information for year 2022, all HCFs operational in States/UTs namely Chandigarh, Delhi, Gujrat, Haryana, Puducherry, Tamil

Nadu, Telangana and West Bengal are using CBWTF for treatment and disposal of biomedical waste. Less than 30 percent of HCFs are utilising CBWTF in the States/UT namely Meghalaya, Tripura, Assam and Bihar and is depended largely on the captive treatment and deep burials for treatment and disposal of biomedical waste. The reason of not using CBWTF is may be non-accessibility of CBWTF due to hilly terrain and presence of the HCF in the remote locations. States/UTs may look into the accessibility and come up with new CBWTFs to cover all HCFs in the State/UT. Utilization of CBWTFs by HCFs (in percentage) is given.

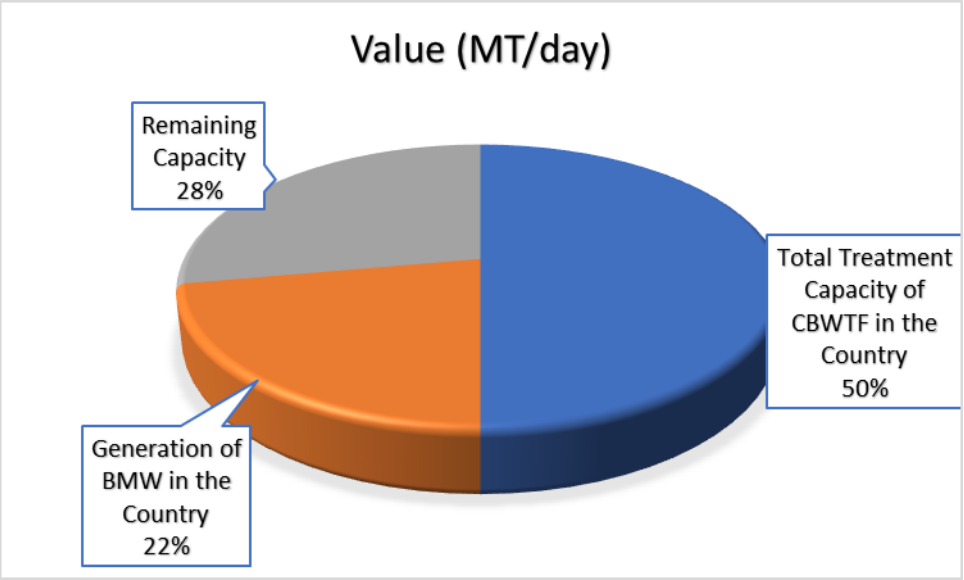


Percentage of HCF utilising the CBWTF in various states/UT

Capacity of CBWTF

The CBWTFs in the country are operating at cumulative treatment and disposal capacity of 1590 MT/day, of which incineration capacity is 858 MT/day and autoclave capacity is 732 MT/day. The present generation of 705 MT/day may look adequate for treatment and disposal of BMW. However, availability of CBWTFs may vary at State Level. Available treatment capacity of CBWTFs

and utilisation of capacity in the country is shown in fig.

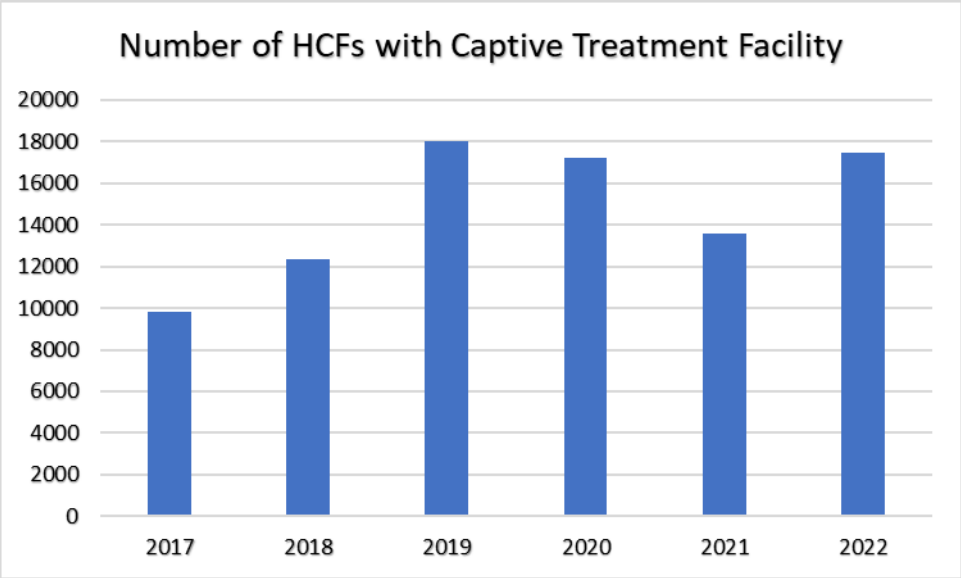


Treatment capacity available and utilization of capacity of CBWTFs in the country

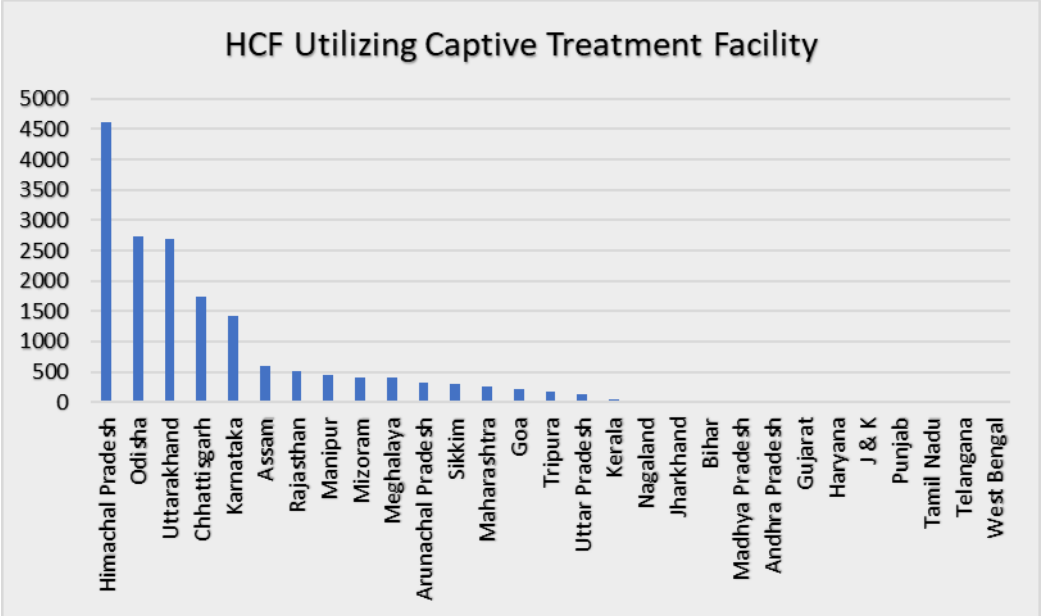
6.Status of Captive Treatment Facilities

BMWM Rules, 2016 restricts on-site treatment and disposal facility, if a service of CBWTF is available at a distance of 75 Km. In cases where service of the common bio-medical waste treatment facility is not available, the Occupiers shall set up requisite biomedical waste treatment equipment like incinerator, autoclave or microwave, shredder prior to commencement of its operation, as per the authorisation given by the prescribed authority. As per the annual report information submitted by SPCBs/PCCs, in 2022, 17,490 number of Healthcare Facilities in the country are utilising the captive treatment facility. Comparing to 2021, an increase in the number of captive treatment facilities operated by HCFs is reported in Further, CPCB has also issued directions to all SPCBs/PCCs regarding to ensure compliance

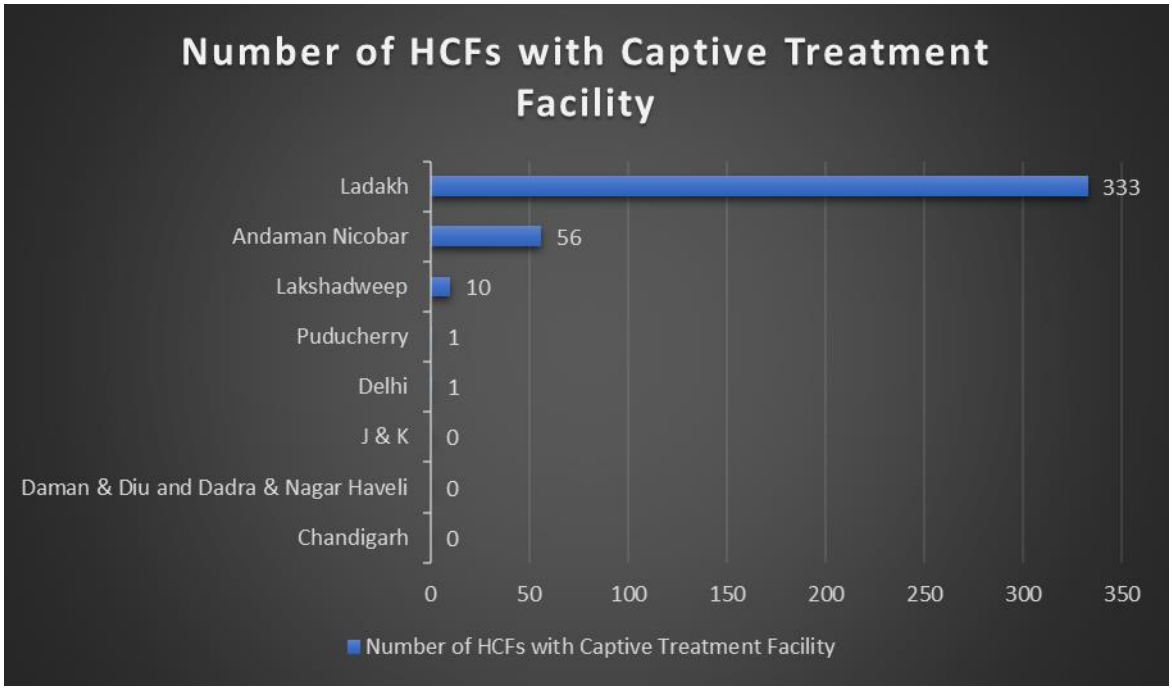
to the standards prescribed under BMWM Rules, 2016 by captive treatment facilities operated by HCFs.



Number of HCFs having captive treatment facilities



Number of HCF having captive treatment in different states

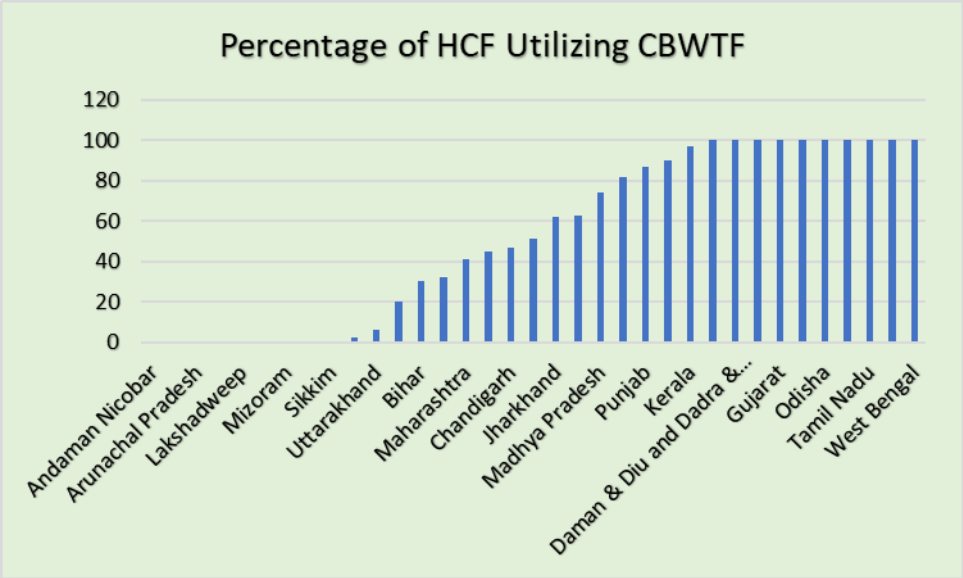


Number of HCF having captive treatment in different UTs

HCFs of the States/UT namely Andaman and Nicobar, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Ladakh, Lakshadweep, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Puducherry, Sikkim, Tripura, Uttarakhand and Uttar Pradesh are operating captive treatment facility (Fig. 14 & Fig. 15). Himachal Pradesh has reported to be using highest number of captive treatment facilities that is around 50% of the HCFs present in the states are using the CTF. In year 2022, no CTF are being utilised in the state of Andhra Pradesh, Goa, Gujrat Haryana, Punjab, Tamil Nadu, Telangana and West Bengal. In UTs, Ladakh has the highest number of HCF utilising the CTF.

The UT of Chandigarh, Daman and Diu and Dadar and Nagar Haveli and Jammu & Kashmir is having no CTF utilised by the HCF. The percentage of HCF out of total HCFs present in the states/UTs utilising the CTF are given in figure 16. 100% of the waste in Arunachal Pradesh, Mizoram and Lakshadweep is being disposed-off the CTF. These States/UT Should explore the

possibility of setting up of CBWTF.

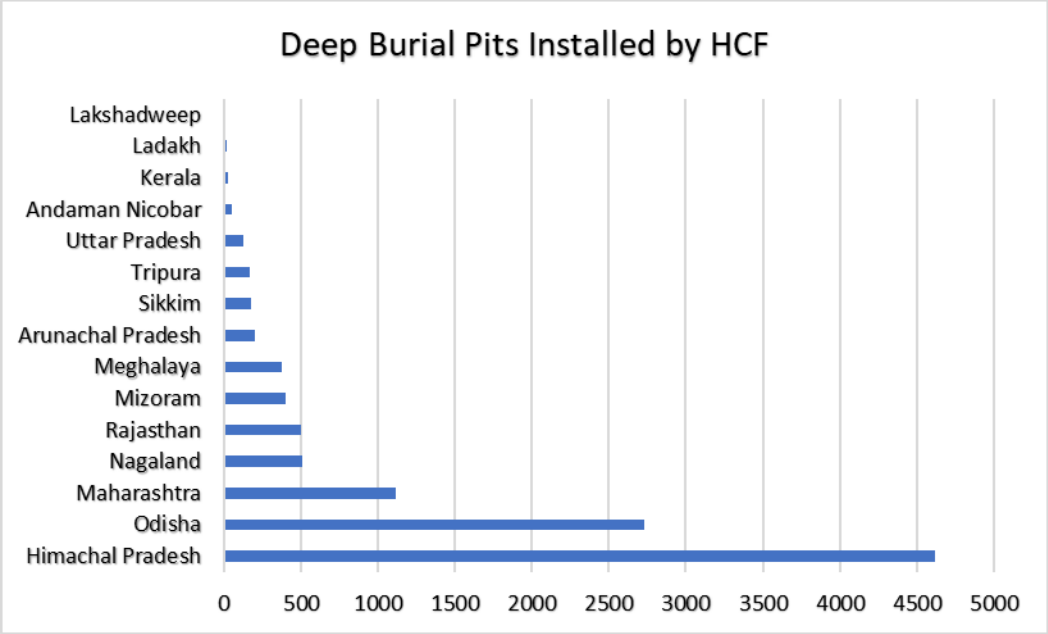


% of HCF utilising the CTF in various states and UT

6.Status of deep burial

Deep burial pits utilised by HCF

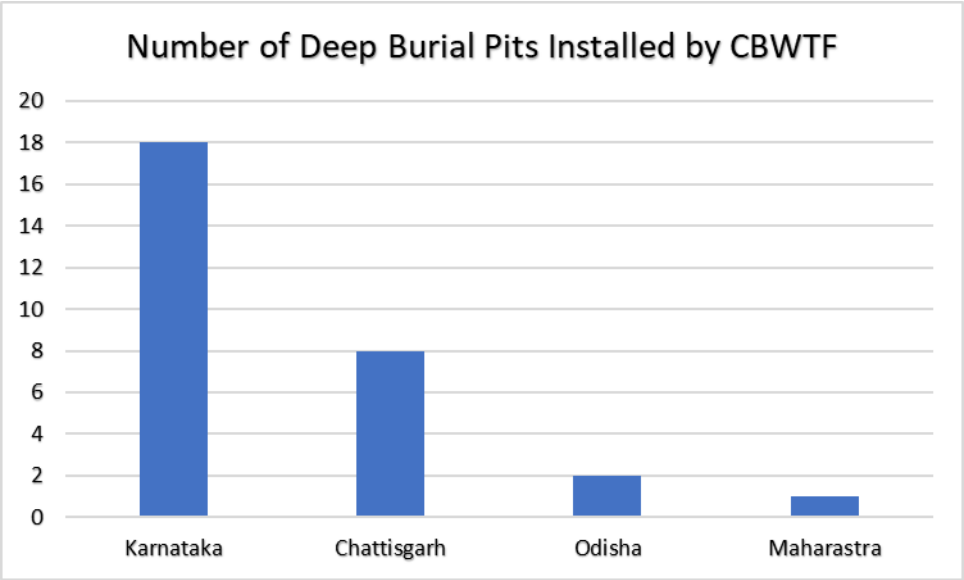
As per BMWM rules, 2016 disposal by deep burial is permitted only in rural or remote areas where there is no access to common bio-medical waste treatment facility. This will be carried out with prior approval from the prescribed authority and as per the Standards specified in Schedule-III. The deep burial facility shall be located as per the provisions and guidelines issued by Central Pollution Control Board from time to time. As per the information submitted by the SPCB/PCCs, deep burial pits installed by the HCFs of Andaman & Nicobar, Arunachal Pradesh, Himachal Pradesh, Jharkhand, Kerala, Ladakh, Lakshadweep,
Maharashtra, Meghalaya, Mizoram, Nagaland, Odisha, Puducherry, Rajasthan, Sikkim and Tripura. The status of deep burial pits installed by HCFs is given in fig. 17. Highest number of HCFs in Himachal Pradesh are using deep burial pits for disposal of BMW. But the numbers have decreased to 4618 in 2022 from 5174 in 2021. UT of Puducherry has lowest that is only one HCF using the deep burial for disposal of BMW.



Deep burial installed by HCFs in States/UTs

Deep burial pits utilised by CBWTF

As per the revised guidelines for CBWTFs, SPCB/PCC should not allowed deep burial of BMW as a part of CBWTF. Any existing CBWTF having disposal of BMW by deep burial should have the requisite treatment equipment as stipulated under the BMWM Rules. CPCB issued directions to all SPCBs/PCCs regarding verification of deep burial pits that authorized and designed in line with standards given under BMWM Rules, 2016. As per the response received by the Odisha PCB, the 2 deep burial pits though existing, are currently not in use. Response from other state boards are still awaited. Respective State Boards should initiate steps to set up CBWTF so as to avoid usage of deep burial pits.

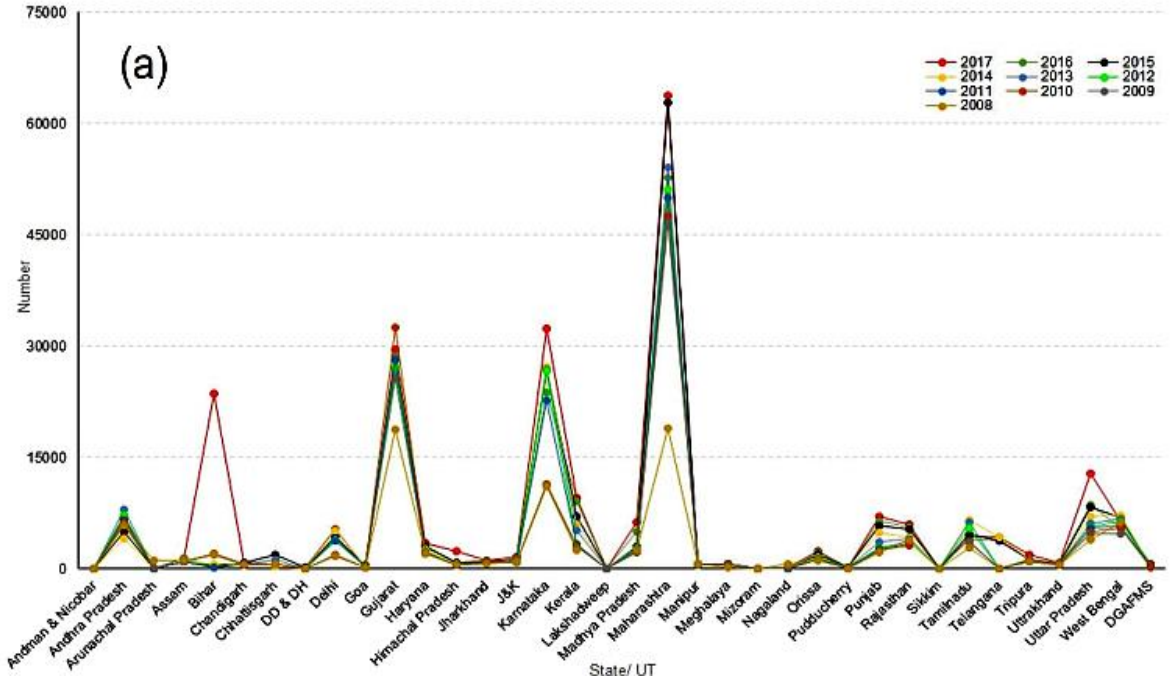


No. of deep burial pits installed by CBWTF

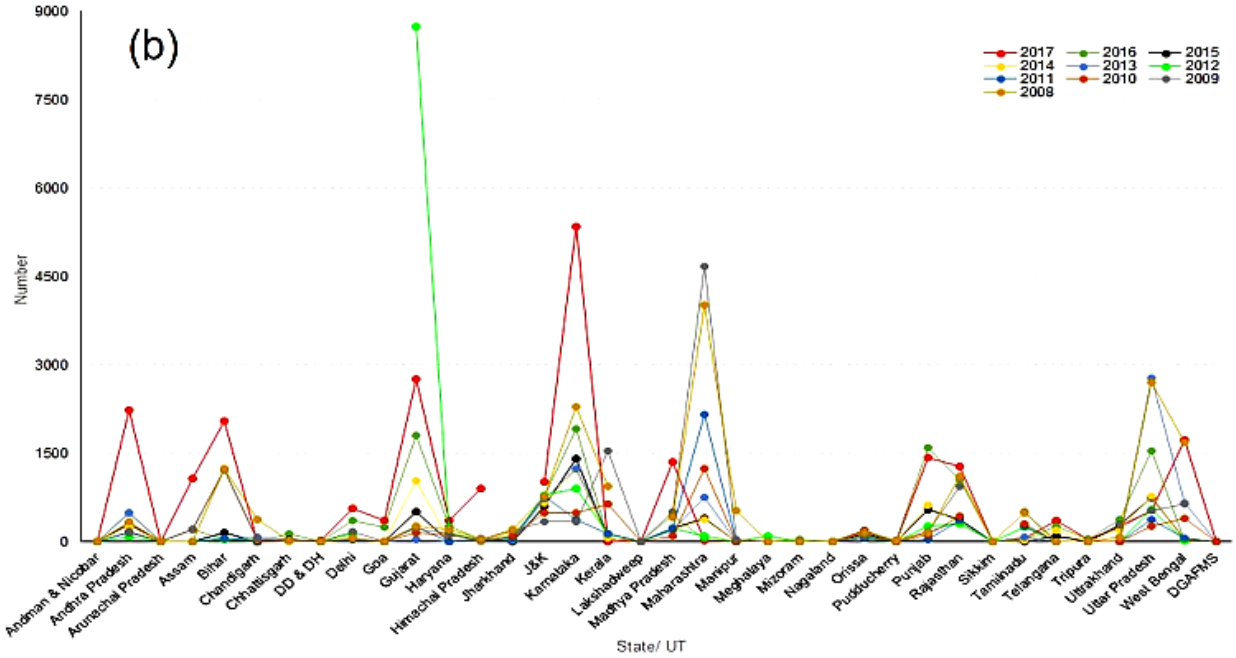
Other issues of concern w.r.to bio-medical waste management

- **100% HCFs are still not authorisation even after 7 years of the notification of the BMWM, 2016.**
- **HCFs are using captive waste treatment facilities in some states instead of CBWTF, SPCB are directed to undertake continuous monitoring of such facilities.**
- **There are less number of CBWTF present in some states in comparison to the population density and number of HCF present. States are required to increase the numbers of CBWTF present so more HCF can utilise CBWTF in place of captive treatment facility.**
- **District Level information of BMWM is not available in every State/UT which is required as per the BMWM Rules, 2016 as well as CPCB guidelines.**
- **Domestic biomedical waste is not collected separately from the households by the Urban Local Bodies as required under BMWM Rules, 2016.**
- **Some CBWTFs and HCFs in the States/UTs have installed deep burial and many of the States/UTs has not provided information w.r.to deep burial pits installed by HCFs. Status of compliance by deep burial should be verified by SPCBs/PCCs.**
- **Liquid waste treatment facility i.e ETP/STP is not installed by all bedded HCFs in the States.**
- **Gap analysis to assess the requirement of additional treatment facility to treat and dispose of the biomedical waste is not conducted as per CPCB guideline**

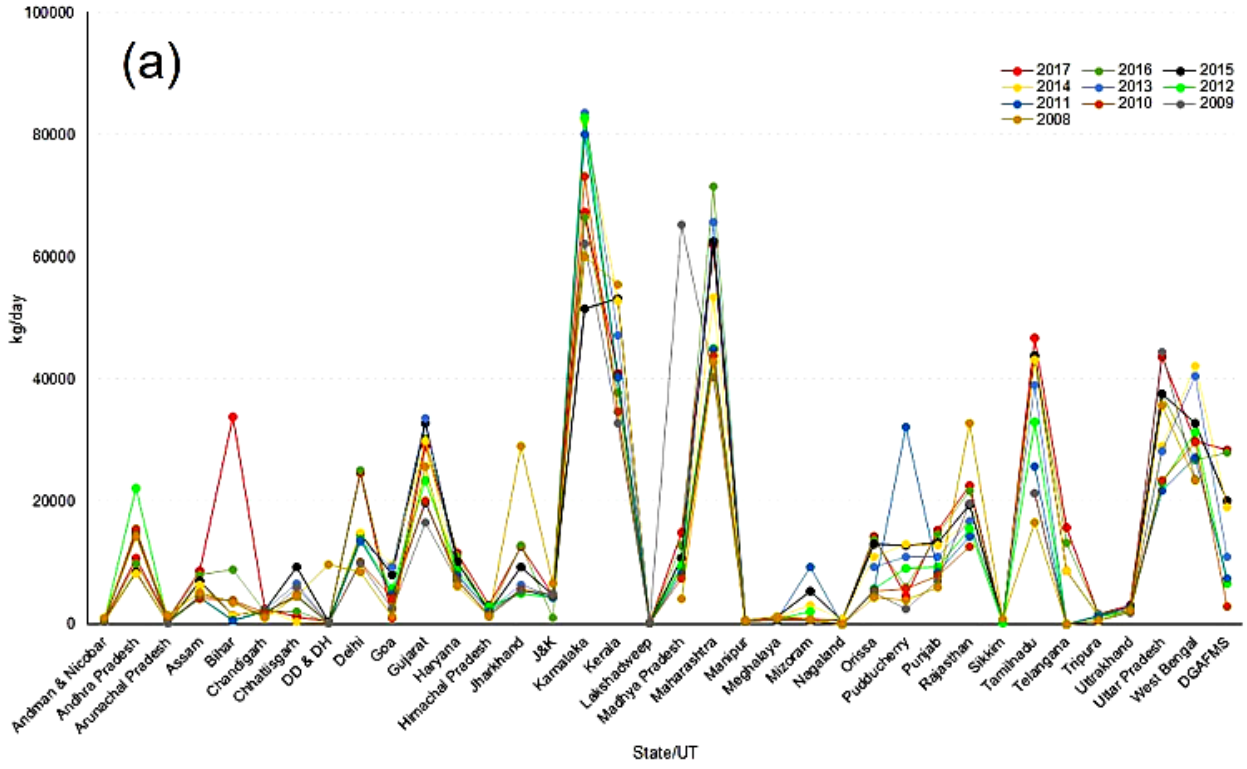
7. Time Series Data over the years:



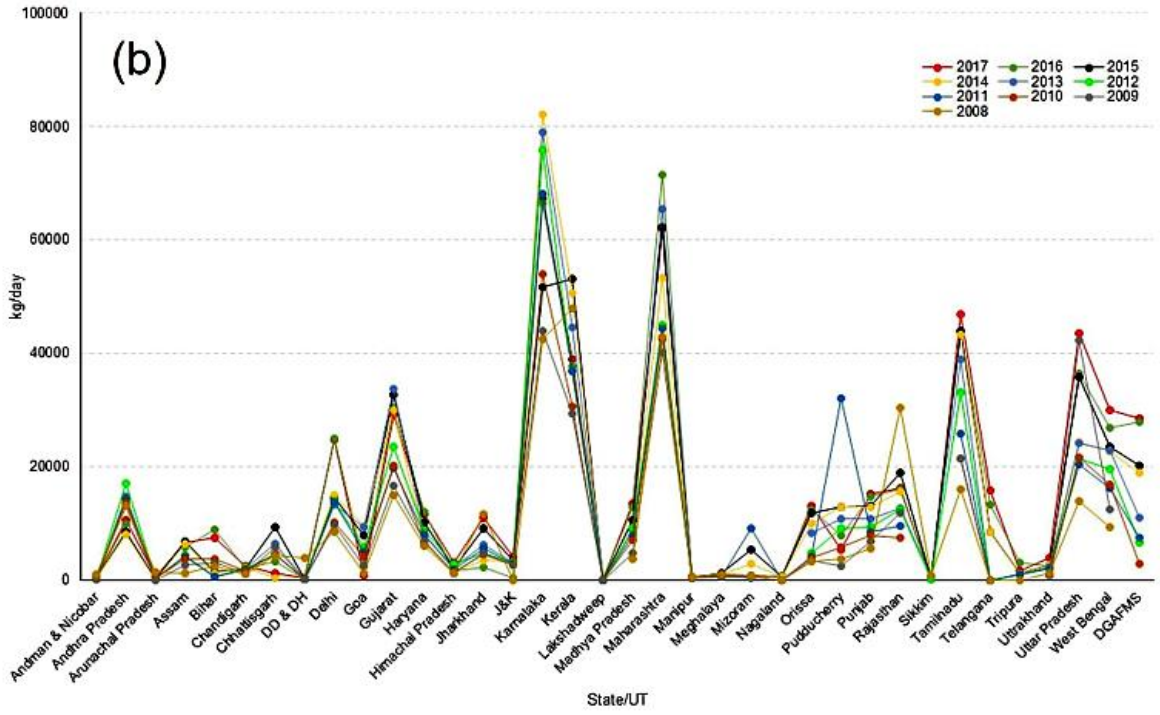
- **Regional Variations:** There are substantial differences in the number of healthcare facilities across different states and UTs. Some states, like Maharashtra, Madhya Pradesh, and Karnataka, consistently have a higher number of facilities compared to others like Nagaland, Mizoram, and Sikkim.
- **Increase in Healthcare Facilities:** Overall, there appears to be an increase in the number of healthcare facilities over the years for most states and UTs. However, the rate of increase varies across different regions.
- **Significant Increase in Certain States:** Some states, like Maharashtra, Manipur, and West Bengal, witnessed a significant increase in healthcare facilities between 2008 and 2017. In contrast, states like Nagaland and Mizoram have seen a relatively slower rate of increase.



- **Overall Trend:** The number of healthcare facilities violating bio-medical waste management rules has been generally declining, particularly in recent years, although this trend is not consistent across all states.
- **States with Higher Violations:** Some states, particularly Kerala, Gujarat, and West Bengal, have consistently had a higher number of violations compared to others, suggesting potential challenges in enforcing regulations in these areas.
- **States with Improvement:** States like Haryana and Karnataka have witnessed a significant drop in violations over the years, indicating successful implementation of stricter measures and better compliance.
- **Seasonal Fluctuations:** There might be seasonal or yearly variations in the number of violations, potentially linked to factors like changes in healthcare practices, staff turnover, or enforcement priorities.
- **Impact of Specific Years:** The spike in violations in 2017, particularly in Kerala and Gujarat, may be attributable to a specific regulatory change or a public health event that might have heightened scrutiny.



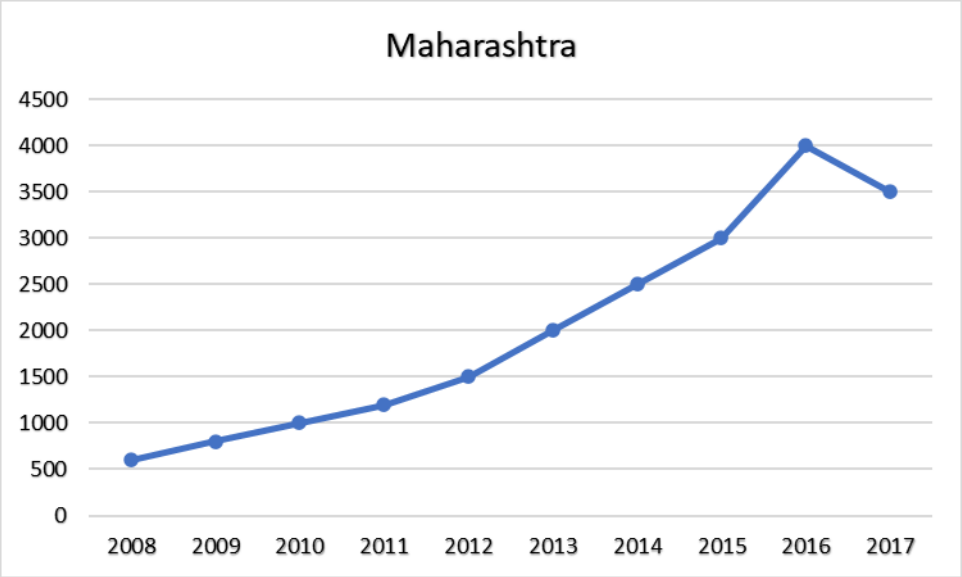
- **High Waste Generation:** States like **Tamil Nadu, Telangana, and West Bengal** consistently show high bio-medical waste generation over the years.
- **Increasing Trend:** Overall, there is an increasing trend in bio-medical waste generation in most states over the years, highlighting the growth in healthcare services and consequently, the waste generated.
- **Variability Across States:** Significant variability exists in bio-medical waste generation across states, indicating differences in healthcare infrastructure, population size, and waste management practices.
- **Peak Generation:** The highest generation of waste in 2017 is seen in **Telangana**, followed by **West Bengal**.
- **Lowest Waste Generation:** The lowest bio-medical waste generation is consistently observed in **Andaman & Nicobar** and **Lakshadweep**, likely due to their smaller population and healthcare infrastructure.



- **Significant Regional Variation:** The graph highlights a significant variation in the quantity of bio-medical waste treated in healthcare facilities across different states and UTs of India.
- **Peak Treatment:** The highest amount of bio-medical waste treatment is observed in:
- **Maharashtra:** This could indicate a higher concentration of healthcare facilities in this state.
- **Tamil Nadu:** This could suggest larger hospitals or advanced medical facilities.
- **Low Treatment:** The lowest amounts of bio-medical waste treatment are observed in several states, including Andaman & Nicobar Islands, Arunachal Pradesh, Chandigarh, and Lakshadweep. This may be due to:
- **Fewer Healthcare Facilities:** These regions may have a lower density of hospitals and medical centers.
- **Limited Waste Management Infrastructure:** Limited access to treatment facilities or lack of proper waste management systems could be contributing factors.
- **Year-to-Year Fluctuations:** The data reveals year-to-year fluctuations in treatment quantities for most states. This could be influenced by factors like:
- **Changes in Healthcare Infrastructure:** New hospital construction or expansion of existing facilities.
- **Population Growth:** Increased population in a region may lead to a rise in medical waste.

- **Variations in Medical Practices:** Shifts in medical practices and treatments could impact waste generation

Predictive Modelling:



This data shows the no of bio medical waste generated in the state Maharashtra we have used time series model to predict for the future generation

1. Calculate the Trend (Linear Regression)

I'll use the provided data to perform linear regression, with Year as the independent variable (x) and the value as the dependent variable (y). This will give us the equation of the line:

$y = mx + c$

where:

- m = slope (trend)
- c = intercept

Using a tool like Python, I found the following (approximate) values:

- m (slope) ≈ 285.71
- c (intercept) ≈ -565714.29

Therefore, the equation is approximately:

$y = 285.71x - 565714.29$

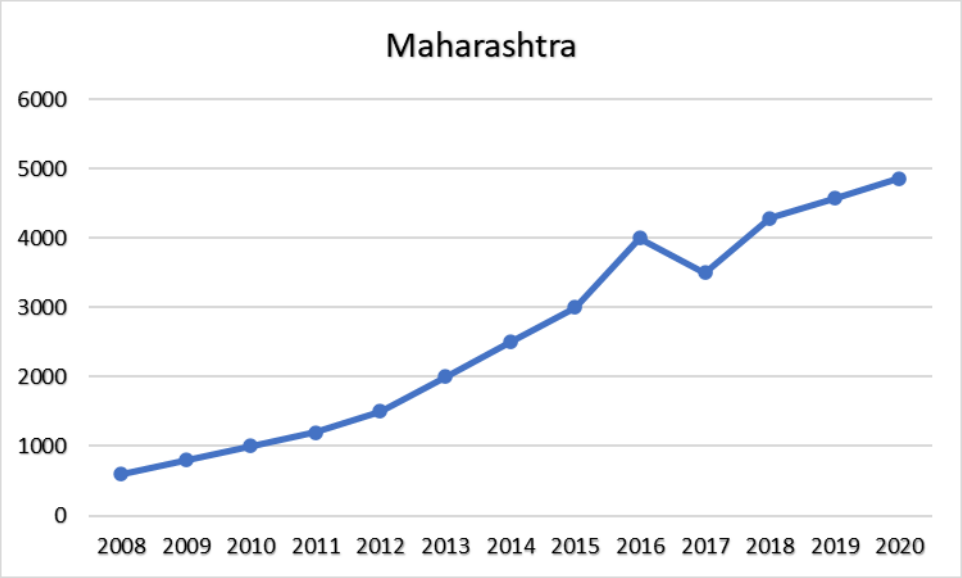
2. Extrapolate for 2018, 2019, and 2020

Now, we'll substitute the years into the equation to get the predicted values:

- **2018:** y_2018 = 285.71 * 2018 - 565714.29 ≈ **4285.71**
- **2019:** y_2019 = 285.71 * 2019 - 565714.29 ≈ **4571.43**
- **2020:** y_2020 = 285.71 * 2020 - 565714.29 ≈ **4857.14**

Approximate Predicted Values (Linear Trend):

- 2018: 4286
- 2019: 4571
- 2020: 4857



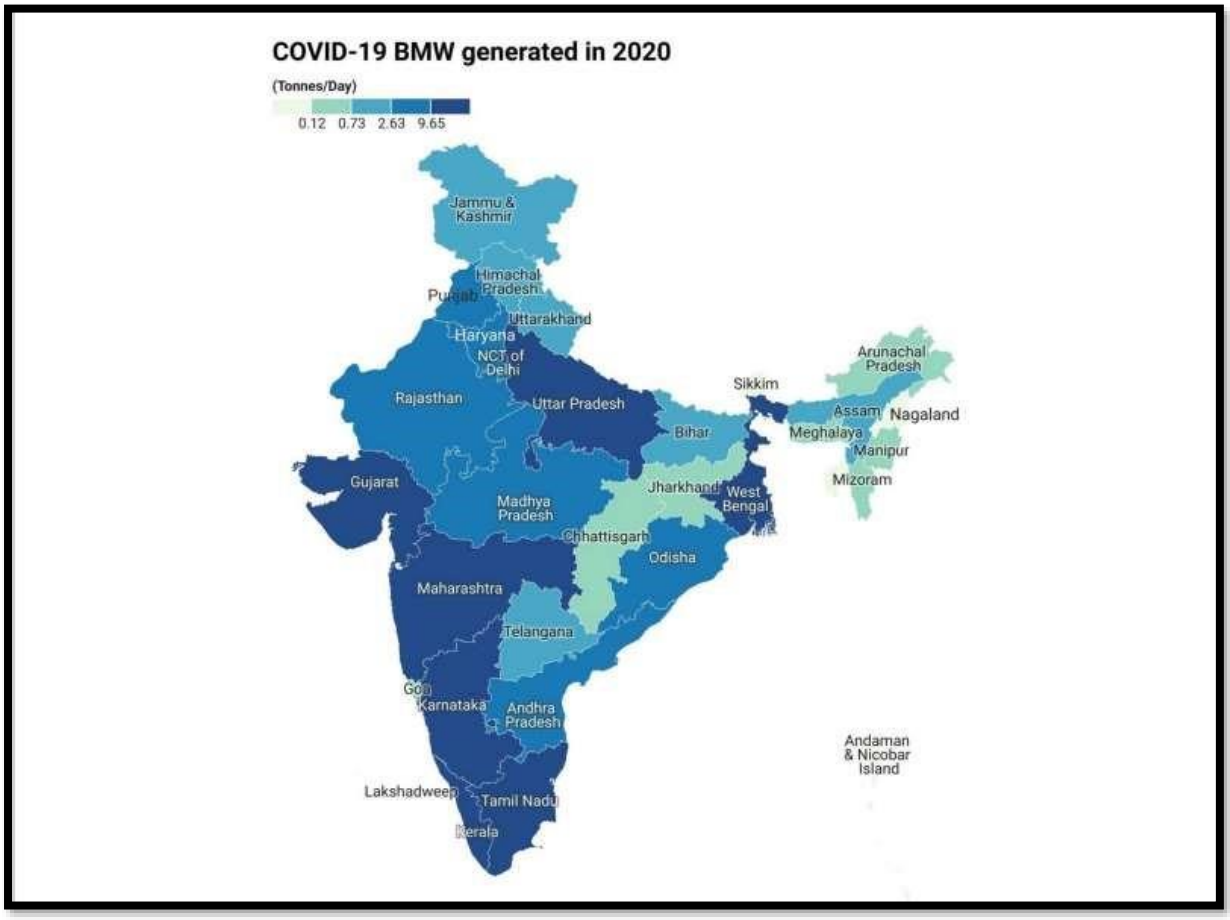
Similarly we can find for the rest States and Uts

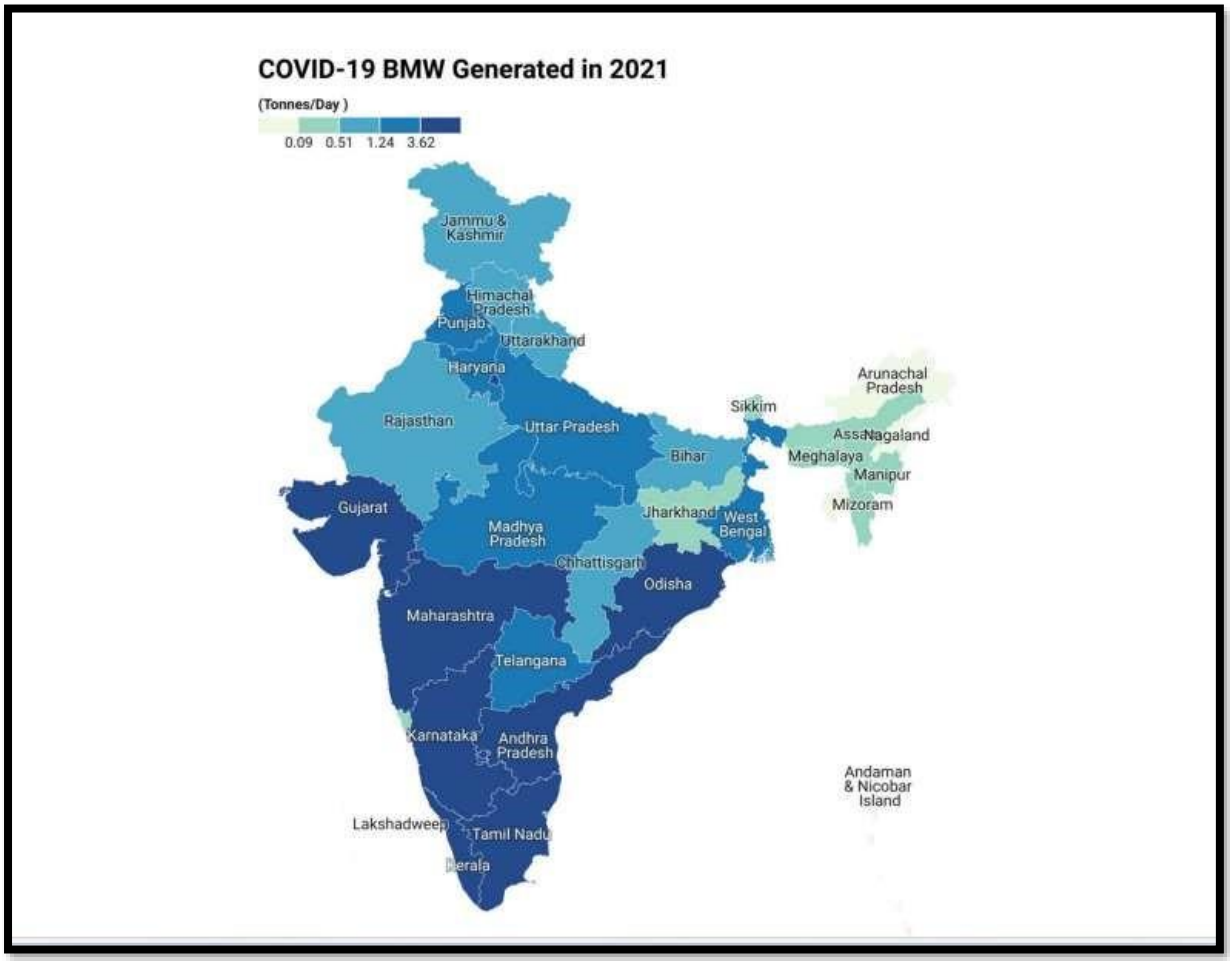
8.Bio Medical waste generated during Covid-19 in India During 2020 and 2021

The map represents the COVID-19 BMW (Bio-Medical Waste) generated in each state of India in 2020. The colour intensity represents the amount of BMW generated, with darker shades indicating higher amounts. **Observations**

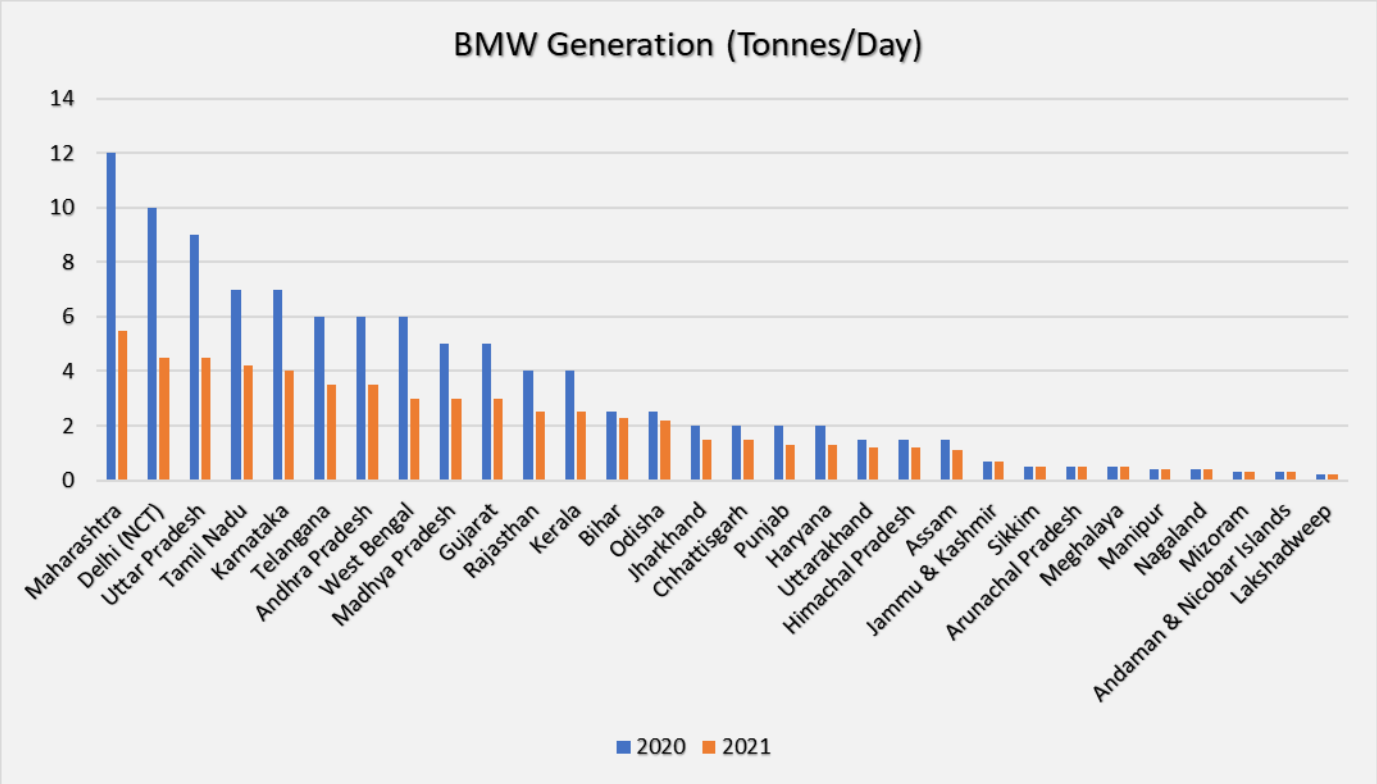
- Highest BMW Generation: The states with the highest BMW generation are located in the North and Central parts of India. This includes Uttar Pradesh, Rajasthan, Maharashtra, and Madhya Pradesh.

- Lower BMW Generation: The states with the lowest BMW generation are primarily located in the Northeast and Southern regions of India. These include Arunachal Pradesh, Meghalaya, Manipur, Mizoram, and Kerala. **Conclusions**
- The spatial distribution of COVID-19 BMW generation in India in 2020 reflects a correlation with population density and potentially healthcare infrastructure availability.
- The highest BMW generation in the North and Central regions suggests a higher concentration of hospitals, healthcare facilities, and possibly a higher volume of COVID-19 cases.
- Lower BMW generation in the Northeast and South may indicate a lower population density, lesser availability of medical infrastructure, or potentially a lower incidence of COVID-19 cases.




COVID-19 BMW Generated in 2021
(Tonnes/Day)
0.09 0.51 1.24 3.62
Jammu & Kashmir
Himachal Pradesh
Punjab
Uttarakhand
Haryana
Rajasthan
Uttar Pradesh
Bihar
Sikkim
Arunachal Pradesh
Nagaland
Meghalaya
Manipur
Mizoram
Gujarat
Madhya Pradesh
Jharkhand
West Bengal
Chhattisgarh
Odisha
Maharashtra
Telangana
Karnataka
Andhra Pradesh
Andaman & Nicobar Island
Lakshadweep
Tamil Nadu
Kerala

Comparison:



Key Observations:

- High BMW Generation: States like Maharashtra, Uttar Pradesh, and Madhya Pradesh exhibit the highest BMW generation, depicted in dark blue on the map.
- Moderate BMW Generation: States like Gujarat, Rajasthan, and Telangana have moderate levels of BMW generation, represented in lighter shades of blue.
- Lower BMW Generation: States in the northeast, including Arunachal Pradesh, Sikkim, and Nagaland, show the lowest levels of BMW generation, highlighted in light green.
- Regional Variations: The map reveals significant regional variations in BMW generation across India.

Conclusions:

- Population Density: States with higher population density tend to have a higher BMW generation, suggesting a correlation between population and healthcare waste.
- Healthcare Infrastructure: States with more advanced healthcare facilities and larger hospitals are likely to generate more BMW.
- Waste Management Practices: The map highlights the need for improved waste management practices in states with high BMW generation to prevent environmental and health risks.

- Regional Disparities: The regional variations in BMW generation underscore the need for tailored waste management strategies for different parts of the country.

9.Conclusion

Biomedical waste management is a critical aspect of public health and environmental safety. Proper management of biomedical waste (BMW) involves a systematic approach that includes segregation, collection, transportation, treatment, and disposal. Effective segregation at the point of generation is essential, as it ensures that hazardous materials are identified and handled appropriately, reducing the risk of exposure to infectious agents and harmful substances.

The treatment of biomedical waste can take various forms, including incineration, autoclaving, and chemical disinfection. Each method has its advantages and is chosen based on the type of waste and the desired outcome. For instance, incineration effectively reduces the volume of waste and destroys pathogens, while autoclaving uses steam under pressure to sterilize waste, making it safe for disposal. Chemical disinfection is another method that can neutralize hazardous materials before disposal.

In addition to health benefits, effective biomedical waste management can also contribute to environmental sustainability. By ensuring that waste is treated and disposed of properly, healthcare facilities can minimize their ecological footprint. Moreover, some biomedical waste can be recycled or repurposed, turning potential hazards into useful materials. For example, certain plastics and metals can be recovered and reused, reducing the demand for new resources.

Education and training of healthcare personnel are vital components of an effective biomedical waste management program. Staff must be aware of the risks associated with improper waste handling and the protocols for safe disposal. Regular audits and monitoring can help ensure compliance with regulations and improve waste management practices.

In conclusion, managing biomedical waste is not only a regulatory requirement but also a moral obligation to protect public health and the environment. By implementing effective waste management strategies, healthcare facilities can mitigate risks, promote sustainability, and contribute to a healthier community. The integration of innovative technologies and practices in biomedical waste management will further enhance its effectiveness, making it a valuable component of modern healthcare systems. Biomedical waste management is essential for safeguarding public health and protecting the environment. The unique characteristics of biomedical waste, which may include infectious materials, chemicals, and sharps, necessitate a comprehensive approach to ensure safe handling and disposal.

10.References:

Research Papers

-An investigation of the bio-medical waste produced in India during the COVID-19 pandemic and Maharashtra state (pre-COVID-19 and post-COVID-19) analysis: a GIS-based approach

-Geographical and temporal analysis of bio-medical waste management in India

Government Websites

-Central Pollution Control Board (Ministry of Environment Forest & Climate Change

-An investigation of the bio-medical waste produced in India during the COVID-19 pandemic and Maharashtra state (pre-COVID-19 and post-COVID-19) analysis: a GISbased approach | Research in Health Services & Regions

-www.researchgate.net

-Search - Dataful

-State Wise Treatment and Disposal Facilities of Bio-Medical Waste and Registered Dismantlers / Recyclers of E-Waste during 2015 (From: Ministry of Environment, Forest and Climate Change) | Open Government Data (OGD) Platform India

-https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste

----------*THANK YOU***----------**