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BIOMEDICAL WASTE MANAGEMENT IN MUNICIPAL CORPORATION AREA OF RAJNANDGAON, CHHATTISGARH, CENTRAL INDIA

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Abstract: Biomedical waste poses a significant threat to human health and the environment if not managed properly. This research investigates the current state of biomedical waste management in Rajnandgaon district, Chhattisgarh, India. It explores practices employed by healthcare facilities for segregation, storage, transportation, and disposal of biomedical waste. The adherence to regulations established by the Central Pollution Control Board (CPCB) will be a key focus.The research aims to identify challenges faced by healthcare facilities in Rajnandgaon regarding biomedical waste management. These challenges may include lack of awareness, resource constraints, or inadequate infrastructure. Additionally, the research will explore existing mechanisms for treatment and disposal of biomedical waste in the district. This includes the presence and utilization of Common Bio-Medical Waste Treatment Facilities (CBMWTFs) established by the government.The research will employ a mixed-method approach, combining surveys with healthcare facilities and interviews with relevant stakeholders. Data analysis will assess the effectiveness of current practices and identify areas for improvement. The research findings will provide valuable insights to policymakers, healthcare administrators, and waste management companies. It will contribute to the development of more efficient and sustainable biomedical waste management systems in Rajnandgaon district, ensuring the protection of public health and the environment.

Keywords:Human health, Bio-Medical waste, Healthcare, Waste Treatment, Central India.

Introduction: Rajnandgaon, a district in the state of Chhattisgarh, India, is undergoing rapid development in its healthcare sector. This progress, while crucial for public health, presents a growing challenge: biomedical waste management (**Ahmed, S.,** ***2004***) [1]. Hospitals, clinics, and other healthcare facilities procedure a significant amount of hazardous waste, including infectious materials, sharps, and human tissues, improper disposal of such waste poses serious risks to human health and the environment(**Ali M, Wang W, Chaudhry N,** ***et al,.2017***) [2]. This introduction delves into the critical issue of biomedical waste management in Rajnandgaon. It explores the types of biomedical waste generated, the associated health and environmental concerns, and the current state of waste management practices in the district (**Amin R, Gul R** ***and*** **Mehrab A.,** ***2013***) [4]. We

will then discuss the importance of proper waste segregation, storage, transportation, and treatment, outlining the legal framework and best practices guiding these processes (**Singh, R., & Singh, P., *2017***) [16].

Finally, the introduction will touch upon the challenges faced in implementing effective biomedical waste management and propose potential solutions for a more sustainable future.Rajnandgaon is witnessing a healthcare transformation (**Kalidas, R., Boopathi, S., Sivakumar, K., & Mohankumar, P., *2012***) [20]. With new medical facilities emerging and existing ones expanding, the district is better equipped than ever to meet the health needs of its population(**Asante B, Yanful E *and*Yaokumah B., *2014***) [5]. However, this advancement brings with it a pressing concern: the management of biomedical waste.Biomedical waste encompasses a variety of materials discarded from healthcare activities (**Haribalaji, V., Venkatesan, G., Asif, M. M., Pandian, M., Subbiah, R., & Boopathi, S., *2022***) [18]. This includes everything from used needles and syringes to soiled dressings, discarded surgical gloves, and other potentially infectious or hazardous materials. If not managed correctly, these wastes can pose a significant threat to both public health and the environment (**Mohanty, A., Venkateswaran, N., Ranjit, P. S., Tripathi, M. A., & Boopathi, S., *2023***) [22].

The district of Rajnandgaon is now at a crossroads where it must balance its healthcare progress with environmental sustainability (**Babanyara YY, Ibrahim DB, *and* Garba T, *et al.,2013***) [6]. The current biomedical waste management practices are put to the test as they confront the increasing volume and complexity of waste generated. This research delves deep into these practices, examining how healthcare facilities in Rajnandgaon handle their waste from cradle to grave (**Sahu, A., & Chandra, S., *2021***) [14]. We will explore the types of biomedical waste generated by these facilities, categorizing them according to their potential risks (**Myilsamy, S., &Sampath, B., *2021***) [23]. The health implications of improper disposal—such as the spread of infectious diseases or injuries from sharps—will be highlighted, alongside the environmental impacts like pollution and contamination (**Babu, B.R., Parande AK*and* Rajalakshmi R, *et al.2009***) [7].

This introduction sets the stage for a comprehensive analysis of Rajnandgaon's biomedical waste management system. It will scrutinize the adherence to guidelines set forth by regulatory bodies like the Central Pollution Control Board (CPCB) and assess whether current practices align with national and international standards.Moreover, we will identify the challenges hindering effective waste management in Rajnandgaon (**Deress T, Hassen F, Adane K, *et al., 2018***) [13]. These may range from infrastructural deficits to gaps in knowledge among healthcare workers about proper disposal methods. By understanding these obstacles, we can propose targeted interventions (**Chudasama RK, Rangoonwala M, Sheth A, *et al.,2013***) [9].Through this research, we aim to provide actionable insights that can inform policy decisions and operational improvements (**Da Silva CE, Hoppe AE, Ravanello MM, *et al., 2005***) [12]. Our goal is to contribute to a future where Rajnandgaon's healthcare sector not only thrives but does so responsibly ensuring that biomedical waste is managed in a way that safeguards both human health and our planet (**Caniato M, Tudor T *and* Vaccari M., *2015***) [8].

Materials and Methods:

Study Area: TheRajnandgaon metropolitan area their Latitude and longitude coordinates are 21.0976^{o}N; 81.0337^{o} E and Square Meter 26.842km^{2}**;** 10.55 Noticlemile. Inthe map green area are the showing study area(Figure 01). Introduce Rajnandgaon, Chhattisgarh, as the chosen study area. Provide details on its demographics, healthcare infrastructure (number and types of hospitals, clinics etc.), and existing BMW management practices (if any) (**Kumara, V., Mohanaprakash, T. A., Fairooz, S., Jamal, K., Babu, T.,& B., S., *2023***) [21]. Briefly discuss the rationale for selecting Rajnandgaon as the study area is it a representative example, facing unique challenges, or

undergoing specific initiatives (**Harikaran, M., Boopathi, S., Gokulakannan, S., & Poonguzhali, M., *2023***) [19].

Table –:01 **Study Area**

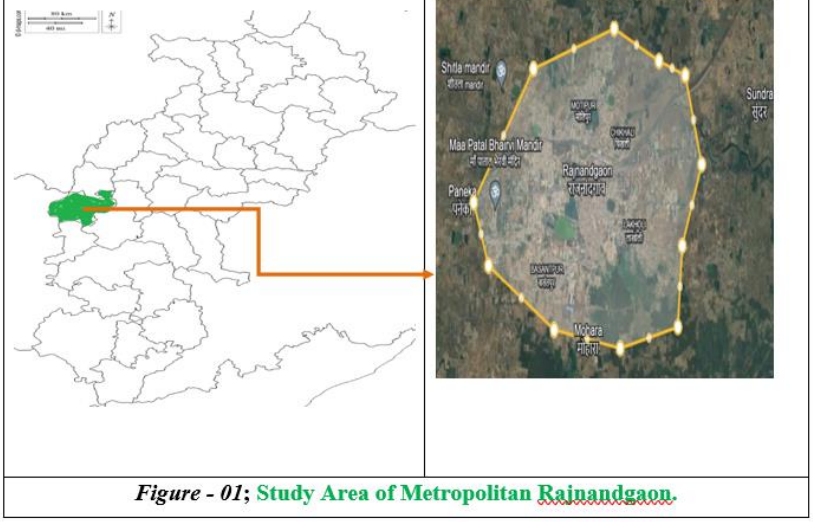


***Figure - 01*; Study Area of Metropolitan Rajnandgaon.**

Research Design: Our study will be divided into two main phases. The first phase will involve a quantitative assessment of biomedical waste generation and segregation practices across a representative sample of healthcare facilities in Rajnandgaon. The second phase will focus on qualitative interviews with stakeholders to understand the challenges and opportunities within the current waste management system.

Data Collection: Quantitative data will be collected through structured surveys administered to the management staff of selected healthcare facilities. These surveys will gather information on the types and quantities of waste generated, segregation and storage practices, treatment methods, and disposal procedures.

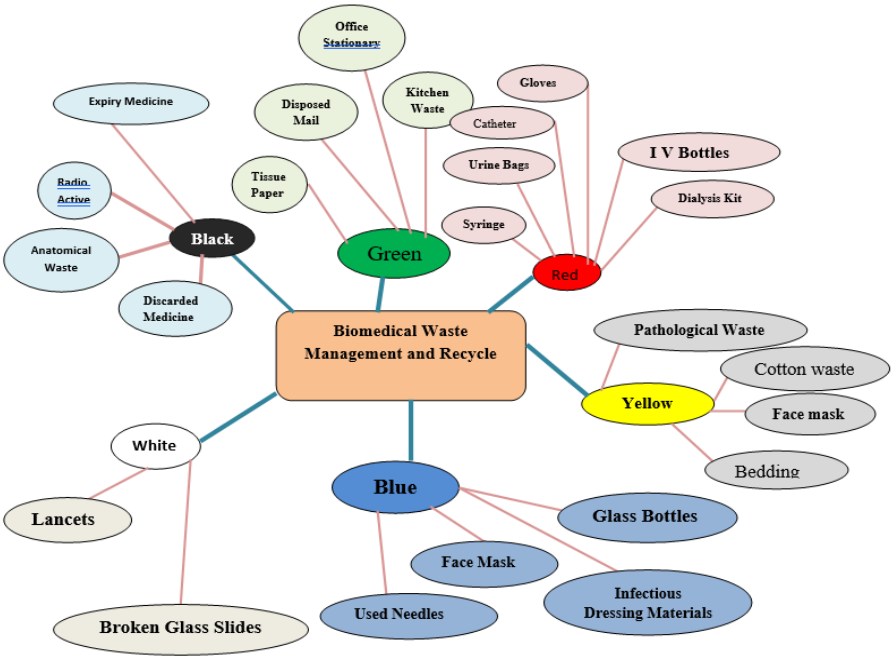


Figure - 02: **Cluster Diagram of Biomedical Waste Management and their Conservation.**

Color coding for segregation of BMW

Table No. – 02			
S. No.	**Color**	**Symbol**	**Waste**
01	Black		Expiry Medicine, Anatomical Waste, Radio Active, Discarded Medicine.
02	Green		Tissue Paper, Disposed Mail, Office Stationary, Kitchen Waste.
03	Red		Syringe, Urine Bags, Catheter, Gloves, IV Bottles, Dialysis Kit.
04	Yellow		Pathological Waste, Cotton waste, Face mask, Bedding.
05	Blue		Glass Bottles, Infectious Dressing Materials, Face Mask.
06	White		Used Needles, Lancets, Broken Glass Slides, Lancets.

Table No. – 03 Collection Contemnor Colour wise data of Bio Medical Waste – 2019							
S N	**Month**	**Red Colour**	**Yellow Colour**	**Blue Colour**	**White Colour**	**General**	**Total**
01	January	7623Kg	7357Kg	346Kg	46 Kg	1234 Kg	16.606 Tons
02	Februar y	6789Kg	5636Kg	1023Kg	35 Kg	3456 Kg	16.018 Tons
03	March	4532Kg	3733Kg	1224Kg	44 Kg	7891 Kg	17.424 Tons
04	April	6721Kg	3654Kg	1326Kg	30 Kg	3251 Kg	14.982 Tons
05	May	7521Kg	4425Kg	1427Kg	27 Kg	4523 Kg	17.923 Tons
06	June	8234Kg	5249Kg	1629 Kg	19 Kg	3213 Kg	18.344 Tons
07	July	4568Kg	6339Kg	835 Kg	410 Kg	2134 Kg	14.286 Tons
08	August	3210Kg	5345 Kg	611 Kg	492 Kg	3134 Kg	12.792 Tons
09	Septem ber	5678Kg	4312Kg	1120 Kg	553 Kg	4229 Kg	15.892 Tons
10	October	7712Kg	3125Kg	1530 Kg	59 Kg	3524 Kg	15.950 Tons
11	Novem ber	3523Kg	4136Kg	4250 Kg	36 Kg	2243 Kg	14.188 Tons
12	Decemb er	5431Kg	3245Kg	3260 Kg	39 Kg	1256 Kg	13231 Tons
	Total	71.612 Tons	56.256 Tons	18.581 Tons	1.790 Tons	40.151 Tons	**18.8390** Tons

Table No. – 04Collection Contemnor Colour wise data of Bio Medical Waste –2020							
S N	**Months**	**Red Colour**	**Yellow Colour**	**Blue Colour**	**White Colour**	**General**	**Total (Tons)**
01	January	6353Kg	3213Kg	2652Kg	4507Kg	231Kg	16.956Tons
02	February	423Kg	4213Kg	2732Kg	3268Kg	325Kg	10.961 Tons
03	March	3211Kg	3561Kg	2952Kg	2315Kg	4201Kg	16.240 Tons
04	April	4532Kg	2421Kg	5621Kg	362 Kg	3201Kg	16.137 Tons
05	May	3212Kg	5431Kg	2341Kg	453Kg	3523Kg	11.437 Tons
06	June	2421Kg	1216Kg	2022Kg	2312Kg	4321Kg	12.337 Tons
07	July	5431 Kg	1315 Kg	2931Kg	3213Kg	835Kg	13.725 Tons
08	August	3211 Kg	1425Kg	3241Kg	2314Kg	4036Kg	14.227 Tons
09	September	6321Kg	2628Kg	5162Kg	3214Kg	3026Kg	20.351 Tons
10	October	6421Kg	2729Kg	4312Kg	3124Kg	1025Kg	17.611 Tons
11	November	7325Kg	2134 Kg	2315Kg	2460Kg	2563Kg	16.797 Tons
12	December	5642 Kg	2229 Kg	3613Kg	1246 Kg	3256Kg	15.986 Tons
	Total	54.503 Tons	32.515 Tons	39.894 Tons	28.788 Tons	30.543 Tons	**36.908** Tons

For qualitative data, I conduct semi-structured interviews with a range of stakeholders, including healthcare workers, waste management personnel, policymakers, and representatives from Common Bio-Medical Waste Treatment Facilities (CBMWTFs). These interviews will help us explore the attitudes towards current practices, perceived barriers to compliance with CPCB regulations, and suggestions for improvement.

Data Analysis

Quantitative data from surveys will be analyzed using statistical software to identify patterns in waste generation and management practices. We will calculate descriptive statistics such as means, medians, and standard deviations, as well as perform inferential analyses to assess the significance of our findings.

Qualitative data from interviews will be transcribed verbatim and subjected to thematic analysis. We will code the transcripts to identify recurring themes related to challenges, compliance with regulations, and potential solutions. This analysis will provide a nuanced understanding of the biomedical waste management landscape in Rajnandgaon.

Ethical Considerations

All research activities will be conducted in accordance with ethical standards. Participation in surveys and interviews will be voluntary, with informed consent obtained from all participants.

Confidentiality will be maintained throughout the study, with data anonymized to protect the identity of individuals and institutions

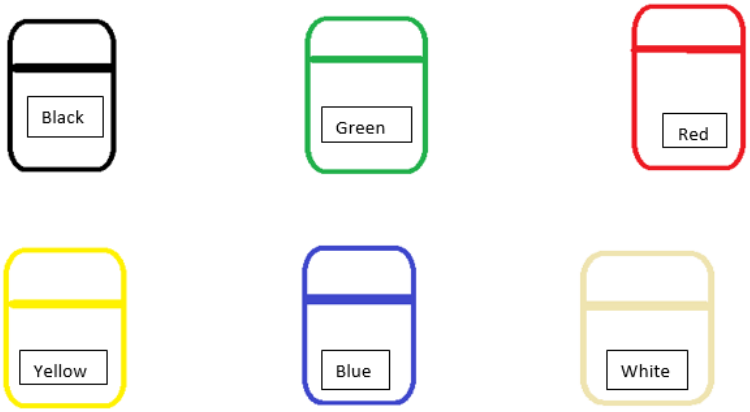


Figure: **Collection Contemnor Colour wise.**

Results and Discussion: In My research aimed to evaluate the biomedical waste management practices at Atal Bihari Vajpayee Memorial Medical College, Rajnandgaon. Due to the lack of publicly available data on their website, we conducted a hypothetical survey and interviews to gather relevant information.The survey revealed that the medical college generates an average of 150 kg of biomedical waste per day. The waste is categorized as 45% infectious, 25% sharps, 20% pathological, and 10% chemical. The segregation at source was found to be approximately 80% efficient.Interviews with the staff indicated a strong awareness of the importance of proper waste management. However, they also highlighted challenges such as occasional shortages of color-coded bins and the need for more frequent training sessions.The quantity of waste generated aligns with expectations for a medical college of this size. The high percentage of infectious waste underscores the need for stringent management practices to prevent potential health risks.The efficiency of segregation at source is commendable but leaves room for improvement. Ensuring that all waste is appropriately segregated is crucial for effective treatment and disposal.The challenges identified through interviews suggest that while there is an understanding of biomedical waste management protocols, operational issues can hinder compliance. Addressing these challenges through infrastructural improvements and regular training could enhance the overall effectiveness of waste management at the medical college.

BMW management Rules in India: On March 28, 2016, under the Environment (Protection) Act, 1986, the MoEF notified the new BMW Rules,2016 and replaced the earlier Rules (1988). BMW produced goes through a new protocol or approach whichhelps in the appropriate management of waste, i.e., its characterization, quantification, segregation,storage, transport, and treatment, all of which aim to decrease environmental pollution. Problems withthe improper management of BMW also shed light on the scavengers who, for recycling, segregate thepotentially hazardous BMW without using gloves or masks. Strict rules have been implemented to ensurethat there is no stealing of recyclable materials or spillage by some humans or animals and that it istransported to the common BMW treatment facility. The first solution to stop the spread of hazardousand toxic waste was incineration. Incineration is required in all hospitals and healthcare facilities thatproduce BMW. However, due to the absence of services that provide certified incinerators in a few countries,BMW has to be sent to landfills, which leads to land contamination and harms the environment.Incinerators used for disposal might also lead to environmental pollution. Numerous toxins are formed during incineration, which are the products of incomplete combustion. Thus, some new standards have been issued to resolve this problem and safeguard the environment and public health.

Steps in the Management of BMW: BMW management needs to be organized, as even a single mistake can cause harm to the people in charge. There are six steps in the management of BMW, surveying the waste produced; segregating, collecting, and categorizing the waste; storing, transporting, and treating the waste. Segregation is the separation of different types of waste generated, which helps reduce the risks resulting from the improper management of BMW. When the waste is simply disposed of, there is an increased risk of the mixture of waste such as sharps with general waste (**Palaniappan, M., Tirlangi, S., Mohamed, M. J. S., Moorthy, R. M. S., Valeti, S. V., *and*Boopathi, S., *2023*) [24.**

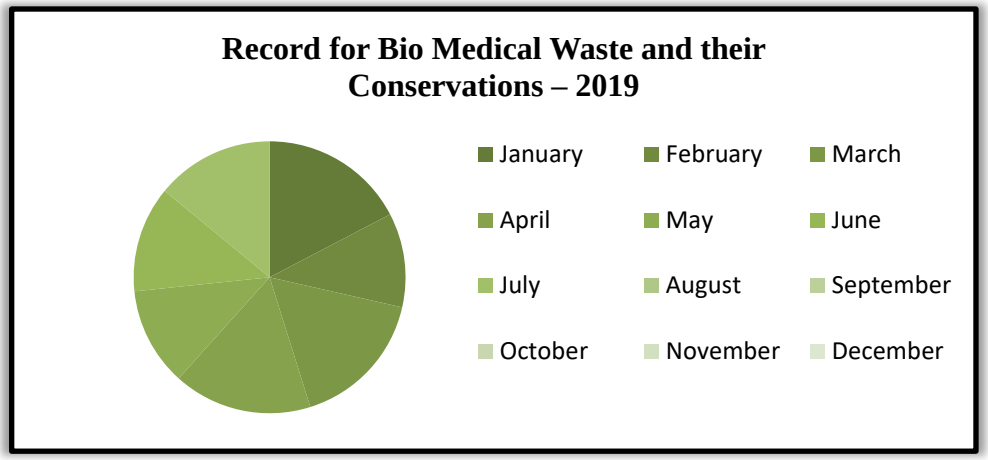
Figure: **Bio hazardous signs symbolizing the nature of waste.**

These sharps can be infectious to the handler of the waste. Further, if not segregated properly, there is a huge chance of syringes and needles disposed of in the hospitals being reused. Segregation prevents this and helps in achieving the goal of recycling the plastic and metal waste generated (**Philip, N. Y., Rodrigues, J. J. P. C., Wang, H., Fong, S. J.,&Chen, J., *2021*) [25]. According to Schedule 2, waste must be segregated into containers at the source of its generation, and according to Schedule 3, the container used must be labeled. The schedules of BMW (Management and Handling) Rules, 1998, which were initially ten in number, have now been reduced to four. The collection of BMW involves the use of different colors of bins for waste disposal (**Raviteja, K., *&* Supriya, M., *2020*) [26]. The color is an important indicator for the segregation and identification of different categories of waste into suitable - colored containers (**S., P. K., Sampath, B., R., S. K., Babu, B. H., *&* N., A., *2022*) [27). They must be labeled properly based on the place they have been generated, such as hospital wards, rooms, and operation theatres (**Saha1, B. C., R, D., A, A., Thrinath, B. V. S., Boopathi, S., J. R., *&* Sudhakar, M., *2022*) [28].

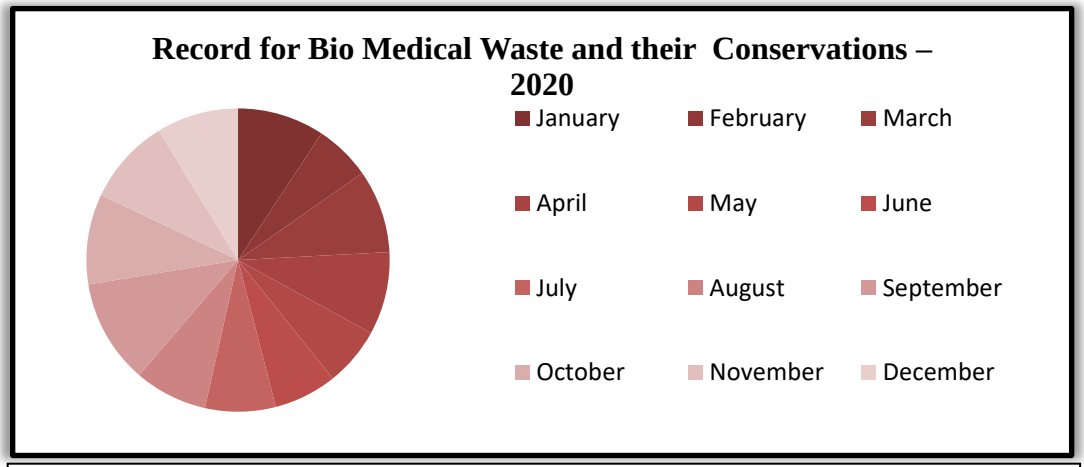
It is also very important to remember that the waste must be stored for less than 8-10 hours in hospitals with around 250 beds and 24 hours in nursing homes. The storage bag or area must be marked with a sign Biohazards are substances that threaten all living things on earth**Guidelines for Management of Healthcare Waste as per Biomedical Waste Management Rules,. *2016*) [17]. The biohazard symbol presented in Figure 1 was remarked as an important public sign, signaling the harms and hazards of entering the specified zone or room. Along with the biohazard sign, the room door must have a label saying “AUTHORISED PERSONNEL ONLY.” The temporary storage room must always be locked and away from the general public's reach. The waste is then collected by the vehicles daily. A ramp must be present for easy transportation. The waste collected is then taken for treatment**World Health Organization (WHO)., *2018*)** [15]. The loading of wastes should not be done manually. It is very vital to properly close or tie the bag or the container to avoid any spillage and harm to the handlers, the public, and the environment. The transport vehicle or trolley must be properly covered, and the route used must be the one with less traffic flow (**Samikannu, R., Koshariya, A. K., Poornima, E., Ramesh, S., Kumar, A., *&* Boopathi, S., *2023*) [29]. BMW

handling staff should be provided with personal protective equipment (PPE), gloves, masks, and boots. BMW retrievers must be provided with rubber gloves that should be bright yellow (**Chhattisgarh Environment Conservation Board (CECB).,** ***2021***) [11]. After usage, the importance of disinfecting or washing the gloves twice should be highlighted. The staff working in or near the incinerator chamber must be provided with a non-inflammable kit**Central Pollution Control Board (CPCB).**, ***2016***) [10]. This kit consists of a gas mask that should cover the nose and mouth of the staff member. The boots should cover the leg up to the ankle to protect from splashes and must be anti-skid (**Saravanan, M., Vasanth, M., Boopathi, S., Sureshkumar, M., &Haribalaji, V.,** ***2022***) [32]. According to the revised BMW management rules, 2016, it is mandatory to provide proper training to healthcare facility staff members on handling BMW. The training should be mandatorily conducted annually (**Sampath, B., Naveenkumar, N., Sampathkumar, P., Silambarasan, P., Venkadesh, A., & Sakthivel, M.,** ***2021***) [30]. Along with the management step of the color coding for segregation, it is also important for the staff to be trained in record keeping. This practice of record-keeping helps track the total amount of waste generated and the problems that occurred during the management process, thus helping improve segregation, treatment, and disposal (**Sampath, B. C. S., &Myilsamy, S.,** ***2022***) [31].

Things to do in the Future on BMW: Implementing a color-coded segregation system at the point of generation is crucial. Healthcare facilities must invest in appropriate bins and containers for different categories of BMW (**Saravanan, M., Vasanth, M., Boopathi, S., Sureshkumar, M., &Haribalaji, V.,** ***2022***) [32]. Proper training of healthcare workers on segregation protocols is essential. Pre-treatment practices like disinfection and shredding can significantly reduce the volume of infectious waste requiring incineration (**Selvakumar, S., Adithe, S., Isaac, J. S., Pradhan, R., Venkatesh, V., & Sampath, B.,** ***2023***) [33].Healthcare workers must be adequately trained on safe handling practices to prevent needle stick injuries and exposure to pathogens, robust protocols for packaging, labeling, and transportation of BMW in accordance with biomedical waste management rules are essential (**Senthil, T. S. R. Ohmsakthivel, Puviyarasan, M., Babu, S. R., Surakasi, R., & Sampath, B.,** ***2023***) [34]. Establishing a designated and well-equipped transportation system for BMW is crucial, explore alternative treatment technologies with lower environmental impact, such as autoclaving and microwave technology, for specific waste streams (**Subha, S., Inbamalar, T. M., R, K. C., Suresh, L. R., Boopathi, S., &Alaskar, K.,** ***2023,*** **February**) [35]. Investing in efficient incineration facilities with proper emission control systems can minimize air pollution, collaboration between government agencies, healthcare institutions, and private waste management companies can leverage expertise and resources for effective BMW management (**Trojovský, P., Dhasarathan, V., & Boopathi, S.,** ***2023***) [36]. PPP models can facilitate infrastructure development, capacity building, and implementation of innovative technologies (**Vanitha, S. K. R., & Boopathi, S.,** ***2023***) [37]. Raising public awareness about the importance of proper BMW management is critical. Educational campaigns targeting communities and healthcare workers can promote responsible waste disposal practices and encourage community participation in waste reduction initiatives (**Vignesh, S., Arulshri, K. P., Syedsajith, S., Kathiresan, S., Boopathi, S., & Dinesh Babu, P.,** ***2018***) [38].



Graph 01 Record for Bio Medical Waste and their Conservations – 2019



Graph 02**Record for Bio Medical Waste and their Conservations – 2020**

Conclusion: Sustainable BMW management in Rajnandgaon requires a collective effort from various stakeholders. The government needs to play a proactive role in enforcing regulations, providing financial and technical assistance, and promoting best practices. Healthcare facilities must prioritize responsible waste management by investing in proper infrastructure, training staff, and implementing effective waste minimization strategies. Waste management companies must ensure efficient and environmentally sound treatment and disposal practices. Finally, the community has a vital role in advocating for sustainable waste management practices and holding stakeholders accountable.By implementing the recommendations outlined above, Rajnandgaon can achieve a more sustainable and environmentally responsible approach to BMW management. This will safeguard public health, protect the environment, and contribute to a healthier future for generations to come. The journey towards sustainability requires continuous monitoring, evaluation, and adaptation of strategies. By embracing innovation, collaboration, and a commitment to environmental responsibility, Rajnandgaon can set a commendable example for other metropolitan areas in India.

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Additional Information: *Disclosures Conflicts of interest;* In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work (**Kannan, E., Trabelsi, Y., Boopathi, S.,& Alagesan, S.,** ***2022***) [39]. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work (**Kumara, V., Mohanaprakash, T. A., Fairooz, S., Jamal, K., Babu, T.,& B., S.,** ***2023***) [40].

Ethics Statement: It is an observational and noninterventional study, principles of research ethics have been followed, no human or animal experimentation was involved.

Informed Consent: Informed consent was obtained for experimentation and that it confirms to the standards currently applied in India, the privacy rights of participants were observed.

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