Section: Microbiology

Original Research Article

MANAGEMENT OF COVID-19 MEDICAL WASTE BASED ON PYROLYSIS-SWOT ANALYSIS

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Received : 03/12/2023
Received in revised form : 10/01/2024
Accepted : 27/01/2024

Keywords:
Global pandemic, SWOT analysis, Pyrolysis, COVID-19, Medical waste management.

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DOI: 10.47009/jamp.2024.6.1.129

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2024; 6 (1); 647-655

Abstract

Background: The challenges posed by the disposal of waste have grown as a result of the 2019 coronavirus illness outbreak. During the COVID-19 epidemic, isolation in the ward, institutional quarantine centres, COVID testing facilities, and even family quarantine, are producing a significant volume of biomedical waste (BMW) on a global scale. The main contributors to recyclable quantities are personal safety gear (PPE), testing kits, medical facemasks, and gloves made of nitrile. The sustainability of the environment and global public safety is seriously threatened by the release of the new form of BMW (COVID-waste) if it is handled poorly. **Materials and Methods:** This study investigates the possibilities of pyrolysis as a long-term means of managing and treating COVID-19 medical waste. The study encompasses a data collection on waste composition, and laboratory-scale pyrolysis experimentation. A SWOT evaluation is also performed to evaluate the benefits, drawbacks, possibilities, and risks related to pyrolysis-based governance. **Results:** In SWOT analysis, a total of 30 interactions has been identified in strengths/opportunities. A total of 18 interactions has been identified in weaknesses/opportunities. **Conclusion:** The outcomes of this investigation will provide valuable insights into the feasibility of implementing pyrolysis as a management strategy for COVID-19 medical waste and will offer recommendations to policymakers and waste management authorities for the safe and efficient disposal of this waste stream.

INTRODUCTION

The volume of garbage produced by humans has rapidly increased during the last several decades. The handling of medical waste has grown to be a serious problem for the environment. Biomedical waste (BMW) is the residue of procedures used to sample, test, diagnose, treat, vaccinate, and operate on humans, animals, and other study subjects.(1) They are a class of hazardous trash that, if not managed and disposed of appropriately, can transmit infectious diseases. Worldwide production of healthcare waste has significantly increased as a result of the COVID-19 epidemic. It is essential to effectively manage this trash to reduce the impact on the environment and associated health hazards. The management of COVID-19 medical waste is covered in the following paragraphs in general terms, covering waste kinds, sources of information, and related difficulties. The importance of implementing proper waste management practices is emphasized, along with the need for collaboration among healthcare facilities, waste management authorities, and regulatory bodies. Sorts of COVID-19 Clinical Waste material refers to COVID-19 healthcare waste that may be broken down into many sorts, including contaminants, laboratory trash, and medication waste as well as personal protective equipment. Each type poses unique challenges in terms of handling, storage, and disposal.

Healthcare facilities, including hospitals, clinics, and testing centers, are the primary sources of COVID-19 therapeutic excess. Managing COVID-19 medical waste presents several challenges. These include increased waste volume, potential contamination risks, shortage of waste management infrastructure, limited resources, and regulatory compliance. (2) Addressing these challenges requires strategic planning, resource allocation, and adherence to waste management guidelines and regulations. Establishing best practices for COVID-19 handling of healthcare waste has emerged as a result. Doing so will help to reduce hazards and maintain the preservation of the environment. These practices include waste segregation, proper packaging and labeling, safe transportation, effective treatment methods, and monitoring of waste management processes. Compliance with local regulations and guidelines is essential to maintain safety standards. (3)

A conventional deployment with a standard output of 250 kg/h is anticipated to cost PLN one hundred million dollars, making this approach accessible to smaller firms and boosting their competitiveness and appeal. The process of pyrolysis has promise for the neutralization of municipal solid waste. The potential for using the mixture of solid and volatile byproducts generated by pyrolysis, which lowers the total expense of pyrolysis, is another key factor in favor of a wider application of this technique. (4) In comparison with incineration (and co-incineration), the process of pyrolysis is carried out at a lower temperature. The management of COVID-19 medical waste is an ongoing challenge that requires continuous improvement and adaptation. Future directions include the development of more sustainable and cost-effective treatment technologies, improved waste tracking systems, and increased research on the potential reuse and recycling of certain medical waste materials. (5) By prioritizing proper waste management practices, we can minimize the environmental impact and protect public health during and beyond the COVID-19 pandemic. The key contributions of the research study are as follows,

- Data collection process is carried out in COVID-19 restricted area to access and estimate the medicinal waste flow generation
- Challenges involved in managing COVID-19 medical waste is identified
- Comprehensive SWOT analysis of pyrolysis-based management of COVID-19 medical waste is conducted to assesses the internal and external factors influencing the adoption and implementation of pyrolysis
- Addressing the challenges associated with COVID-19 medical waste management to promote the environmental sustainability and public health.

MATERIALS AND METHODS

Research Framework

The research framework tackles the issue of COVID-19 medical waste management through a comprehensive and multidisciplinary approach. It encompasses the research key components that synergistically address the challenges at hand. The research approach involves waste characterization and quantification. By conducting on-site analysis and studying the composition, volume, and properties of COVID-19 medical waste, we can gain valuable insights into its nature and potential hazards. This knowledge forms the basis for developing appropriate waste management strategies. Then the process focuses on waste minimization and segregation. This research aims to promote practices that minimize the generation of medical waste and encourage proper segregation at the source. Through awareness campaigns targeting healthcare workers, patients, and other stakeholders, we can reduce the overall volume of waste and enhance its manageability. Fig. 1 represents the flow of research frame work enabling for COVID-19 medical waste management.

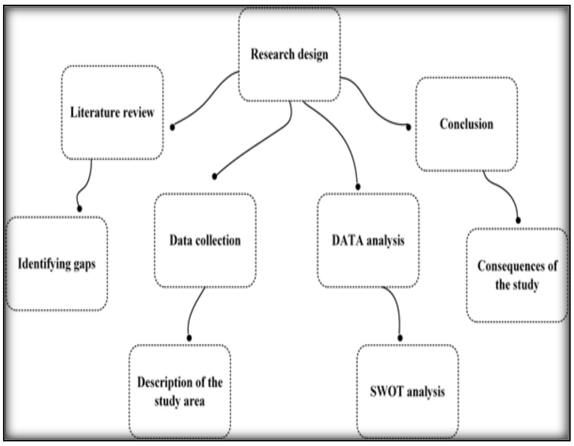

Figure 1: Framework of research methodology

Hence, the framework explores innovative waste treatment and disposal technologies. Process evaluates a range of options, including thermal treatment methods like autoclaving and microwave treatment, chemical disinfection processes, and advanced waste-to-energy technologies. Our goal is to identify sustainable alternatives that minimize environmental impact, ensure public safety, and maximize resource recovery. It revolves around policy development and stakeholder engagement. We actively involve policymakers, waste management authorities, healthcare institutions, and other relevant stakeholders to create comprehensive policies and guidelines. By gathering insights through stakeholder consultations and conducting economic and environmental assessments, we aim to establish effective regulations, standards, and best practices. By integrating these components into our research framework, we aim to provide evidence-based recommendations for the safe, efficient, and sustainable management of COVID-19 medical waste. Our research endeavors to mitigate the environmental and public health risks associated with the pandemic while fostering a more resilient and resource-conscious healthcare system.

Data Collection

The project on the management of COVID-19 therapeutic waste based on pyrolysis-SWOT analysis, a comprehensive secondary data collection plan has been devised. The primary objective is to gather relevant information from various sources to conduct a thorough analysis. The plan involves identifying key sources such as scientific journals, research papers, government reports, industry publications, and online databases. To assess the strengths of pyrolysis, the focus will be on research studies highlighting its efficiency, effectiveness, and reduction of environmental impact. Case studies and reports showcasing successful implementations will also be explored. Weaknesses will be evaluated through studies addressing technical challenges, emission concerns, and economic factors such as initial investment costs. Opportunities will be identified by examining market research reports, policy documents, and advancements in pyrolysis technology. Threats will be analyzed through reports on competing waste management technologies, regulatory changes, public perception, and economic factors. The collected data will be thoroughly evaluated, ensuring credibility and relevance, to derive meaningful insights into the SWOT factors associated with pyrolysis-based medical waste management. Proper citation and referencing will be employed to maintain academic integrity throughout the process.[6]

COVID-19 Waste Flow Estimation in Healthcare Facilities

For evaluating the movement of Covid-19-related garbage, as explained in the next section, a precise estimation of Covid-19 waste is essential. The average amount of hazardous waste produced daily per bed in hospitals in nations with high incomes is 0.5 kg, compared to 0.2 kg in nations with low incomes. Notably, developing countries face challenges with separate collections of hazardous and non-hazardous items, leading to an increased proportion of hazardous waste due to contamination. At the national level, medical waste in Romania can be categorized as follows: add specific data/figures for the various categories of medical waste in Romania.

Mw = No. of active COVID-19 cases per day × Mwgr (kg·bed·day-1) (1)

Where Mwgr = Medical-waste-generation. In institutions receiving care for verified COVID-19 patients, but without healed or deceased patients, are called "active cases." Generally speaking, during emergency status, hospitals handled all COVID-19 patients.

Subnational level (county): Mw = confirmed COVID-19 cases per day × Mwgr (kg·bed·day-1) (2)

It might be difficult to find current and precise COVID-19 numbers at the level of the county due to a lack of documentation. At this magnitude, there may be discrepancies in the reported totals of confirmed instances, fatalities, and recovery. Daily statistics given by the Romanian nation's strategic communications group are taken into account for an estimate in order to alleviate this problem. This helps to minimize the impact of potential inconsistencies. The calculation of COVID-19 medical waste flow is based on the number of active cases at the national level, while at the subnational level; it is derived from the daily confirmed cases. The management of data reporting systems by local county agencies and afterward reporting to the National Institutes of Public Health may make it more challenging to assess healthcare waste at the subnational level. It is important to remember that between 19 March and 2 April, national agencies stopped submitting statistics at the local level. On the twentieth of March, Geo-spatial.org and 17 non-governmental organizations (NGOs) released an agenda requesting that national authorities in Romania share crucial daily COVID-19 data on statistics at the county level. The required data contains specific demographics splits (including age and gender) under each group, along with details on cases that have been confirmed, turnarounds, fatalities, and the total number of people living in isolation or confinement. To successfully monitoring the COVID-19 situation in Romania and stop the transmission of false knowledge and disinformation, information sharing must be transparent. The infectious disease department at the Medical Institute of Craiova recorded to serve as the investigation's base. This estimate is consistent with El-Haggar's advice, which states that a median volume of waste from medicine is produced per bed every day.

The emergency room of the Medical Clinic of Craiova was found to have the greatest amount of medical waste at 1.814 kg per bed per day. In comparison with lesser healthcare establishments, major hospitals generate about 1-1.8 kg of medical debris per patient every day. Italy produces the most medical waste (5.96 kg per bed, per day), followed by critical care (3.37 kg per bed, per day). Medical waste production reached 240 t per day in Wuhan (China). The study also takes into consideration the maximum allowance (1.8 kg) established by earlier research in Romanian. As a consequence, in connection with the COVID-19 spread, the average prevalence of infectious diseases is predicted to be lower than the health waste flow related to people receiving hospital care.

Mw = No. of COVID-19 patients in ICU.day-1 × 1.8 kg·bed-1·day-1 (3)

The overall COVID-19 medical waste flow, as determined by Equation (1), includes the ICU waste.

Calculation of Potential Infectious Waste Produced in Quarantine Sites or by Self-Isolated Individuals in Homes

Quarantine/self-isolation waste = no. of people in quarantine/self-isolated (national & subnational levels) × WGR,WGR = waste generation rate (0.55 kg·inhab·day-1) (4)

Massive collections that include plastic vessels are created in quarantine zones as a result of all three daily meals being served on single-use, one-time-use plates, glasses, and utensils. Glasses and plastic manufacturing rose in Turin (Italy), while overall

ISSN (O): 2687-5365; ISSN (P): 2753-6556

MSW production fell by 11.5% in March 2020 compared to March 2019. In the nation of Thailand, garbage made of plastic also increased, but due to the closure of enterprises, restaurants, and other sectors, the amount of rubbish sent to an Indonesian cemetery decreased by as much as forty percent.

Pyrolysis Mechanism for transforming Organic Materials through Heat

The hydrochars, which were under inquiry, were subjected to pyrolytic breakdown experiments utilizing a Pyroprobe model 5200 (CDS Analytical) in conjunction with a GC-MS instrument (GC: model 7890B; MS: version 5977A, Agilent). At 400 °C, 500 °C, and 600 °C, three distinct temperatures were used for the pyrolysis testing. A quartz tube was filled with around 2.5 mg of the sample for each run, closed with quartz wool, and set on a platinum filament. The material was cleaned using a harmless gas before decomposition. The specimen was heated to the required temperature during the course of pyrolysis at a rate of °C s1 and held there for 10 s. The identical sample was heated to 400 °C, then to 500 °C, and finally to 600 °C in that order. The generated analytes were introduced to the GC-MS apparatus for measurement using a transmission line retained at 300 °C after each breakdown step. Additionally, the GC injector temperatures were adjusted to 300 °C, and split mode (20:1) was used for the evaluation. Utilizing an Agilent HP-5MS capillary column (30 m 0.25 mm 0.25 m), the chemicals were separated.[7] The GC oven's thermal program includes a hold period of 7 minutes at 40 °C, which is followed by a 4 °C min1 heating ramp from 40 °C to 250 °C. A 30-minute adiabatic hold at 250 °C was achieved. Using this convolution method, the chemicals and their peak regions were identified. For analysis, only substances with peak heights greater than 1.0% of the greatest peaks were taken into account. A reference MS library (chemical base G1034C) was used to evaluate the MS spectra that were obtained. The 60% matching factor criteria were established using calculations based on electronic library search methods. To verify the precision and dependability of the findings, every measurement was carried out three times. By multiplying the peak area of an individual compound by the sum of the peak regions of all discovered substances, the relative percentage of chosen compounds found throughout each pyrolysis stage was computed.[8]

SWOT Analysis of Pyrolysis-Based Medical Waste Management

Strengths

Implementing pyrolysis-based medical waste management for COVID-19 waste offers several strengths. Pyrolysis provides an effective solution to address the growing volume of medical waste generated during the pandemic. It can handle various types of waste, including contaminated PPE, disposable medical instruments, and biological waste, ensuring comprehensive waste management. Additionally, pyrolysis contributes to environmental sustainability by diverting waste from landfills and incineration, thereby reducing greenhouse gas emissions and preventing the release of harmful pollutants into the atmosphere. The resource recovery aspect of pyrolysis is another significant strength, as it allows for the extraction of valuable resources like metals and reusable materials from medical waste. These recovered resources can be further processed and reintroduced into the production cycle, minimizing the need for raw material extraction. Furthermore, pyrolysis generates a considerable amount of energy in the form of syngas, which can be utilized for heat and power generation.[9] This energy can offset the facility's energy requirements and even contribute to the local energy grid. Lastly, the versatility of pyrolysis technology makes it suitable for handling the diverse waste streams encountered in healthcare facilities. Proper management of COVID-19 medical waste through pyrolysis mitigates public health risks by prevented.

Weaknesses

However, implementing pyrolysis-based medical waste management also faces certain weaknesses. The initial investment costs for setting up a pyrolysis facility can be substantial, encompassing equipment procurement and infrastructure development. This financial burden may pose challenges, particularly for healthcare institutions with limited financial resources. Operating a pyrolysis facility requires specialized knowledge and expertise in handling the technology. Adequate training and collaboration with external partners may be necessary to ensure safe and efficient operations. Regulatory compliance is another concern, as medical waste management is subject to stringent regulations and permits. Healthcare facilities must navigate and adhere to local, regional, and national waste management regulations, which may entail additional costs and administrative efforts. Waste sorting and pre-treatment processes, such as shredding or sterilization, are often necessary before pyrolysis, increasing the disposal of waste system's complexity and expense. Additionally, the scale and capacity of the pyrolysis facility must align with institution to prevent inefficiencies or delays in waste management. Appropriate handling and management of the pyrolysis process's waste materials, such as ash and residues, need to be addressed to prevent any potential environmental or health risks.

Table 1: Internal and External factors of SWOT

Strengths	Favorable Aspects	Unfavorable Aspects
Internal factors	**Strengths** Effective handling of various types of	**Weaknesses** Regular compliances and permitting challenges

ISSN (O): 2687-5365; ISSN (P): 2753-6556

	medical waste	
External factors	**Opportunities** Knowledge and experience gained	**Threats** Economic viability and affordability challenges

Opportunities

There are several opportunities associated with implementing pyrolysis-based medical waste management for COVID-19 waste. The increased generation of medical waste during the ongoing pandemic presents a significant market opportunity for pyrolysis-based solutions. Governments and regulatory bodies may provide financial support, incentives, and grants to encourage the adoption of sustainable waste management technologies like pyrolysis. Healthcare facilities can take advantage of these opportunities to mitigate the initial investment costs. Collaborative partnerships with waste management companies, technology providers, or research institutions offer potential synergies in terms of knowledge sharing, resource pooling, and cost reduction. Furthermore, as public awareness of environmental issues continues to grow, highlighting the sustainable aspects of pyrolysis-based medical waste management can improve public perception and garner support from stakeholders. The knowledge and experience gained from implementing pyrolysis-based medical waste management can also be applied to other sectors dealing with hazardous waste, broadening the scope of application and creating additional opportunities for replication and implementation.[10]

Threats

Despite the strengths and opportunities, implementing pyrolysis-based medical waste management for COVID-19 waste also faces certain threats. Technological limitations or breakdowns in the pyrolysis process could result in operational disruptions and increased costs. Fluctuating market conditions, such as changes in waste disposal regulations or the availability and cost of feedstock materials, could impact the economic viability of the pyrolysis facility. The potential for public resistance or skepticism towards the implementation of new waste management technologies, including concerns over emissions or safety, may pose challenges to gaining necessary approvals and public support. Changes in waste management regulations or policies at local, regional, or national levels could impact the feasibility and implementation of pyrolysis-based medical waste management. Staying updated with relevant regulations and advocating for supportive policies is essential.[11]

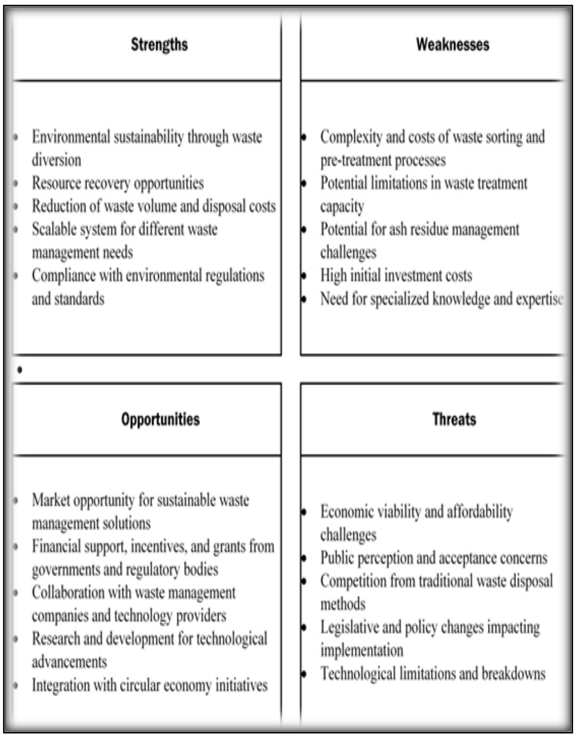

Figure 2: SWOT analysis chart

RESULTS

In SWOT analysis, the strengths of pyrolysis effectively leverage the identified opportunities were showed in Table 2. A total of 30 interactions has been identified in strengths/opportunities (S1=3, S2=4, S3=5 and S4=3 vs O1=4, O2=2, O3=2, O4=3, O5=4) and a total of 7.06 total products were identified which were generated by weights and interactions. Weaknesses of pyrolysis impede the realization of the identified opportunities were showed in Table 3. A total of 18 interactions has been identified in weaknesses/opportunities (W1=1, W2=3, W3=3 and W4=2 vs O1=3, O2=0, O3=0, O4=2, O5=4) and a total of 4.36 total products were identified which were generated by weights and interactions.

Table 2: SWOT analysis- Can the strengths of pyrolysis effectively leverage the identified opportunities?

Strengths/Opportunities	O1	O2	O3	O4	O5	Weightage	Total Interactions	Generated by weights and interactions
S1	1	0	0	1	1	0.22	3	0.66
S2	1	0	1	1	1	0.3	4	1.2
S3	1	1	1	1	1	0.3	5	1.5
S4	1	1	0	0	1	0.18	3	0.54
Weights	0.31	0.15	0.2	0.14	0.2			
Total Interactions	4	2	2	3	4			
Generated by weights and interactions	1.24	0.3	0.4	0.42	0.8			
Adding up interactions							30	

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Adding up products								7.06

Table 3: SWOT analysis- Can the weaknesses of pyrolysis impede the realization of the identified opportunities?

Weaknesses/Opportunities	O1	O2	O3	O4	O5	Weights	Total Interactions	Generated by weights and interactions
W1	0	0	0	0	1	0.17	1	0.17
W2	1	0	0	1	1	0.24	3	0.72
W3	1	0	0	1	1	0.28	3	0.84
W4	1	0	0	0	1	0.31	2	0.62
Weights	0.31	0.15	0.2	0.14	0.2			
Total Interactions	3	0	0	2	4			
Generated by weights and interactions	0.93	0	0	0.28	0.8			
Adding up interactions							18	
Adding up products								4.36

DISCUSSION

Based on pyrolysis-SWOT analysis, the study project covered a number of important issues with the treatment of COVID-19 medical waste. It involved conducting pyrolytic decomposition tests at different temperatures to examine the thermal behavior and composition of the waste. Additionally, a comprehensive to assess the benefits, drawbacks, potential benefits, and dangers related to the management of medical waste, a SWOT analysis was performed. The study also explored the potential utilization of by-products generated from the pyrolysis process, such as biochar and recovered chemicals. Based on the findings and analysis, the research project provided recommendations to enhance COVID-19 medical waste management, including infrastructure improvements, training and guidelines for healthcare professionals, public awareness campaigns, optimization of pyrolysis processes, and regulatory compliance. By addressing these areas, the aim is to improve the overall environmental protection.

The final step of the study involved bringing in specialists to analyze the linkages between each of the four distinct sets of strategic elements and provide ratings of each group's traits in regard to the use of the pyrolysis method for solid waste from municipalities in Poland. Particular variables that can affect the use of pyrolysis were given weights by the experts in the range of 0 to 1. Every factor group's weight added up to 1.0 in total. This made it easier to investigate the subsequent issues:,[1] Can the advantages of pyrolysis successfully make use of the chances found?,[2] Can the advantages of pyrolysis effectively counteract any threats?,[3] Can the shortcomings of pyrolysis prevent the potential from being realized?,[4] Can the drawbacks of pyrolysis worsen the effects of current dangers?

A questionnaire survey was conducted as part of the research's mixed methodology, which included both qualitative and quantitative components, in 15 Upazila of Bangladesh's 4 Districts. Rayhan, Liza, and Rahman,[6] concentrated on a national proper COVID-19 vaccination pressure, drivers, state, impact, garbage estimating, and response (DPSIR) framework evaluation, and SWOT analysis to determine the current state of healthcare waste management in this research region. The examination found that while the division technique worked perfectly every time, there was bad management of waste (35.5%), inadequate elimination of syringes and other dangerous materials (46.6%), and poor vial removal (without disinfection/open dump 52%) for vaccine wastes. Between 58 and 257.85 tonnes of unused syringes (with syringes and packaging) and vaccine vials (Sinopharm 2 doses) respectively were generated when the mass immunization project started. The bulk of the advantages, disadvantages, possibilities, and dangers were found to be successful division strategies, inadequate ex-situ disposal, enough space for managers, and environmental and health problems after doing a SWOT analysis. Regarding the creation of vaccine waste and its impacts on the study area, a DPSIR framework was finally developed. The research would be helpful in Bangladesh in developing a proper approach for managing vaccine waste.

Shammi et al,[12] focuses on a quick and concise Strategic environmental assessment (SEA) that was carried out during COVID-19 to determine the current state and any legal voids in the rules governing medical waste disposal. Key informant interviews, or KIIs, were conducted with regulators, institutions affiliated with public and private medical schools, pharmaceutical companies, civil society organizations, and third-party organizations engaged in the elimination of healthcare waste. Based on a SWOT analysis, issues with the present biomedical waste management system include organizational disagreements, an absence of control, and environmental restrictions. The updated laws must be put into effect while adhering to the "3-R policies," the "pollution pays principle," and a consequence assessment led by the SEA.

In this article titled "Identifying the Impacts of the COVID-19 Pandemic on Home Medical Waste Management" Silva et al,[13] A thorough investigation was undertaken to determine how the global epidemic will affect home healthcare waste management by the organization Turning Risks into Opportunities and Weaknesses into Managing

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Advantages (MWM). The research specifically focused and MWM in Caruaru, Brazil. Prior to the onset of the pandemic, the researchers conducted an extensive survey spanning three months (from October to December) involving structured and semi-structured interviews with various stakeholders, including health professionals, caregivers, and patients. Through these interviews, the researchers collected qualitative and quantitative data to gain a comprehensive understanding of the situation. To evaluate the existing practices of HCS and MWM, as well as to identify potential threats and weaknesses, the authors applied the SWOT-TOWS analysis framework. They were able to develop plans using this evaluation to successfully protect the planet and the general population. The results of the research revealed important flaws, namely the lack of formal education among medical experts and the inadequate instruction given to carers about appropriate MWM practices. It was observed that, apart from the management of sharp waste, the overall MWM practices were deemed inadequate, thus posing substantial threats, especially during a pandemic period. Consequently, the study underscores the urgent need for targeted improvements in training, guidance, and overall MWM practices to effectively mitigate risks and of both the public.

Rayhan et al,[6] presents a rapid assessment method for analyzing the flow of potentially infectious waste in Romania, the emergency state period. During this time, Romania implemented a national lockdown and imposed various restrictive measures, including social distancing and limitations on population mobility and economic activities. This study closes a key knowledge gap regarding the flow of healthcare waste considering urban and clinical processes controlling the propagation of the viral infection. The research identifies COVID-19 patients, those in quarantine, and people who have secluded themselves as the main sources of possibly contagious trash. The suggested assessment model approximations that the national COVID-19 waste flow amounted to 4,312 tons from 25 February to 15 June, with 2,633 tons generated during the emergency state period. The findings of the evaluation highlight pre-existing flaws in Romania's healthcare and urban waste management processes that were made worse by the spread and pose current risks to the natural world and human health. The paper also analyses the key difficulties trash managers confront and discusses a few successful approaches seen across the economic downturn. The report makes many proposals to solve COVID-19 trash-related concerns based on the results and discussions, and it emphasizes the critical need for an accurate registry of medical and municipal trash in controlling such biological risks at both the national and EU levels. Leaders must closely monitor COVID-19 waste movement through these models in order to reduce the danger of contaminated and related environmental problems, particularly in middle-income and low-income nations with poor waste management and incomplete waste statistics.

Manupati et al,[14] presents an evaluation system in this research centered around triple-bottom-line and socio-technical viewpoints for the optimal HCW disposal strategy. Based on a survey of the available literature, we have established ten criteria by which the optimal HCW disposal strategies should be chosen. The Fuzzy VIKOR approach is then used to assess nine different HCW alternatives for disposal. An actual-world case study taking place in India has been used to illustrate the efficacy of the suggested structure. We have contrasted the outcomes using Fuzzy TOPSIS (Technique of Preference for Order Similarities to the Ideal Solution) in order to evaluate the stability of the suggested technique. The outcomes assist the local authorities in developing a rigorous strategy to select the optimal HCW disposal methods. According to our research, incineration is the most effective way to dispose of garbage compared to other options. Even though the evidence suggests that "incineration" is the optimum approach, we must not ignore the environmental issues raised by this approach. The data analysis suggests that incineration could be the best option during a COVID; however, "COVID" should not be used as a justification for creating "Environmental Pollution."

Sharma et al,[15] outlines the many difficulties with solid waste management industry had over the COVID-19 outbreak and suggests viable ways to solve systemic inadequacies. The research specifically examines the management of health-care waste, which have all emerged as significant concerns during this crisis. The danger of mixing virus-contaminated biomedical waste with conventional solid trash, which presents significant safety and health hazards for sanitation personnel, is one crucial problem that has been raised. The report foresees a rise in only used once plastic use as a result of increased concerns about sanitation, particularly with regard to safety gear and healthcare supplies. While not perishable purchases made during the shutdown and worries about food shortages may have reduced the amount of food wasted at home, there is a chance that supply strands will be disrupted, causing food items to get stuck in travel because of limited vehicle movements or a shortage of staff members capable of handling perishable merchandise in storage facilities. The research emphasizes the significance of creating robust and localized supply networks to better handle such circumstances in the event of epidemics in the not-too-distant future. Alongside proposing innovative solutions to address existing waste management challenges, the research provides key recommendations to policymakers to adopt a comprehensive approach in handling potential future pandemics.

Shammi, Behal, and Tareq,[16] propose a structure that, if the BMW produced at medical centres and

ISSN (O): 2687-5365; ISSN (P): 2753-6556

residences is not properly managed, Could boost the COVID-19 pandemic's atmospheric and societal spread. Any use of the BMW, including safety suits, PPE, gloves, and shields, masks, would probably eventually lead to micro-plastic pollution, which would be bad for the ecology. The present hospital and home waste disposal guidelines, plans, and suggestions should be updated and revised. Additionally, it is advised that clinics do occupational health and safety audits for the waste disposal staff. For effective waste management, it is advised to install burning facilities with the requisite capacity and supporting infrastructures. With a quick impact assessment and proper application of the regulations and guidelines, due to a shortage of smoldering infrastructure, existing commercial furnaces, concrete kilns, and portable burning materials can be utilized.

This essay suggests integrating a SWOT analysis with a variety of preference relations approaches to assess ABC, an instance of a firm looking to improve its usage of social networking sites, for its advantages, disadvantages, possibilities, and dangers. The study incorporates expert opinions to identify relevant SWOT factors specific to social media for ABC. The multiple preference relations approach is then used to evaluate and rank these criteria. There are an overall 17 recognized criteria in the assessment model's four primary areas of strengths, weaknesses, opportunities, and threats. "O2: Possibility to contact an enormous amount of users concurrently at a reasonable price" stands out amongst these variables as being the most crucial. The results obtained from the evaluation are used to develop alternative strategies for ABC's social media endeavors. The originality of this study lies in the integration of using the variety of demand relationships approach; the SWOT analysis offers a viewpoint on shared decision-making. This method is novel in the context of social media-related literature. The study not only identifies the most suitable strategic factors for ABC's social media efforts but also determines alternative strategies based on the obtained results.[17]

CONCLUSION

This study focused on the management of COVID-19 medical waste using pyrolysis as a waste disposal technique, supported by a SWOT analysis. The pyrolysis tests provided valuable insights into the decomposition process of the medical waste, shedding light on the thermal behavior and composition of the waste. By rapidly heating the samples at different temperatures and analyzing the evolved analyses using a GC-MS system, we gained a better understanding of the decomposition process. The SWOT analysis further complemented the findings by identifying the strengths, weaknesses, opportunities, and threats associated with the management of COVID-19 medical waste. The strengths and opportunities highlighted the potential of pyrolysis as an efficient and environmentally friendly waste disposal method. It offers the advantage of converting the waste into valuable by-products while minimizing the risks of contamination and transmission of infectious diseases. However, the analysis also identified weaknesses and threats that need to be addressed. These include potential challenges in scaling up pyrolysis operations, ensuring proper handling of hazardous waste, and mitigating the environmental impact of the process. It is crucial to consider these factors when implementing pyrolysis-based management of COVID-19 medical waste. Based on the findings and SWOT analysis, several recommendations can be made to enhance the management of COVID-19 medical waste.

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