Survey on The Future of Waste Management: Innovation And Environmental Stewardship

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Abstract- *In the face of escalating environmental challenges, effective waste management has become a critical global concern. This comprehensive survey paper synthesizes and analyses recent advancements, challenges, and future prospects in waste management. Focusing on technology-driven strategies, emerging contaminants, life-cycle assessments, optimization models, smart systems, and societal perspectives, the survey aims to provide a nuanced understanding of the current state of waste management practices on a global scale. By examining 32 selected papers published between 1998 and 2023, the paper identifies common themes, assesses gaps, and proposes implications for future research. The findings of this survey are intended to inform policymakers, practitioners, and researchers, facilitating the development of sustainable waste management strategies worldwide.*

Keywords- Waste management, technology, optimization, emerging contaminants, life-cycle assessment, smart systems.

I. INTRODUCTION

The unprecedented growth in global population and industrialization has led to an exponential increase in waste generation, presenting a pressing environmental challenge. Efficient waste management is crucial for mitigating environmental impact, ensuring public health, and fostering sustainable development. This survey addresses the need for a comprehensive understanding of recent advancements in waste management practices by examining studies that delve into technology-driven solutions, emerging contaminants, life-cycle assessments, optimization models, smart systems, and societal perspectives. As we stand at the intersection of technological innovation and environmental stewardship, a holistic review of contemporary literature in waste management is imperative to guide future endeavours.

II. METHODOLOGY

The methodologies adopted in the selected studies exhibit a diverse range of systematic approaches to address the complexities of waste management. In the Sustainable Solid Waste Management System study by Gupta et al. (2023), a robust methodology involved extensive fieldwork in an Indian city, focusing on technology-driven end-of-pipe strategies. The Emerging Contaminants in Waste Management research (He et al., 2023) compiled a comprehensive understanding of emerging contaminants through the systematic review of analytical methods and fate assessments. Mandpe et al.'s (2022) Life-Cycle Assessment Approach integrated life-cycle assessment with route optimization, conducting a sensitivity analysis to identify critical intervention points. Rabbani et al. (2021) uniquely integrated a social performance assessment into a multi-objective optimization model for waste management. Wang et al.'s (2021) Smart Municipal Waste Management System relied on deep learning and IoT integration, with scalability assessments and recommendations for real-time data analytics. The Assessment of Solid Waste Management in Chandigarh City, India (Rana et al., 2015) involved a detailed policy evaluation to identify deficiencies in the current waste management system and raise environmental awareness. These methodologies collectively contribute to a nuanced understanding of waste management challenges and potential solutions, offering insights for future research endeavours.

III. LITERATURE REVIEW

Waste management, a multifaceted domain at the intersection of environmental science, public health, and technology, has garnered increasing attention as global waste generation reaches unprecedented levels. This literature review encapsulates the richness of recent studies that contribute to the evolving landscape of waste management, emphasizing technology-driven solutions, emerging contaminants, life-cycle assessments, optimization models, smart systems, and societal perspectives.

Sr. no.	Author/ Organization Name	Title (Year)	Advantages	Disadvantages	Future Scope
1	1.Rachita Gupta 2.Harish Hirani 3.Ravi Shankar	Sustainable solid waste management system using technology-enabled end-of-pipe strategies (September 2023)**[12]**	**1. Focus on Technology**: The research highlights technology-driven EOP strategies, demonstrating their effectiveness in waste management solutions. **2. Practical Validation:** The Indian city case study validates the research, showcasing tangible savings and benefits from the proposed strategies, enhancing their real-world relevance.	**1. Limited Applicability:** Findings from the Indian city case study might not be universally applicable due to diverse socio-economic and infrastructural variations across regions. **2. Comprehensive Approach Needed:** While EOP strategies are crucial, a comprehensive waste management approach should also integrate preventive measures for greater effectiveness.	**1. Innovative Segregation Technologies:** Research on AI-driven sorting and robotic automation improves waste sorting accuracy and efficiency, reducing human error for effective waste management. **2. Circular Economy Integration:** Emphasize recycling, reusing, and repurposing materials in waste management, promoting sustainable consumption and optimizing resource use.
2	1.Pinjing He 2.Ilje Pikkar 3.Debra Reinhart	Emerging Contaminants in Waste Management: Current Trends and Future Challenges in Fate, Pollution Control, Processes and Policy (August 2023)**[13]**	**1. Knowledge Advancement:** The special issue compiles research, reviews, and data, advancing knowledge in emerging contaminants in waste management for scholars and practitioners. **2. Holistic Understanding:** Covering analytical methods, fate, interactions, and removal techniques, it offers a comprehensive view of emerging contaminants.	**1. Scope Limitations:** Despite being comprehensive, the special issue might miss certain emerging contaminants, creating gaps in understanding the overall issue. **2. Depth Concerns:** The broad coverage might result in insufficient depth, especially for complex topics like legislative initiatives against plastic waste management, potentially limiting the	**1. Integrated Pollution Control:** Research on integrated approaches, combining technologies like bioremediation and advanced oxidation, can effectively tackle multiple emerging contaminants in mixed environments. **2. Global Policy Collaboration:**

				depth of insights provided.	Develop innovative cross-border policies and agreements for unified global management of emerging contaminants, acknowledging their transboundary impact on environmental pollution.
3	1.Ashootosh Mandpe 2.Ayush Bhattacharya 3.Sonam Paliya 4.Vinay Pratap 5.Athar Hussain 6.Sunil Kumar	Life-cycle assessment approach for municipal solid waste management system of Delhi city (September 2022)**[14]**	**1.Holistic Approach:** Integrating LCA with route optimization offers a comprehensive evaluation of waste management, considering environmental and economic factors. The inclusion of ArcGIS enhances precision by optimizing transportation routes spatially. **2.In-Depth Analysis:** The study's sensitivity analysis provides valuable insights into the inverse relationship between recycling rates and environmental impacts, emphasizing the critical role of recycling in mitigating negative environmental effects.	**1. Comprehensive Impact Assessment**: Consider a broader range of environmental impact categories for a comprehensive understanding of waste management consequences. **2. Feasibility Analysis:** Address practical challenges like land acquisition and community acceptance for proposed solutions, requiring detailed feasibility analysis for real-world implementation.	**1. Advanced Route Optimization:** Research can enhance route optimization with machine learning and real-time data analytics, minimizing costs and environmental impact in waste transportation. **2. Circular Economy Promotion:** Future studies should focus on recycling incentives, advanced sorting tech, and awareness campaigns in Delhi. Sustainable recycling models reduce landfill burden and environmental hazards.
4	1.Masoud Rabbani, 2.Kimiya Mokarrari 3.N. Akbariansaravi	A multi-objective location inventory routing problem with pricing decisions in a sustainable waste management system (December 2021)**[15]**.	**1.Comprehensive Optimization:** The multi-objective optimization model offers a holistic approach, incorporating cost minimization, reduced greenhouse gas emissions, and efficient waste collection and treatment times. It considers both economic and environmental factors.	**1. Complex Decision Challenges:** Pricing decisions add complexity to the system, requiring careful balancing of multiple objectives and social metrics, demanding expertise in decision-making processes. **2. Case Study Limitations:** Findings are	**1. Social Impact Metrics:** Future research should develop comprehensive metrics for waste management, considering not only environmental but also social benefits like job creation and public health

			2.Social Aspect Integration: The study uniquely integrates social performance assessment, addressing the social dimension of waste treatment technologies. By evaluating the impact of social performance on objective functions.	specific to the southeast Tehran case, limiting generalizability to diverse contexts, such as varying geographies and cultures.	improvements. **2. Dynamic Decision Frameworks:** Explore dynamic models integrating real-time data and predictive analytics, enabling adaptive strategies in response to changing factors such as population growth and technology advancements, enhancing long-term system resilience and sustainability.
5	1.Cong Wang 2.Jiongming Qin 3.Cheng Qu 4.Xu Ran 5.Chuanjun Liu 6.Bin Chen	A smart municipal waste management system based on deep-learning and Internet of Things (November 2021)**[16].**	**1. Precise Waste Classification:**The system employs deep learning and cloud computing for accurate waste sorting, optimizing recycling and reducing management costs. **2. IoT Smart Monitoring:** Integration of IoT devices enables real-time container monitoring, enhancing decision-making, adaptive deployments, route optimization, and resource utilization efficiency.	**1. Technology Challenges:** Implementing and maintaining advanced technologies like deep learning and IoT devices might be challenging, especially in resource-limited areas, raising concerns about system reliability during technical failures. **2. Scalability Limitations:** Adapting the system to diverse environments may require substantial modifications, limiting its scalability beyond the demonstrated context.	**1. Scalability and Interoperability:** Future research should focus on scaling the system for larger urban areas and ensuring compatibility with diverse waste container types and sensor setups, optimizing practical effectiveness. **2. Predictive Analytics Integration:** Incorporating predictive analytics using historical data and machine learning can anticipate peak waste generation, enabling proactive planning, reducing costs, and improving overall waste management efficiency.

6	1.Akhilesh Kumar, 2.Avlokita Agrawal	Recent trends in solid waste management status, challenges, and potential for the future Indian cities – A review (December 2020)**[17].**	**1.Comprehensive Overview:** The study provides a holistic overview of the Municipal Solid Waste Management (MSWM) situation in India, encompassing various factors such as population growth, urban density, cultural diversity, and changing lifestyles . **2.Identification of Challenges:** By identifying key challenges like unsorted solid waste, social taboos, citizen attitudes, poor assessment, and inadequate strategies, the study sheds light on the multifaceted issues hindering effective waste management.	**1.Lack of Specific Solutions:** While the study identifies challenges, it might lack specific, actionable solutions to address each issue. Providing concrete, detailed strategies would enhance the practical applicability of the study's findings, guiding policymakers and practitioners on the necessary steps to take. **2.Limited Focus on Implementation:** While the study points out the need for the involvement of various sectors (municipalities, informal sectors, private agencies), it may not delve deeply into the practical aspects of implementing these collaborations.	**1.Actionable Solutions:** Future research can focus on specific, actionable waste management strategies, offering clear steps for policymakers and practitioners, ensuring practical and impactful implementation. **2.Collaborative Implementation:** Further studies should explore successful case studies and challenges in collaborative efforts. Understanding practical intricacies can guide effective partnerships between sectors in waste management projects.
7	1.Nidhya R., 2.Manish Kumar, 3.Renjith V. Ravi , 4.Deepak V.	Enhanced Route Selection (ERS) algorithm for IoT enabled smart waste management system (November 2020)**[18].**	**1.IoT-Driven Modernization:** The proposed system, utilizing IoT technology, modernizes waste management practices, ensuring efficient data transmission and promising advancements in smart cities and environments. **2.ERS Algorithm Efficiency:** ERS addresses data transmission delays in wireless sensor networks by optimizing end-to-end delay, remaining energy, and energy consumption, enhancing system efficiency.	**1.Technical Challenges:** Implementing IoT systems with advanced algorithms like ERS demands expertise. Managing wireless sensor networks and resolving technical issues can be challenging, especially for regions lacking specialized knowledge and resources. **2.Real-World Validation:** The proposed architecture's real-world effectiveness is unverified. Challenges like network congestion and unexpected events could impact the algorithm differently in dynamic environments.	**1.Efficient IoT Devices:** Future innovations should focus on energy-efficient IoT devices to extend operational life, ensuring continuous data transmission in waste management systems. **2.Real-Time Data Analytics:** Implementing real-time data analytics using machine learning can enhance decision-making, predicting waste generation patterns and optimizing

					collection routes dynamically for more efficient waste management.
8	1.Ayush Thada, 2.Uday Karan Kapur, 3.Saif Gazali , 4.Nikhil Sachdeva, 5.S Shridevi	Custom Block Chain Based Cyber Physical System for Solid Waste Management (November 2019)**[19].**	**1.Blockchain Security:** The system ensures secure waste management records using blockchain, enhancing data integrity and transparency, even against adversaries. Its cryptographic features provide tamper-proof record-keeping. **2.Smartphone Integration:** Utilizing embedded systems and an Android app, the system maximizes smartphone capabilities, ensuring efficiency and user-friendliness. This familiar technology enhances accessibility and user acceptance.	**1.Technical Complexity:** Integrating database servers, blockchain, embedded systems, and mobile apps demands expertise and resources. Synchronizing these components is challenging, leading to operational difficulties if not managed effectively. **2.Smartphone Dependency:** System effectiveness relies on smartphone availability. Limited smartphone usage or tech infrastructure may restrict applicability, excluding segments of the population.	**1.Smart Waste Management System:** This study presents a smart waste management system using blockchain, databases, and smartphone apps to optimize trash bin operations, ensuring functionality in all conditions. It aligns with India's updated waste policy, enhancing waste management practices. **2.Blockchain Verification:** Utilizing blockchain's decentralized and secure transaction features, the system verifies trash bin usage, promoting transparency and reliability in waste management operations.
9	1.Zongguo Wen, 2.Shuhan Hu , 3.Djavan De Clercq , 4.M.Bruce Beck , 5.Hua Zhang , 6.Huanan Zhang, 7.Fan Fei, 8.Jianguo Liu	Design, implementation, and evaluation of an Internet of Things (IoT) network system for restaurant food waste management(March 2018)**[20]**	**1.Improved Waste Management:**The IoT system led to a 20.5% increase in collected food waste and a 207% rise in official contracts, demonstrating better management of restaurant food waste generation. **2.Enhanced Law Enforcement:**Monitoring capabilities enabled better law enforcement against malpractice, reducing illicit	**1.Operating Costs:**RFID tag renewal due to frequent handling increased operating costs, impacting the system's sustainability. **2.Sensor Accuracy:**Automatic weight sensors showed higher error rates compared to manual methods, affecting the precision of waste measurements.	**1.Sensor Technology Refinement:**Future work can focus on developing more durable RFID tags and enhancing the accuracy of dynamic weight sensors to reduce operational costs and improve data precision. **2.Interagency Collaboration:**Addr

			activities and optimizing the food waste value chain processes.		essing disagreements between government agencies regarding data interpretation can enhance system efficiency, emphasizing the need for streamlined collaboration for effective waste management.
10	1.Pardeep Kumar Sadh 2.Surekha Duhan 3.Joginder Singh Duhan	Agro-industrial wastes and their utilization using solid state fermentation: a review (December 2004)**[10].**	**1.Resource Efficiency:** Agricultural waste, when properly recycled and utilized, can serve as a valuable resource for various industrial purposes. This approach promotes resource efficiency by extracting maximum value from agricultural by-products and waste materials, reducing the need for virgin resources. **2.Energy Recovery:** Agricultural waste can be converted into biofuels, such as biogas or bioethanol, through processes like anaerobic digestion or fermentation.This facilitates energy recovery and reduces dependence on fossil fuels, contributing to a more sustainable energy mix.	**1.Technological and Infrastructural Limitations:** Recycling and utilizing agricultural waste require advanced technologies and infrastructure, which might be lacking in certain regions. The initial investment in equipment and infrastructure can be a barrier to implementing effective waste management practices. **2.Contaminant Concerns:** Agricultural waste may contain contaminants such as pathogens, chemical pollutants, and physical impurities	**1.Advanced Waste Conversion Technologies**: Continuous research and development in waste conversion technologies can lead to more efficient and cost-effective methods for recycling and utilizing agricultural waste technologies like pyrolysis, gasification, and hydrothermal treatment hold promise for converting waste into valuable resources. **2. Circular Economy Approach**: The future of agricultural waste management lies in adopting a circular economy approach, where waste materials are viewed as valuable inputs for various industries.

11	1.Insung Hong 2. Sunghoi Park 3.Beomseok Lee 4.Jaekeun Lee 5. Daebeom Jeong 6. Sehyun Park	IoT-Based Smart Garbage System for Efficient Food Waste Management (April 2014)**[21].**	1.**Waste Reduction:** The primary advantage of the IoT-based SGS is its effectiveness in reducing the amount of food wasteIn the experiment showed a significant reduction of 33% in the average amount of food waste. 2.**Environmental Benefits:** Efficient waste management through SGS can have positive environmental impacts by reducing landfill waste, lowering greenhouse gas emissions, and preventing the release of harmful substances from decomposing waste.	1.**Cost and Implementation Challenges:** Implementing and maintaining an IoT-based SGS can be costly. It involves the initial investment in smart garbage bins, wireless mesh networks, servers, and routers, as well as ongoing operational costs. 2.**Privacy and Data Security Concerns:** Collecting and analysing data from smart garbage bins may raise privacy concerns. People may worry about their waste disposal habits being monitored and recorded.	1.**Data Analytics and Predictive Maintenance:** Utilize the collected data to develop advanced analytics and predictive maintenance algorithms. This can help in optimizing waste collection schedules, detecting anomalies, and ensuring the efficient use of resources . 2.**Integration with Sustainable Practices:** Integrate the SGS with sustainable waste-to-energy solutions, such as biogas or composting facilities, to further reduce the environmental impact of waste disposal.
12	1.Rishi Rana 2.Rajiv Ganguly 3.Ashok Kumar Gupta	An Assessment of Solid Waste Management System in Chandigarh City, India (April 2015)**[22].**	1.**Policy Recommendations:** By identifying deficiencies in the current waste management system, the paper can inform policy decisions and improvements. 2.**Environmental Awareness:** The research raises awareness about the environmental consequences of improper waste management, encouraging responsible practices.	1.**Limited Information:** The abstract provides only a brief overview of the paper, lacking the in-depth details, methodology, and specific findings that would be present in the full research paper. 2.**Lack of Citations:** The abstract does not include citations to other research or sources, which are typically found in academic papers to support claims and provide context.	1.**Technological Upgrades:** Implementing modern waste collection and processing technologies to enhance efficiency. 2.**Public Awareness Campaigns:** Increasing awareness among residents about the importance of proper waste disposal. 3.**Recycling Initiatives:** Promoting recycling programs to reduce the volume of waste

					sent to landfills.
13	1.K.G. Kiran 2.Sanjay Kini 3.Ravi K. 4.Santhosh N.P. 5.N. Udaya Kiran	KAP study of solid waste disposal of households in Kuttar & Manjanadi Panchayath covered under gramaskhema programme of K.S. Hegde Medical Academy (September 2015)**[23].**	1.**Local Relevance:** Understanding the waste management practices in a local context is important because it can lead to tailored solutions that fit the needs of the community. 2.**Baseline Data**: The study provides baseline data on the knowledge, attitudes, and practices related to solid waste management in the area. This data is crucial for developing effective waste management policies and interventions.	1.**Limited Generalizability:** The study's findings may not be generalizable to other regions due to its specific focus on one location. 2.**Incomplete Information**: The text doesn't provide details about the methodology used, sample size, or data collection techniques. Without this information, it's difficult to evaluate the quality and rigor of the study. 3.**Lack of Attribution**: The text doesn't attribute the study to any specific authors or institutions, making it challenging to verify the credibility and source of the information.	1.**Community Engagement**: The study emphasizes the role of residents in waste management. Future work could focus on community engagement and participation in waste reduction and recycling programs. 2.**Comparative Studies**: Comparative studies with other regions or countries could help identify best practices and innovative solutions in waste management.
14	1.W.A.A.I. Warunasinghe 2.P.I. Yapa	A survey on household solid waste management (SWM) with special reference to a peri-urban area (Kottawa) in Colombo (Octomber 2015)**[24].**	1.**Data Collection:** The study employs a systematic data collection method using a pretested and self-administered questionnaire, providing valuable insights into household waste management practices. 2.**Willingness to Participate:** The high percentage (96%) of respondents willing to cooperate and participate in proper waste management programs suggests potential community support for future initiatives.	1.**Sample Size:** The study's sample size is relatively small, with data collected from 50 households in one peri-urban area. While it can provide localized insights, the findings may not be entirely representative of the broader population. 2.**Limited Geographic Scope:** The study focuses on Kottawa, a specific peri-urban area in Colombo. Findings may not be directly applicable to other regions with potentially different waste management challenges.	1.**Education and Awareness:** Given the high level of awareness among respondents, future efforts could concentrate on educating communities about best waste management practices and sustainable behaviours. 2.**Waste Reduction and Recycling:** Strategies for waste reduction, recycling, and composting could be explored in more depth to reduce the overall waste generation and promote

					sustainability. 3.**Community Engagement:** Engaging communities in waste management decision-making processes and encouraging active participation can lead to more effective and sustainable solutions.
15	1.Gombojav Delgermaa 2. Toru Matsumoto	A Study of Waste Management of Households in Ulaanbaatar Based on Questionnaire Surveys (May 2016)**[25].**	**1.Environmental Benefits:** Improved waste management practices can significantly reduce environmental pollution, soil contamination, and air quality degradation in urban areas. 2.**Cost Reduction:** Implementing waste classification and pre-collection can reduce transportation costs associated with taking waste to dump sites. 3.**Resource Recovery:** Increased recycling and proper waste management can lead to resource recovery from recyclable items, contributing to sustainability.	1.**Limited Focus**: The study primarily concentrates on household waste, potentially overlooking industrial and commercial waste sources, which are also significant contributors to pollution. 2.**Outdated Information:** The research was published in 2016, and waste management conditions may have changed since then, rendering the data less relevant. 3.**Incomplete Solutions:** While the research identifies problems and suggests solutions, it might not address the complexities of implementing these solutions in practice.	1.**Comprehensive Coverage:** Future research can expand its scope to encompass all waste sources, including industrial and commercial sectors. 2.**Longitudinal Studies:** Conducting follow-up studies to track changes and improvements in waste management practices in Ulaanbaatar City over time. **3.Economic and Environmental Assessments:** Investigate the economic and environmental impacts of implementing improved waste management practices, including waste-to-energy conversion and recycling.
16	1.Zahra Namvar	Survey of Hospital Solid Waste	1.**Data Collection:** The study collects valuable data	1.**Data Collection Methods:** The study relies	1.**Longitudinal Studies:** Conducting

	2.Hosseinali Asgharnia 3.Hourieh Fallah 4.Abdoliman Amouei	Management in North of Iran (June 2016)**[6].**	on hospital waste management practices in the Mazandaran province, which can serve as a basis for informed decision-making and policy development. 2.**Comparison:** The research provides insights into how hospital waste management practices in Iran compare with those in other countries, contributing to a global perspective on this issue.	on a researcher-made questionnaire, which may introduce biases or limitations in data collection. 2.**Limited Scope:**The study focuses on a specific region (Mazandaran province) in Iran, which may limit the generalizability of its findings to other areas within or outside the country.	longitudinal studies to track changes and improvements in hospital waste management practices over time. 2.**Comparative Analysis**: Comparing waste management practices across different regions in Iran and other countries to identify best practices and areas for improvement. 3.**Technological Solutions:** Exploring the use of advanced technologies and equipment for safe and efficient hospital waste disposal.
17	Mr.C. Balakrishnan	A Survey of Household Solid Waste Management in Chennai (A Case Study of Residents around Kodungaiyur, Chennai, Tamil Nadu) (November 2016)**[7].**	1.**Local Relevance:** Focusing on a specific locality (Kodungaiyur) allows for a more in-depth understanding of local challenges and needs. 2.**Policy Implications:** The findings can inform policy decisions related to waste management and environmental protection.	1.**Limited Scope:**The study is limited to a specific area of Chennai, and the findings may not be entirely representative of the entire city or other regions. 2.**Single Author:** The paper has a single author, which may limit the diversity of perspectives and expertise in the research.	**1.Longitudinal Studies:** Future research can track changes in residents' attitudes and behaviours over time to assess the impact of waste management initiatives. **2.Comparative Analysis:** Comparing the findings from Kodungaiyur with other neighbourhoods or cities can provide valuable insights into regional variations in waste management practices.

18	1. Prahasan P. 2.Punith Kumar 3. Hema R 4. Arti Arya	Waste Management Survey Of Bangalore City (December 2016)**[8].**	1.**Confidence Interval:** The use of statistical methods like confidence intervals and hypothesis testing adds rigor to the survey, providing a quantitative understanding of the data. 2.**Correlation Analysis:** The correlation analysis between different survey questions helps identify relationships and patterns within the responses.	1.**Regional Consideration**: Acknowledge regional variations in waste practices, tailoring solutions to local contexts. **2.Cautious Interpretation**: Be mindful that correlation doesn't imply causation in data interpretation. **3.Qualitative Integration**: Combine quantitative data with qualitative research to gain a deeper understanding of behaviours and attitudes, enhancing intervention effectiveness.	**1.Addressing Awareness-Action Gap**: Investigate reasons behind the gap between awareness and waste segregation practices. **2.Policy Development & Campaigns**: Develop policies and campaigns for improved waste segregation based on survey insights. **3.International Best Practices**: Comparative studies with waste management practices from other countries can help identify international best practices and innovative solutions that can be adapted to the Indian context.

19	1.Zarifah Abdullah 2.Salniza Md Salleh 3. Ku Nor Izah Ku Ismail	Survey of Household Solid Waste Management and Waste Minimization in Malaysia: Awareness, Issues and Practices (December 2017)**[9].**	**1.Privatization Insights:** It contributes to understanding the impact and challenges of privatizing waste management services, crucial for improving efficiency and addressing urbanization issues. **2.Environmental Practices:** By examining waste minimization practices like recycling and composting, the research promotes sustainable waste management and reduced environmental impact.	**1.Regional Focus:** The study's regional focus limits its representativeness, making it less applicable to the entire country's waste management context. **2.Self-Reporting Bias:** Reliance on self-reported household data may introduce reporting bias, affecting data accuracy. **3.Economic Aspects Missing:** The study doesn't delve into the economic and financial dimensions of waste management privatization, an area of significant importance.	1.**Campaign Effectiveness:** Future research can evaluate the impact of awareness campaigns and educational efforts on household waste minimization practices. **2.Regulation Outcomes:** With the enforcement of waste separation regulations, subsequent research can examine the outcomes and challenges associated with these regulations. **3.Financial Evaluation:** Explore the financial aspects of waste management privatization, including cost-effectiveness and the economic sustainability of such initiatives.
20	1.S. Garg 2.B. Prasad	Plastic Waste Generation and Recycling in Chandigarh (February 2003)**[11].**	**1.Utility and Versatility:** Plastics have become a preferred material due to their lightweight nature, ease of handling, and versatility. They can be molded into various shapes	**1.Environmental Impact:** One of the major disadvantages of plastic is its non-biodegradable nature. Plastics take a long time to decompose naturally, resulting in	**1.Sustainable Alternatives:** The future of plastic waste management lies in the development and adoption of

			and sizes, making them suitable for a wide range of applications in industries such as packaging, construction, automotive, electronics, and healthcare. **2. Durability**: Plastics are known for their durability and resistance to wear and tear. They have a long lifespan compared to many other materials, which makes them useful for creating long-lasting & products.	significant environmental pollution. Improper disposal and unsuitable management of plastic waste can lead to littering, marine pollution, and harm to wildlife. **2. Health Hazards:** Some types of plastics contain toxic chemicals, such as phthalates and bisphenol A (BPA), which can leach into the environment and pose health risks to humans and animals.When plastic waste is burned, it releases harmful pollutants into the air, contributing to air pollution and respiratory issues.	sustainable alternatives to conventional plastics. Biodegradable and compostable plastics made from renewable resources, such as plant-based materials, offer potential solutions to the environmental impact of plastic waste. **2. Improved Recycling Technologies:**Advancements in recycling technologies can enhance the efficiency and effectiveness of plastic waste recycling.Developing innovative recycling methods, such as chemical recycling and pyrolysis, can enable the conversion of plastic waste into valuable resources and reduce dependence on virgin plastics.
21	1.Shuchi Gupta 2. Krishna Mohan 3.Rajkumar Prasad 4.Sujata Gupta 5. Arun Kansal	Solid waste management in India: options and opportunities (November 1998)**[1].**	**1.Environmental Protection:**Implementing scientific wastemanagement practices can help protect the environment by reducing pollution, preventing groundwater contamination, and minimizing contributions to global warming **2. Resource Conservation:** By	**1.Infrastructure and ImplementationChallenges:** Establishing the necessary infrastructure and implementing scientific waste management practices require significant investments in terms of funds, technology, and human resources. Lack of proper infrastructure, technical expertise, and financial resources can	**1.Technology Advancements:**Continuous research and development in waste management technologies can lead to more advanced and efficient systems. Technologies such as waste-to-energy conversion, advanced recycling techniques, and

			implementing recycling and composting practices, valuable resources can be recovered from waste materials.Recycling reduces the need for virgin resources, conserves energy, and reduces greenhouse gas emissions.	hinder the efficient management of municipal solid waste (MSW). **2.Public Awareness and Participation:**Encouraging public participation and raising awareness about waste segregation, recycling, and proper waste disposal practices are crucial but can be challenging. Lack of awareness and a lack of commitment from the public can undermine the effectiveness of waste management efforts.	innovative composting methods can contribute to a more sustainable and resource-efficient waste management system. **2.Circular Economy Approaches:**Embracing the principles of a circular economy can help shift the focus from waste disposal to resource recovery.Implementing strategies that promote waste reduction, reuse, and recycling can create opportunities for the development of new industries and business models that operate in a more sustainable manner.
22	1.Dr. Debjani Ghosh 2.Jagan Shah	Urban Solid Waste Management in Indian Cities (1999)**[2].**	**1.Multi-objective Analysis:** The interactive goal programming model takes into account multiple objectives in urban solid waste management, rather than focusing solely on cost minimization. **2.Resource Planning Optimization:** By applying the model, it becomes possible to identify the resource gaps and deficiencies within the current solid waste management system. The model helps determine the optimal resource requirements necessary to achieve the desired objectives, providing insights into the necessary resource	**1.Data Availability and Accuracy:** One of the limitations of the model is the availability and accuracy of data required for effective analysis. Obtaining accurate data on resource levels, waste generation, and operational costs can be challenging, particularly in resource-constrained settings. **2.Complexity and Technical Expertise:**Implementing the model requires technical expertise in goal programming and urban solid waste management. The complexity of the model may limit its accessibility to decision-makers who lack the	**1.Integration of Sustainability Metrices:** The future scope lies in incorporating sustainability metrics into the goal programming model. This could involve considering environmental impacts, such as greenhouse gas emissions, energy consumption, and waste diversion rates, as additional objectives to optimize in the decision-making process. **2. Sensitivity Analysis**:

				necessary skills or resources for its	Conducting sensitivity analysis can help assess the robustness of the model's results and identify key factors influencing resource planning and objective achievement.This analysis allows decision-makers to understand the potential variations and uncertainties in different
23	1.Fahimeh Rahimi 2.Farideh Atabi 3.J. Nouri	Using Life Cycle Assessment Method for Selecting Optimal Waste Management System in Tehran City (January 1995**) [3].**	**1.Holistic Approach:** The book takes a holistic approach to waste management, addressing environmental quality and economic cost considerations **2.Cutting-Edge Experience:** The book incorporates cutting-edge experience and best practices from across Europe.Readers can benefit from the latest advancements and innovative solutions in waste management, gaining valuable insights from real-world case studies and experiences.	**1.Geographical Specificity:** Although the book draws on European experiences, some of the information and recommendations may have limited applicability outside of Europe. **2.Technical Complexity:** The book may contain technical content and concepts that may require a certain level of expertise to fully understand and implement. Some readers, especially those with limited technical background or knowledge of waste management, may find certain sections challenging or overwhelming.	**1.Global Context:** Expanding the scope of the book to include global perspectives and experiences would make it more relevant and valuable to a broader range of readers. **2. Sustainable Solutions:** As waste management increasingly becomes a focal point in sustainability efforts, future editions of the book could delve deeper into sustainable waste management practices.
24	1.Do Nam Trung 2. S. Kumar	Resource use and waste management in Vietnam hotel industry (January 2005)**[4].**	**1.Assessment of Resource Use:** The study assesses the energy and water consumption, as well as waste generation, in the hotel industry in Vietnam. **2.Comparison with Other Countries:** By comparing the resource use in Vietnamese hotels with	**1.Limited Sample Size:** The study conducted a survey in only 50 hotels, which may not represent the entire hotel industry in Vietnam. The findings and benchmarks may be limited in their applicability due to the small sample size. **2.Data Accuracy:** The	**1.Longitudinal Studies:** Conducting longitudinal studies over an extended period can provide a more comprehensive understanding of resource use trends in the hotel industry in Vietnam.

			those in other countries, the study allows for benchmarking and the identification of best practices.	accuracy of the data collected through surveys and self-reporting by hotels may be subject to biases or errors. Variations in data collection methods and data quality among different hotels may affect the reliability of the findings.	**2.Sector-Specific Strategies:** Future research can focus on developing sector-specific strategies and guidelines for resource management in Vietnamese hotels.
25	Samson Elisha Kasala	1. Critical Analysis of the Challenges of Solid Waste Management Initiatives in Keko Machungwa Informal Settlement, Dar es Salaam(January 2014)**[26].**	1.**Environmental Conservation**: Sustainable waste management practices contribute to reduced environmental pollution, preservation of natural resources, and protection of ecosystems. **2.Public Health Benefits:** By managing waste sustainably, the risk of diseases, contamination of water sources, and air pollution is minimized, leading to better public health outcomes.	1.**Complexity**: Achieving sustainable waste management can be complex and costly, requiring significant investments in infrastructure, technology, and public awareness. 2.**Policy and Regulatory Challenges:** Developing and implementing policies and regulations to support sustainability can be challenging, and there may be resistance from various stakeholders.	1.**Innovative Technologies:** The future of sustainable waste management lies in the development and adoption of innovative technologies, such as advanced recycling methods, waste-to-energy solutions, and smart waste collection systems. 2.**Behavioral Change:** Encourage behavioural change at the community and individual levels through education and awareness campaigns, fostering responsible waste disposal and recycling habits.
26	1.Ebikapade Anasuomo 2.Jim Baird	The Concept of Waste and Waste Management.(November 2016**) [27].**	**1.Flexibility in Resource Utilization:** Subjectivity allows for flexibility in resource utilization. What one person sees as waste, another may see as a valuable resource. This flexibility can lead to innovative approaches to repurpose and reuse materials, promoting sustainability. **2.Local Context Consideration:** Subjective	1. **Inconsistent Definitions:** Subjective views can lead to inconsistent definitions of waste, making it challenging to create standardized waste management policies and regulations. This lack of clarity can hinder effective waste management. **2.Environmental and Health Risks:** Without clear waste definitions,	**1.Revisiting Waste Definitions**: Future research can delve deeper into the subjective nature of waste classification. This can involve interdisciplinary studies that explore the sociocultural, economic, and environmental factors influencing how people perceive waste.

			classifications take into account the local context, needs, and conditions. It allows communities and individuals to adapt waste management strategies to their specific situations, reducing the imposition of one-size-fits-all solutions	hazardous materials may be mishandled or disposed of improperly, leading to environmental contamination and health risks.	**2.Waste-to-Resource Transition:** The subjective nature of waste classification presents an opportunity to transition from a linear "take-make-waste" economy to a circular economy. **3.Policy Frameworks:** There is a need for the development of policy frameworks that strike a balance between subjective views and regulatory clarity.
27	David C. Wilson	Development Drivers for Waste Management (July 2007)**[28].**	**1.Improved Public Health:** Prioritizing public health as a driver for waste management leads to cleaner and safer environments, reducing the risks of disease outbreaks and improving the overall well-being of communities. **2.Environmental Protection:** Environmental concerns drive the adoption of sustainable waste management practices, leading to reduced pollution, habitat preservation, and a lower ecological footprint.	1. **Complexity:** The presence of multiple drivers can make the waste management landscape more complex and challenging to navigate, requiring careful coordination and decision-making. **2.Resource Conflicts:** The pursuit of waste as a resource may lead to conflicts over resource allocation and the potential exploitation of waste materials. **3.Transition Challenges:** Shifting from traditional waste management approaches to more holistic and sustainable models can be challenging and may face resistance from established practices.	**1.Interdisciplinary Research:** Future research can focus on interdisciplinary approaches to address waste management challenges comprehensively, considering the interplay of drivers and their impacts on the waste management landscape. **2.Localized Solutions:** Develop localized waste management solutions that take into account the unique balance of drivers in each region, catering to specific environmental, social, and economic contexts.

28	1.Mufeed Sharholy 2.Kafeel Ahmad 3.Gauhar Mahmood 4.R. C. Trivedi	Municipal Solid Waste Management in Indian cities(2008)**[29].**	1.**Resource Recovery:** Implementing proper waste management practices can facilitate resource recovery through recycling and waste-to-energy technologies, leading to economic opportunities and reduced resource depletion. **2.Public Health Improvement:** By reducing the risks of disease transmission and air and water pollution, MSWM can contribute to improved public health outcome	1.**Unscientific Disposal:** A significant portion of MSW in India is disposed of unscientifically in open dumps and landfills, causing environmental problems, public health risks, and the depletion of land resources. 2.**Infrastructure Challenges:** Many Indian cities face infrastructure challenges in terms of waste collection, transportation, and disposal facilities, which hinders the implementation of effective MSWM.	1.**Infrastructure Development:** Invest in the development of modern waste management infrastructure, including sanitary landfills, recycling facilities, and waste-to-energy plants, to improve waste disposal practices. 2.C**ommunity Engagement:** Encourage community engagement in waste management by involving local residents in waste separation, recycling, and collection efforts. 3.**Policy Reforms**: Revise and strengthen MSWM policies and regulations, with an emphasis on sustainability, to promote scientific waste disposal and recycling practices.
29	1.Ahmad Kamruzzaman Majumder 2.Sanjay Nath Khanal 3.Gyanendra Chaudhary 4.Silu Bhochhibhoya 5.Sunita Kumari	Characterization, quantification And management situation of medical Waste in Nepal (November 2007)**[30].**	**1.Resource Recovery:** Some medical waste materials can be recycled or repurposed, contributing to resource conservation and sustainability. **2.Compliance with Regulations:** Implementing proper medical waste management practices ensures compliance with local and	**1.Health Risks:** Improper handling and disposal of medical waste can lead to the spread of infections and pose serious health risks to healthcare workers, patients, and the general public. **2.Environmental Contamination:** Inadequate waste management can result in the contamination of soil,	**1.Technology Integration:** Implementing advanced technologies for the treatment and disposal of medical waste, such as autoclaving, microwave treatment, and advanced incineration, can

	Yadav 6.Ashma Vaidya		international regulations, promoting a safer and healthier environment.	water, and air, causing long-term environmental damage and affecting biodiversity.	enhance efficiency and reduce environmental impact. **2.Training and Education:** Investing in training programs and educational initiatives for healthcare professionals, waste handlers, and the general public can promote better awareness and understanding of proper waste management practices
30	1.Jaleshwari Dilip Ghatage 2.Sidhiee Jaiddep Mohitey 3.Shireen Shahanawaj Jamadar 4.J.M.Waykule4	Garbage Management (February 2018)	**1.Swachh Bharat Abhiyan Support:** The proposed system aligns with the Swachh Bharat Abhiyan, a national cleanliness campaign in India. It contributes to the goal of maintaining cleanliness and hygiene in public spaces. **2.Environmentally Friendly:** By promoting timely waste collection, the system helps prevent the environmental impact of littering, reducing the risk of soil and water pollution.	**1.Technological Dependency:** The system relies on technology, and any technical failures or issues with the electronic components could lead to gaps in the waste management process. **2.Privacy Concerns:** If the system involves the collection of data on waste generation patterns, there may be concerns about privacy and data security. Proper measures need to be in place to address these concerns.	**1.Collaboration with Private Sector:** Collaboration with private waste management services can be explored to optimize resource utilization and improve the overall efficiency of waste collection and disposal processes. **2.Continuous Improvement:** Regular feedback and evaluation of the system's performance can lead to continuous improvements, ensuring that it remains effective and aligned with the evolving needs of waste management in urban areas.

31	1.Michelle Bardales Cruz 2.Eri Saikawa 3.Mayari Hengstermann 4.Alexander Ramirez 5.John P. McCracken	Plastic waste generation and emissions from the domestic open burning of plastic waste in Guatemala(July 2022)**[31].**	**1.Environmental and Public Health Protection:** By addressing domestic open burning, there is a potential to reduce air pollutants and greenhouse gases, leading to improvements in air quality and the protection of public health. **2.Mitigation of Climate Change:** The reduction of greenhouse gas emissions, particularly CO2, contributes to global efforts to mitigate climate change and its associated impacts.	**1.Infrastructure and Access Challenges:** The primary reason for domestic open burning is the lack of access to waste collection services, especially in rural areas. Addressing this issue requires significant investments in waste management infrastructure. **2.Behavioral Change:** Changing long-standing practices of open burning requires community engagement and behavioral change, which can be challenging to achieve.	**1.Waste Management Infrastructure Development:** Investing in waste management infrastructure, especially in rural areas, can significantly reduce the reliance on open burning. This includes establishing waste collection services and recycling facilities. **2.Community-Based Solutions:** Engaging communities in waste management practices and promoting community-based solutions can lead to sustainable waste disposal practices.
32	1.Joannna Kulczycka 2.Zygmunt Kowalski	Principles of municipal waste management in Poland and selected regions of Europe (2008)**[32].**	**1.Resource Conservation:** Prioritizing waste prevention and reduction efforts contributes to the conservation of valuable resources. It promotes recycling, reuse, and recovery, reducing the need for raw materials. **2.Public Health Improvement:** Effective waste management practices contribute to the prevention of public health hazards associated with improper waste disposal. It minimizes the risk of contamination of air, water, and soil.	**1.Waste Sorting and Collection Logistics:** Implementing effective waste sorting and collection systems demands proper infrastructure and logistics. Developing and maintaining such systems can be complex and resource-intensive. **2.Policy Enforcement:** Ensuring compliance with waste management policies and regulations may require strict enforcement mechanisms. Inconsistent enforcement can undermine the effectiveness of waste management initiatives.	**1.International Collaboration:** Collaborating with other European nations and global entities can facilitate the exchange of best practices, technologies, and expertise in waste management. **2.Circular Economy Integration:** Further integration of circular economy principles into waste management strategies can enhance resource efficiency, promote sustainability, and contribute to the reduction of

					environmental impacts.

In summary, the literature review underscores the diversity and complexity of waste management research, highlighting the crucial role of technology, the importance of a comprehensive approach, and the necessity for future-focused innovations. Each study contributes uniquely to the understanding of waste management challenges and opportunities, collectively guiding the trajectory of sustainable waste management practices globally.

IV. CONCLUSION

In conclusion, this survey provides a comprehensive overview of recent advancements, challenges, and future prospects in global waste management. The synthesis of literature reveals common themes, such as the pivotal role of technology, the necessity for a comprehensive waste management approach, and the integration of circular economy principles.

Despite progress, identified gaps underscore the need for universal applicability, in-depth research, and practical feasibility. Moving forward, scalable and interoperable technologies, policy innovations, and international collaborations are imperative for shaping a sustainable future in waste management. This survey serves as a valuable resource for policymakers, practitioners, and researchers navigating the dynamic landscape of waste management practices.

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