Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 7, No. 4, July : 2023

CURRENT STATUS AND METHODOLOGY OF MUNICIPAL SOLID WASTE MANAGEMENT (MSWM) INLUCKNOW: A REVIEW

Km. Shani Bharati Master of Technology, Maharishi University of Information Technology, Lucknow **Email:** shanisb001@gmail.com
Er. A. K. Gautam Assistant Professor, Maharishi University of Information Technology, Lucknow
Pooja Pal Master of Technology, Maharishi University of Information Technology, Lucknow
Email: impoojapal03@gmail.com

Abstract
Municipal solid waste management (MSWM) is a critical issue for urban areas worldwide. Efficient and sustainable waste management is essential to promote environmental protection and public health. Lucknow City, a rapidly growing urban center in India, faces numerous challenges in waste management due to its increasing population and urbanization. This study aims to assess the current state of MSWM in different locations of Lucknow City and provide insights into potential strategies for improvement. To address these challenges, the study suggests several strategies for improving MSWM in Lucknow City. These strategies encompass multiple dimensions, including infrastructure development, policy and regulatory frameworks, public awareness and participation, waste segregation at source, efficient collection and transportation systems, recycling and resource recovery, and the integration of informal waste sector workers. Therefore, the current study conclude the type of municipal waste generated in the Lucknow, and the current status of MSWM methods in Lucknow .

Keywords: *Municipal solid waste management, Lucknow City, waste collection, waste disposal, recycling, resource recovery, urbanization.*

1. Introduction

The problem of municipal solid waste management is a significant issue faced by many countries around the world (Vidanaarachchi et al., 2006). Municipal solid waste (MSW), which includes everyday items we use and discard, poses various environmental and health risks if not managed properly (Ganguly and Chakraborty, 2021). One major concern is the presence of dangerous substances in MSW (Aubert et al., 2006). Landfills and incinerators release potentially toxic chemicals into the air and water through leachate, leading to pollution and health problems (Siddiqua et al., 2022). These substances can include volatile organic compounds, polychlorinated biphenyls (PCBs), and heavy metals (Kumar et al., 2023). Exposure to these substances can lead to cancer and other health issues. Another issue is the inefficient waste management system in place (Rajmohan et al., 2019). Up to 25% of waste placed in recycling bins ends up being burned or buried since it cannot be properly processed (Blair and Mataraarachchi, 2021). This contributes to environmental pollution and the release of harmful substances.

The problem of municipal solid waste management in Lucknow, Uttar Pradesh is a pressing issue due to the increasing population and urbanization (Khajuria et al., 2008). According to a study, Lucknow generates a significant amount of solid waste daily, and the current waste management practices are inadequate (Ramachandra et al., 2018). The study highlights the need for better waste management practices and compliance with regulations to address environmental pollution and health hazards (Sharma et al., 2020). Municipal solid waste management (MSWM) is a critical element towards sustainable metropolitan development. It involves various steps such as segregation, storage, collection, relocation, and disposal (Joshi and Ahmed, 2016). However, the current state of MSWM in Lucknow requires improvement (Srivastava et al., 2005). Efforts should be focused on implementing effective waste management strategies, including the digitization of dumping sites and the development of an integrated waste management system (Fatimah et al., 2020). Addressing the problem of municipal solid waste management in Lucknow requires a

comprehensive andintegrated approach (Joseph et al., 2012).

2. Type of municipal solid waste generated from Lucknow

In Lucknow, like in most urban areas, the municipal solid waste generated can be categorized into different types based on their sources and characteristics (Kumar et al., 2009). These waste types may include:

Organic Waste: This category includes biodegradable waste such as food scraps, vegetable and fruit peels, garden waste, and other organic materials (Pattnaik and Reddy, 2010). Organic waste constitutes a significant portion of the municipal solid waste generated (Nabegu, 2010).

Paper and Cardboard: Waste paper, cardboard packaging, newspapers, magazines, and other paper products make up a substantial portion of the waste stream (Hekkert et al., 2000). Paper and cardboard are recyclable materials and should ideally be separated for recycling (Saidan, 2017).

Plastics: Plastics, including bottles, containers, packaging materials, bags, and other plastic products, contribute significantly to municipal solid waste (Subramanian, 2000). Plastic waste poses environmental challenges due to its non-biodegradable nature and long degradation periods (Zhang et al., 2021).

Glass: Glass bottles, jars, and broken glass from various sources form a part of municipal solid waste. Like paper, glass is also recyclable and should be separated for proper recycling (Banga, 2011).

Metals: Metal waste, such as aluminum cans, steel cans, and other metal packaging materials, are commonly found in the waste stream. Recycling metals helps conserve natural resources and reduce energy consumption (Wernick, 1998).

Textiles: Discarded clothing, fabrics, footwear, and other textile products contribute to municipal solid waste. Textiles can be reused or recycled to minimize their environmental impact (Woolridge et al., 2006).

E-waste: Electronic waste, including outdated or non-functional electronic devices such as computers, mobile phones, televisions, and other electronic appliances, is a growing concern. E-waste contains hazardous materials that require proper handling and recycling to prevent environmental pollution (Garlapati, 2016).

Hazardous Waste: Some types of municipal solid waste may be hazardous, such as batteries, fluorescent bulbs, paints, solvents, and certain household chemicals. These materials require specialized disposal methods to prevent contamination and harm to human health and the environment (Elbeshbishy and Okoye, 2019).

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 7, No. 4, July : 2023

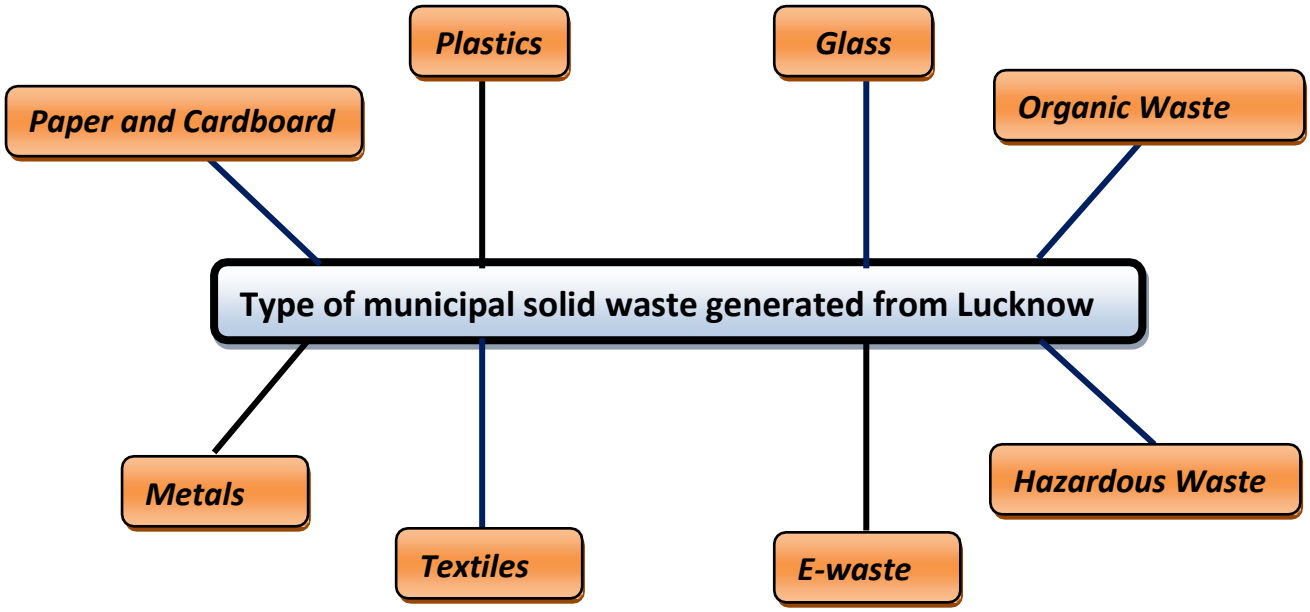

Fig.1. Type of municipal solid waste generated from Lucknow

3. Status of Municipal solid waste (MSW) in Lucknow

Lucknow, the capital city of the Indian state of Uttar Pradesh, faces significant challenges in managing municipal solid waste due to its growing population and urbanization (Prajapati et al., 2021). Lucknow generates a substantial amount of municipal solid waste daily. The city's waste generation is a result of a combination of factors, including population size, economic activities, and consumption patterns (Ramachandra et al., 2018). The municipal corporation of Lucknow is responsible for waste collection from residential, commercial, and institutional areas. The city has implemented door-to-door waste collection in many areas to improve waste management practices (Mani and Singh, 2016). However, the efficiency and coverage of waste collection services may vary across different parts of the city. Waste segregation at the source is a crucial aspect of effective waste management (Sangkham, 2020). Separating waste into different categories such as biodegradable, recyclable, and hazardous at the point of generation can facilitate proper treatment and disposal (Sharma et al., 2020). Lucknow has been making efforts to promote waste segregation practices among citizens, although the level of awareness and compliance may vary (Nandan, 2017). The treatment and disposal of municipal solid waste in Lucknow face challenges. Historically, open dumping and landfilling have been common practices, leading to environmental and health concerns (Priti and Mandal, 2019). However, there have been initiatives to establish waste processing facilities such as composting units and waste-to-energy plants in Lucknow to address waste management issues (Joshi and Ahmed, 2016). Public awareness campaigns and citizen engagement play a crucial role in promoting responsible waste management practices. Lucknow has undertaken awareness programs to educate citizens about waste segregation, the importance of reducing waste, and the benefits of recycling (Noufal, 2021). Like many other cities, Lucknow faces challenges in MSW management. These challenges include inadequate infrastructure, insufficient waste processing facilities, limited resources, and a need for better coordination among various stakeholders involved in waste management (Pritiand Mandal, 2019).

4. Methodology adopted for Municipal solid waste (MSW) in Lucknow

The management of MSW in Lucknow involves a combination of methods and practices to handle waste collection, segregation, treatment, and disposal. These are as follows:

(i) *Door-to-Door Collection*: Lucknow has implemented door-to-door waste collection in many areas. Under this system, waste is collected directly from households, commercial establishments, and institutions. Waste collection vehicles visit designated collection points at scheduled times to collect segregated or mixed waste (Benjamin, 2010).

(ii) *Waste Segregation*: Waste segregation at the source is an essential step for effective waste management. Lucknow encourages citizens to segregate waste into different categories such as biodegradable (organic), recyclable (paper, plastic, metal, etc.), and hazardous waste. Segregated waste can be managed and treated more efficiently (Joshi and Ahmed, 2016).

(iii) *Community Bin System*: Lucknow has community bins placed at strategic locations in various neighborhoods. These bins serve as collection points for residents to deposit their segregated waste. The waste collected from these bins is further processed or transported to appropriate treatment or disposal facilities (Das and Bhattacharyya, 2014).

(iv) *Waste Transfer Stations:* Waste transfer stations act as intermediate points for temporary storage and transfer of waste. These stations receive waste collected from different areas and transfer it to larger vehicles for transportation to processing or disposal facilities. These stations help streamline waste management operations (Memon, 2010).

(v) *Composting*: Composting is an important method for managing organic waste. Lucknow has implemented decentralized composting units in some areas to process biodegradable waste and convert it into nutrient-rich compost. Composting helps reduce the volume of waste going to landfills and produces a useful byproduct for agricultural purposes (Biswas and Ghosh, 2018).

(vi) *Waste Processing Facilities*: Lucknow has been exploring the establishment of waste processing facilities such as waste-to-energy plants or biomethanation plants. These facilities employ technologies to convert non-recyclable waste into energy or produce biogas through anaerobic digestion. These methods help recover energy from waste while reducing the volume of waste going to landfills (Sadef et al., 2016).

(vii) *Landfilling:* Landfilling remains a part of waste management in Lucknow, although efforts are made to minimize the amount of waste sent to landfills. Proper landfill design and management practices are essential to mitigate environmental and health impacts (Vaverkova, 2019).

5. Energy Generation from Municipal Solid Waste in Lucknow

In Lucknow, the energy generation from Municipal Solid Waste (MSW) is being explored as a sustainable waste management solution (Singh et al., 2011). The Lucknow Municipal Corporation (LMC) has initiated efforts to convert MSW into energy through various technologies (Banerjee and Anand, 2021). The LMC is in the process of setting up a Waste- to-Energy plant in Lucknow. This plant will utilize the combustion or thermal treatment of MSW to generate electricity (Cook, 2022). The Waste to Energy (WTE) plant will help in reducing the volume of waste going to landfills and simultaneously produce clean energy. The proposed WTE plant may employ incineration technology, where MSW is burned in a controlled manner to produce high-temperature steam (Ram, 2021). The steam is then used to drive turbines and generate electricity. This technology is capable of handling large quantities of waste and offers high energy conversion efficiency (Singh and Pedersen, 2016). In addition to incineration, advanced technologies like gasification and pyrolysis can be explored for energy generation from MSW. Gasification involves the conversion of waste into synthesis gas (syngas) comprising hydrogen, carbon monoxide, and other combustible gases (Rokni, 2015). The syngas can then be used to produce electricity or further processed for other applications. Pyrolysis, on the other hand, involves the thermal decomposition of waste in the absence of oxygen, resulting in the production of liquid or gaseous fuels (Kabir, 2015). Apart from the WTE plant, Lucknow also promotes biogas generation from organic waste through anaerobic digestion. Organic waste such as food scraps, agricultural residue, and sewage sludge can be processed in anaerobic digesters to produce biogas, which is primarily composed of methane (Dhar, 2017). The captured biogas can be utilized for electricity generation or as a renewable fuel for cooking and heating purposes. To facilitate the integration of energy generated from MSW into the local power

grid, the LMC can enter into Power Purchase Agreements with electricity distribution companies or other relevant entities (Brennan and Rensburg, 2023). PPAs ensure a guaranteed market for the electricity produced from MSW, making it economically viable and encouraging private sector participation.

Summary

A study of Municipal Solid Waste (MSW) management in different locations of Lucknow City provides insights into the waste management practices in the city. Although the specific details of the study are not available, a general overview of MSW management in Lucknow City can be provided. Lucknow City generates a significant amount of municipal solid waste, including household waste, commercial waste, institutional waste, construction and demolition waste, and street sweeping waste. The municipal authorities are responsible for collecting and transporting the waste to designated disposal sites. Waste segregation is an essential step in efficient waste management. It involves separating different types of waste at the source, such as biodegradable waste, recyclables, and non-recyclables.After collection and segregation, the waste undergoes various treatment processes. These include composting of organic waste, recycling of recyclable materials, and energy recovery through waste-to- energy plants. Non-recyclable and non-compostable waste is disposed of in designated landfill sites. Proper landfill management is crucial to prevent contamination of soil and groundwater. Challenges in waste management in Lucknow City include inadequate infrastructure, limited public awareness about waste segregation, and the need for capacity building among municipal staff. However, initiatives such as door-to-door waste collection, public awareness campaigns, and promoting recycling and composting practices are being implemented to improve waste management systems.

References:

Vidanaarachchi, C. K., Yuen, S. T., & Pilapitiya, S. (2006). Municipal solid waste management in the Southern Province of Sri Lanka: Problems, issues and challenges. *Waste management*, *26*(8), 920-930.

Ganguly, R. K., & Chakraborty, S. K. (2021). Integrated approach in municipal solid waste management in COVID-19 pandemic: Perspectives of a developing country like India in a global scenario. *Case Studies in Chemical and Environmental Engineering*, *3*, 100087.

Aubert, J. E., Husson, B., & Sarramone, N. (2006). Utilization of municipal solid waste incineration (MSWI) fly ash in blended cement: Part 1: Processing and characterization of MSWI fly ash. *Journal of hazardous materials*, *136*(3), 624-631.

Siddiqua, A., Hahladakis, J. N., & Al-Attiya, W. A. K. (2022). An overview of the environmental pollution and health effects associated with waste landfilling and open dumping. *Environmental Science and Pollution Research*, *29*(39), 58514-58536.

Kumar, V., Sharma, N., Umesh, M., Chakraborty, P., Kaur, K., Duhan, L., ... & Maitra, S. S. (2023). Micropollutants characteristics, fate, and sustainable removal technologies for landfill leachate: A technical perspective. *Journal of Water Process Engineering*, *53*, 103649.

Rajmohan, K. V. S., Ramya, C., Viswanathan, M. R., & Varjani, S. (2019). Plastic pollutants: effective waste management for pollution control and abatement. *Current Opinion in Environmental Science & Health*, *12*, 72-84.

Blair, J., & Mataraarachchi, S. (2021). A review of landfills, waste and the nearly forgotten nexus with climate change. *Environments*, *8*(8), 73.

Khajuria, A., Yamamoto, Y., & Morioka, T. (2008). Solid waste management in Asian countries: problems and issues. *WIT Transactions on Ecology and the Environment*, *109*, 643-653.

Ramachandra, T. V., Bharath, H. A., Kulkarni, G., & Han, S. S. (2018). Municipal solid waste: Generation, composition and GHG emissions in Bangalore, India. *Renewable and Sustainable Energy Reviews*, *82*, 1122-1136.

Sharma, H. B., Vanapalli, K. R., Cheela, V. S., Ranjan, V. P., Jaglan, A. K., Dubey, B., ... & Bhattacharya, J. (2020). Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic. *Resources, conservation and recycling*, *162*, 105052.

Joshi, R., & Ahmed, S. (2016). Status and challenges of municipal solid waste management in India: A review. *Cogent environmental science*, *2*(1), 1139434.

Srivastava, P. K., Kulshreshtha, K., Mohanty, C. S., Pushpangadan, P., & Singh, A. (2005). Stakeholder-based SWOT analysis for successful municipal solid waste management in Lucknow, India. *Waste management*, *25*(5), 531-537.

Fatimah, Y. A., Govindan, K., Murniningsih, R., & Setiawan, A. (2020). Industry 4.0 based sustainable circular economy approach for smart waste management system to achieve sustainable development goals: A case study of Indonesia. *Journal of Cleaner Production*, *269*, 122263.

Joseph, K., Rajendiran, S., Senthilnathan, R., & Rakesh, M. (2012). Integrated approach to solid waste management in Chennai: an Indian metro city. *Journal of Material Cycles and Waste Management*, *14*(2), 75-84.

Kumar, S., Bhattacharyya, J. K., Vaidya, A. N., Chakrabarti, T., Devotta, S., & Akolkar, A.

B. (2009). Assessment of the status of municipal solid waste management in metro cities,

state capitals, class I cities, and class II towns in India: An insight. *Waste management*, *29*(2),883-895.

Pattnaik, S., & Reddy, M. V. (2010). Assessment of municipal solid waste management in Puducherry (Pondicherry), India. *Resources, Conservation and Recycling*, *54*(8), 512-520.

Nabegu, A. B. (2010). An analysis of municipal solid waste in Kano metropolis, Nigeria. *Journal of Human Ecology*, *31*(2), 111-119.

Hekkert, M. P., Joosten, L. A., & Worrell, E. (2000). Analysis of the paper and wood flow in the Netherlands. *Resources, Conservation and Recycling*, *30*(1), 29-48.

Saidan, M. N., Drais, A. A., & Al-Manaseer, E. (2017). Solid waste composition analysis and recycling evaluation: Zaatari Syrian Refugees Camp, Jordan. *Waste Management*, *61*, 58-66.

Subramanian, P. M. (2000). Plastics recycling and waste management in the US. *Resources, Conservation and Recycling*, *28*(3-4), 253-263.

Zhang, S., Wang, J., Yan, P., Hao, X., Xu, B., Wang, W., & Aurangzeib, M. (2021). Non- biodegradable microplastics in soils: a brief review and challenge. *Journal of Hazardous Materials*, *409*, 124525.

Banga, M. (2011). Household knowledge, attitudes and practices in solid waste segregation and recycling: the case of urban Kampala. *Zambia Social Science Journal*, *2*(1), 4.

Wernick, I. K., & Themelis, N. J. (1998). Recycling metals for the environment. *Annual Review of Energy and the Environment*, *23*(1), 465-497.

Woolridge, A. C., Ward, G. D., Phillips, P. S., Collins, M., & Gandy, S. (2006). Life cycle assessment for reuse/recycling of donated waste textiles compared to use of virgin material: An UK energy saving perspective. *Resources, conservation and recycling*, *46*(1), 94-103.

Garlapati, V. K. (2016). E-waste in India and developed countries: Management, recycling, business and biotechnological initiatives. *Renewable and Sustainable Energy Reviews*, *54*, 874-881.

Elbeshbishy, E., & Okoye, F. (2019). Improper disposal of Household Hazardous waste: Landfill/municipal wastewater treatment plant. *Municipal Solid Waste Management*.

Gupta, S. K., Pandey, S. K., Singh, N. B., Singh, A., Singh, V. K., & Verma, T. (2013). Municipal solid waste characterizations and management strategies for the Lucknow city, India. *Int. J. Eng. Res*, *8*(17), 2031-2036.

Mian, M. M., Zeng, X., Nasry, A. A. N. B., & Al-Hamadani, S. M. (2017). Municipal solid waste management in China: a comparative analysis. *Journal of material cycles and waste management*, *19*, 1127-1135.

Sharma, H. B., Vanapalli, K. R., Cheela, V. S., Ranjan, V. P., Jaglan, A. K., Dubey, B., ... & Bhattacharya, J. (2020). Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic. *Resources, conservation and recycling*, *162*, 105052.

Nandan, A., Yadav, B. P., Baksi, S., & Bose, D. (2017). Recent scenario of solid waste management in India. *World Scientific News*, (66), 56-74.

Priti, & Mandal, K. (2019). Review on evolution of municipal solid waste management in India: practices, challenges and policy implications. *Journal of Material Cycles and Waste Management*, *21*, 1263-1279.

Joshi, R., & Ahmed, S. (2016). Status and challenges of municipal solid waste management in India: A review. *Cogent environmental science*, *2*(1), 1139434.

Noufal, M., Maalla, Z., & Adipah, S. (2021). Households' participation in solid waste management system of Homs city, Syria. *GeoJournal*, *86*, 1441-1463.

Priti, & Mandal, K. (2019). Review on evolution of municipal solid waste management in India: practices, challenges and policy implications. *Journal of Material Cycles and Waste Management*, *21*, 1263-1279.

Prajapati, K. K., Yadav, M., Singh, R. M., Parikh, P., Pareek, N., & Vivekanand, V. (2021). An overview of municipal solid waste management in Jaipur city, India-Current status, challenges and recommendations. *Renewable and Sustainable Energy Reviews*, *152*, 111703.\

Ramachandra, T. V., Bharath, H. A., Kulkarni, G., & Han, S. S. (2018). Municipal solid waste: Generation, composition and GHG emissions in Bangalore, India. *Renewable and Sustainable Energy Reviews*, *82*, 1122-1136.

Mani, S., & Singh, S. (2016). Sustainable municipal solid waste management in India: A policy agenda. *Procedia Environmental Sciences*, *35*, 150-157.

Sangkham, S. (2020). Face mask and medical waste disposal during the novel COVID-19 pandemic in Asia. *Case Studies in Chemical and Environmental Engineering*, *2*, 100052.

Sharma, H. B., Vanapalli, K. R., Cheela, V. S., Ranjan, V. P., Jaglan, A. K., Dubey, B., ... & Bhattacharya, J. (2020). Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic. *Resources, conservation and recycling*, *162*, 105052.

Nandan, A., Yadav, B. P., Baksi, S., & Bose, D. (2017). Recent scenario of solid waste management in India. *World Scientific News*, (66), 56-74.

Benjamin, A. M., & Beasley, J. E. (2010). Metaheuristics for the waste collection vehicle routing problem with time windows, driver rest period and multiple disposal facilities. *Computers & Operations Research*, *37*(12), 2270-2280.

Das, S., & Bhattacharyya, B. K. (2014). Estimation of municipal solid waste generation and future trends in greater metropolitan regions of Kolkata, India. *Journal of Industrial Engineering and Management Innovation*, *1*(1), 31-38.

Memon, M. A. (2010). Integrated solid waste management based on the 3R approach. *Journal of Material Cycles and Waste Management*, *12*, 30-40.

Biswas, D. R., & Ghosh, A. (2018). Municipal solid waste management Vis-a-Vis sustenance of soil health. *Indian Journal of Fertilisers*, 47.

Sadef, Y., Nizami, A. S., Batool, S. A., Chaudary, M. N., Ouda, O. K. M., Asam, Z. U. Z., ... & Demirbas, A. (2016). Waste-to-energy and recycling value for developing integrated solid waste management plan in Lahore. *Energy Sources, Part B: Economics, Planning, and Policy*, *11*(7), 569-579.

Hossain, M. S., Santhanam, A., Norulaini, N. N., & Omar, A. M. (2011). Clinical solid waste management practices and its impact on human health and environment–A review. *Waste management*, *31*(4), 754-766.

Vaverková, M. D. (2019). Landfill impacts on the environment. *Geosciences*, *9*(10), 431.

Singh, R. P., Tyagi, V. V., Allen, T., Ibrahim, M. H., & Kothari, R. (2011). An overview for exploring the possibilities of energy generation from municipal solid waste (MSW) in Indian scenario. *Renewable and Sustainable Energy Reviews*, *15*(9), 4797-4808.

Banerjee, P., & Anand, K. (2021). Social Enterprises as an Emerging Platform in Waste Management. *Climate resilience and environmental sustainability approaches: Global lessons and local challenges*, 351-363.

Cook, E., Velis, C. A., & Cottom, J. W. (2022). Scaling up resource recovery of plastics in the emergent circular economy to prevent plastic pollution: Assessment of risks to health and safety in the Global South. *Waste Management & Research*, *40*(12), 1680-1707.

Ram, C., Kumar, A., & Rani, P. (2021). Municipal solid waste management: a review of waste to energy (WtE) approaches. *Bioresources*, *16*(2), 4275.

Singh, D. V., & Pedersen, E. (2016). A review of waste heat recovery technologies for maritime applications. *Energy conversion and management*, *111*, 315-328.

Rokni, M. (2015). Thermodynamic analyses of municipal solid waste gasification plant integrated with solid oxide fuel cell and Stirling hybrid system. *International journal of hydrogen energy*, *40*(24), 7855-7869.

Kabir, M. J., Chowdhury, A. A., & Rasul, M. G. (2015). Pyrolysis of municipal green waste: a modelling, simulation and experimental analysis. *Energies*, *8*(8), 7522-7541.

Dhar, H., Kumar, S., & Kumar, R. (2017). A review on organic waste to energy systems in India. *Bioresource technology*, *245*, 1229-1237.

Brennan, N., & van Rensburg, T. M. (2023). Does intermittency management improve public acceptance of wind energy? A discrete choice experiment in Ireland. *Energy Research & Social Science*, *95*, 102917.