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Sustainable Development Of Kanpur City Through Municipal Solid Waste Treatment.

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Abstract:
Solid waste management has become a most relevant topic of discussion for local authorities in cities in India as well as for general people. All type of development in the city or country parallelly takes the generation of waste material with their ongoing process and the mismanagement of the waste material affects the total framework of the drainage pattern of the city. When a city undergoes between the development and waste management it changes the characteristics of Municipal Solid Waste Management too. This study has conducted as a case study of the present scenario of MSW in Kanpur city. Increasing migration from the neighboring villages to the city, population density, rapid economic growth and living standards hasten the environmental and physical hazards to inhabitants.Being the commercial and industrial capital of UP Kanpur produces the maximum 1500 tonnes solid waste per day and city has numerous collection centers more than 400 of which are open dumps now in the era of technologies GIS has also been used to analyze maps and data, to digitize the data about wards and disposal sites in Kanpur.Kanpur, a major industrial city in Uttar Pradesh, generates a vast amount of solid waste due to rapid urbanization and industrialization. The lack of efficient solid waste management has resulted in environmental degradation, public health issues, and economic inefficiencies. This paper explores sustainable solid waste treatment practices as a pathway to achieving the city's sustainable development goals. By assessing the current waste management system, identifying challenges, and proposing innovative solutions, the research offers a strategic framework for improving waste management practices in Kanpur.

Keywords: Sustainable development, solid waste treatment, Kanpur city, waste management, waste-to-energy, urban sustainability.

1. Introduction

Kanpur, the commercial capital of UP is the largest industrial city in Uttar Pradesh. In lines with the historical data, it was the second most industrialized city in India due to its textile production it is called the Manchester of north India. Kanpur city is surrounded by the river Ganges and river Pandu to the north and south respectively. The total area of the city is 261 square kilometers and is located about 435 km east to New Delhi. Increasing physical quality of life index, hike in incomes, unplanned urbanization as well as unorganized development and a rapid change in the mechanism have come to the result in the form of changing composition of MSW in Kanpur city. Growing population is directly proportional to the waste generation that affects the whole scenario of Municipal Solid Waste Management. The projected daily solid garbage generated by Kanpur, a city with a population over 2.9 million, is 1500 metric tons. Efficiently handling this garbage has become even more of a concern due to the city's rapidly industrializing economy and its rapidly expanding population. Environmental deterioration, water and soil contamination, emissions of greenhouse gases, and risks to human health have resulted from conventional waste management practices such open dumping and unregulated landfilling. In light of these difficulties, it is critical to implement a long-term strategy for municipal solid waste (MSW) management that reduces negative effects on the environment while simultaneously increasing productivity and boosting profitability. The Brundtland Report in 1987 was the first to promote the idea of sustainable development, which centres on promoting economic progress, protecting the environment, and ensuring social fairness. Minimizing waste, recovering resources, recycling, and disposing of garbage in a safe manner are all part of sustainable practices in municipal solid waste management. Through the creation of green employment and the growth of recycling companies, these strategies seek to lessen the environmental impact of trash while also conserving natural resources and creating economic possibilities. Several important measures are being implemented in Kanpur to achieve sustainable MSW management. First and foremost, it is crucial to segregate trash at the source. To lessen the burden on landfills, proper segregation is essential for separating recyclables from organic trash. Encouragement of waste segregation by families and businesses is essential for recycling and composting and this can only be achieved via public awareness campaigns and community involvement.It is crucial to use modern trash processing technology. With the help of composting plants and waste-to-energy facilities, Kanpur has taken a step in the right direction. Instead of sending organic waste to landfills, it may be turned into compost, which has several uses, including improving soil fertility. Conversely, waste-to-energy facilities lessen our dependency

on fossil fuels and emissions of greenhouse gases by turning non-recyclable garbage into electricity. Setting up an effective collection and transportation system is another critical part of sustainable municipal solid waste management in Kanpur. Garbage build-up and its related environmental dangers may be reduced by improved transportation routes and regular and systematic garbage pickup. **(Zia & Devadas, 2007).**

2. Aims and Objectives

- To assess the current status of solid waste management in Kanpur
- Analyze the potential of adopting decentralized waste management systems.
- To evaluate the environmental, social, and economic impacts of sustainable waste
- Examine the economic benefits, including job creation and cost savings in waste management.
- To Develop educational campaigns to promote waste segregation at the source.

Review of Literature

(S. Kumar et al., 2021) Over the last decade, waste management sustainability has been contested. Each country has different sustainability. Sustainability drivers vary per nation due to political, economic, and environmental concerns. As climate change and environmental degradation show, waste management may have local, regional, or global effects.

(Dixit et al., 2022) waste management practices via user fees for garbage collection services and penalties for not following trash segregation rules. There are obstacles in the way of Kanpur's sustainable MSW management initiatives. Limited funding, out-dated infrastructure, and a lack of qualified staff are some of the challenges the city must overcome.

(Mehra & Bhargava, 2020) The lack of enough facilities to treat and dispose of the larger amount of MSW generated daily in metropolitan cities is putting MSW management through a critical phase. All parts of the environment and human health are negatively affected by scientific disposal.

(Debashish Sengupta, 2022) This book enriches the understanding of reader about the variety of solid waste and hazardous waste management and its problem and possible remedial measures.

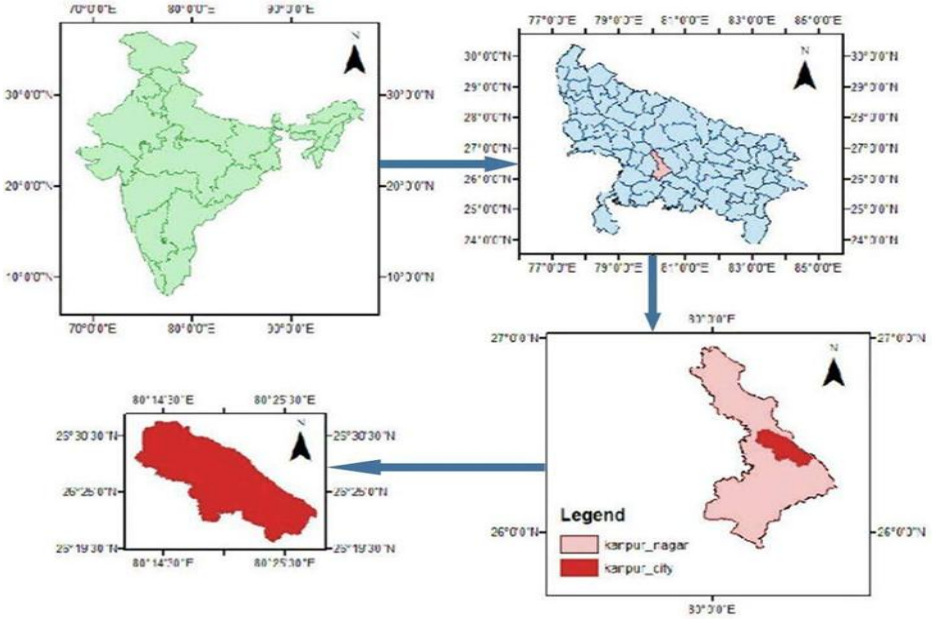
(Ramanathan, 2010) This book intensively reflects with every aspect of organic and inorganic waste management and describes the importance of categorizing the types of waste material correctly.

Methodology - The research employs a mixed-method approach, combining quantitative data analysis and qualitative insights to achieve the stated objectives:

Primary data:- The primary data will be collected from personal observation.
Secondary sources: - Secondary data related to plastic waste and its impact on environment will be collected from published and unpublished records, Government offices and private agencies. Published data, reports will be collected from the Census office, Kanpur Nagar Nigam, KDA, CPCB and other government authorities, media and also through mobile applications.

Study Area

Kanpur is located between 25°26'N and 26°58'N latitudes and 79°31E' and 80°34'E longitudes. It is located on important national highways No. 2 and 25, as well as state highway. The area covers 291.78 km2 and has a population of 3,415,058 people (based on 2010 projections) [14]. Kanpur, the state's largest city and the hub of commerce and industry, is now referred to as the state's commercial capital. It is well-known for its cotton, wool, and leather industry. In addition to the leather and textile industries, the city is also home to fertilizer, chemicals, clothing, two-wheelers, and engineering businesses. Kanpur cit is split into six zones and 110 Wards.



Geographical location of Kanpur City

Solid Waste trends in KanpurCity

Waste Generation and Composition

The rapid urbanization and industrialization of Kanpur, one of India's major cities, have led to a significant increase in the generation of solid waste. Solid waste, encompassing municipal, industrial, and hazardous waste, poses a critical challenge to environmental sustainability and public health if not managed effectively. Understanding the quantity and composition of waste is the first step in designing an efficient and sustainable waste management system. This section delves into the types and sources of waste generated in Kanpur, the factors influencing waste composition, and the implications for sustainable development.

1. Waste Generation in Kanpur

Kanpur generates approximately 1,500 to 1,600 metric tons of solid waste daily, a figure that is steadily increasing due to urban growth, population rise, and industrial expansion. Several key sources contribute to this waste generation:

Municipal Solid Waste (MSW)

O **Residential Areas:** Households contribute significantly to MSW, producing organic waste such as food scraps, garden waste, and paper, as well as inorganic waste like plastics, metals, and glass for exampleKalyanpur, Kidwai Nagar, Panki, Shyam Nagar are the most populated area that generate a big share of waste material.

O **Commercial Establishments:** Markets, restaurants, and offices produce mixed waste, with a substantial share of biodegradable material from food markets and packaging waste from businesses.There are many commercial bodies like restaurant segregate large amount of waste. Some important hotels in Kanpur are Landmark, Hotel Gee, Delhi Darbar, some famous Dhaba as well. These hotels collect the generated waste in drums. The floating population in the city is 75000 to 100000 and considering waste generation rate (0.2kg/capita/day) total waste generated from floating population can be estimated 15-20t/day.

Industrial Waste: Major industries in Kanpur are LML Industries, Cerulin Chemicals, Rajendra Steel, Hindustan Aeronautics, ICI Nickel and Small Arms Factory. As informed by the officials from KNN total waste generated from the industries is 18tons per day approx. The site for disposal of the hazardous waste has been identified at Rooma, 12-15km away from sewage treatment plants.

Construction and Demolition (C&D) Waste: With ongoing urban development, construction activities generate waste such as concrete, bricks, and debris. Demolition activities add to the waste load, which often remains unsegregated and improperly disposed of.

Biomedical WasteHospitals: - At present Kanpur city has about 9 govt. 33 private & 600 clinics. Some majorly important hospitals are LLR Medical College Hospital, ESI hospital, Regency hospital etc. The average quantity of biomedical waste generated in Kanpur is 6750kg per day. Out of total bio waste generated, only 1350 kg (about20%) is sent to the centralized bio-medical waste management facility. About 305 of bio- medical waste is getting mixed up with other type of waste.

E-Waste: With the increasing penetration of electronic devices, discarded appliances, and gadgets contribute to Kanpur's e-waste, which includes hazardous substances like lead, mercury, and cadmium.

Table 1: -Solid waste generation trends in Kanpur city

Year	Waste Produced per year (in kg)	Waste Produced per year (in tons)
1951	3,97,733	1,45,173
1961	6,58,860	2,40,484
1971	10,49,582	3,83,097
1981	15,93,115	5,81,487
1991	22,77,500	8,31,288
2001	33,34,399	12,17,056
2011	41,23,141	15,04,947
2021	53,02,197	19,35,302

Source: - Kanpur annual report 2021

As per the above data of the table 1 from the year 1951 to 2021 waste production of Kanpur city has been increased in kg as well as in tons. This variation shows that day by day growth of population and human resources multiply the waste generation that cause health issues but with the use of technology we can execute waste to energy projects.

2. **Composition of Solid Waste**

Understanding the composition of Kanpur's waste stream is critical for identifying appropriate treatment and disposal methods. Source of waste composition as follows:

Table 2: - Waste Composition in Kanpur (in %)

Waste Composition	ICDP	NEERI
Organic Waste	47.27	56.67
Inert Material	38.82	40.07
Plastic Waste	4.5	-
Paper Cardboard	3.58	3.18
Rubber, Leather and Synthetics	2.72	0.48
Rags	3.97	-
Glass	-	0.48
Metal	0.24	0.59

Source: - ICDP & NEERI

Table 2 shows the % of waste composition in the city that has a bigger share of organic waste Sources include food scraps, garden trimmings, and agricultural residues. This type of waste is ideal for composting and bio-methanationthe waste includes single-use plastics, packaging materials, and multi-layered plastic (MLP), which are challenging to recycle and often end up in landfills.Papercardboard is not fully recyclable while metal & glass after recycling mixed with other waste.

Population density and urbanization play a significant role, with densely populated areas generating higher amounts of non-biodegradable waste. The increasing ratio of solid waste according to population is as follows:

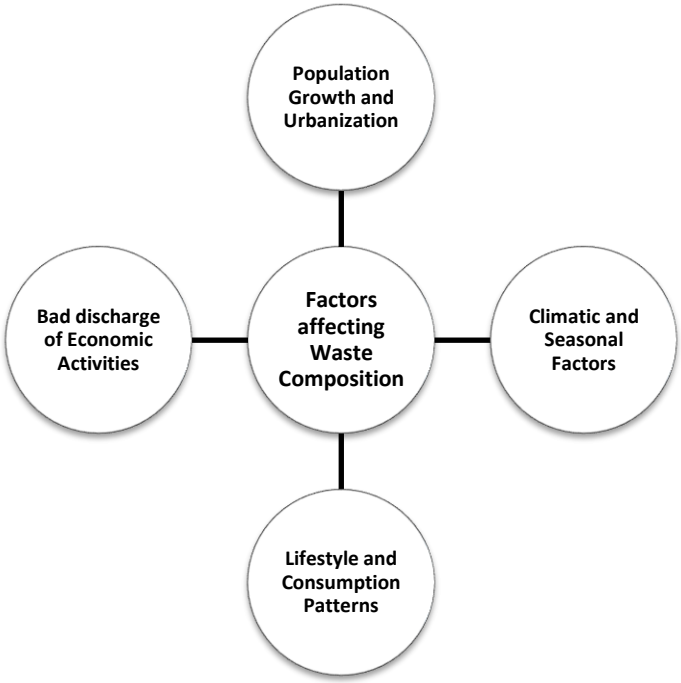
Table 3: - Population growth and waste production

Year	Population(in Lakh)	Waste Produced per day (in tons)
1951	13,25,778	398
1961	16,47,150	659
1971	20,99,164	1,050
1981	26,55,191	1,593
1991	32,53,572	2,278
2001	41,67,999	3,334
2011	45,81,268	4,123
2021	53,02,197	5,302

Source: -Kanpur annual report 2021

Table 3 describes growing rate population increases the rate of waste discharge on daily basisin 1951 to 2021population increases 40 lakhsapprox.and waste production increases by 4500 tons per day. This data analyses if population increases 4 times in 10 years, then waste discharge increases 12 times approximately.Waste composition is affected not only with population growth and urbanizationsome other interconnected factors, like climate and seasonal variations, lifestyle and consumption patterns, and the discharge of economic activities are also noticeable.Climate and seasonal factors also play a

role; warm climates accelerate the decomposition of organic waste, while festivals and harvest seasons contribute to higher volumes of biodegradable materials. Lifestyle changes and evolving consumption patterns, such as reliance on packaged goods and electronic devices, increase the proportion of plastics, e-waste, and other non-biodegradable materials. Additionally, economic activities, including industrial and agricultural processes, significantly impact waste composition. Impact of these factors can be understood by this following chart: -



Sustainable Waste Treatment in Kanpur City

❖ **Composting and Bio-Methanation**

Composting and bio-methanation are vital solutions for managing Kanpur's significant organic waste, which constitutes 50–60% of the city's total waste. Composting involves aerobic decomposition of organic waste to produce nutrient-rich compost that can be used as a soil conditioner, promoting sustainable agriculture and reducing the dependency on chemical fertilizers. On the other hand, bio-methanation utilizes anaerobic digestion to convert organic waste into biogas, a renewable energy source, and digestate, which can also serve as a fertilizer. Implementing decentralized composting units and bio-methanation plants in residential neighborhoods, markets, and commercial hubs can reduce the transportation burden, minimize landfill use, and lower greenhouse gas emissions. By integrating these technologies, Kanpur can not only manage its organic waste efficiently but also generate economic value through energy production and compost sales, fostering a circular economy

❖ **Treatment of organic waste for biogas production and compost**

The treatment of organic waste through biogas production and composting offers an environmentally friendly solution to managing Kanpur's substantial organic waste, which constitutes nearly 50–60% of the city's daily waste. Biogas production involves the anaerobic digestion of organic materials such as food scraps, agricultural residues, and garden waste to generate methane-rich biogas and nutrient-rich slurry. This biogas can be used as a renewable energy source for cooking, electricity generation, or even powering municipal vehicles, while the slurry serves as an excellent organic fertilizer. Composting, on the other hand, is an aerobic process that decomposes organic waste into humus-like compost, which enhances soil fertility and reduces the reliance on chemical fertilizers. Establishing decentralized biogas plants and composting units near markets, residential areas, and institutions can lower waste transportation costs, decrease landfill dependency, and mitigate greenhouse gas emissions. Such initiatives not only create value from waste but also align with sustainable development goals by promoting energy efficiency, resource recovery, and environmental conservation.

❖ **Small-scale composting units for residential areas**

Establishing small-scale composting units in residential areas is a practical and sustainable approach to managing Kanpur's organic waste, which constitutes around 50–60% of the city's daily waste generation. These units enable households and communities to compost kitchen and garden waste locally, reducing the need for transportation and centralized waste processing. Simple technologies such as aerobic bins, vermicomposting, or rotary drums can be implemented based on the volume of waste and available space. Each unit can process approximately 25–50 kilograms of organic waste daily, producing high-quality compost that residents can use for gardening or sell, creating an additional economic benefit. Moreover, community composting initiatives encourage waste segregation at the source and raise awareness about sustainable waste management practices. With adequate training, awareness campaigns, and financial support from

municipal authorities, small-scale composting units can significantly reduce the load on Kanpur's landfills while promoting a circular economy and environmental sustainability at the grassroots level.

❖ **Waste-to-Energy Systems**

Kanpur's growing urban population generates approximately 1,500 metric tons of solid waste daily, of which 20–25% is non-recyclable and combustible. Waste-to-Energy (WTE) systems present an opportunity to transform this fraction into a resource while reducing landfill dependency. A proposed WTE plant in Kanpur aims to process 600 metric tons of waste daily, producing around 15–18 megawatts of electricity, enough to power thousands of homes. By utilizing technologies such as incineration with heat recovery and refuse-derived fuel (RDF) production, the city can convert municipal waste into energy efficiently. However, for successful implementation, segregation at source is critical, as mixed waste lowers the calorific value required for optimal energy production. Integrating WTE with Kanpur's existing waste management framework can significantly reduce the environmental burden, curb methane emissions from landfills.

Table 4: -Compost energy Production of Kanpur City through Solid Waste

Year	Waste quantity in 1000 tons/day	Waste quantity in 1000 tons/year	Compost production in tons /year	Bio fuel production in m3 /year	Energy production in MW/day
2011	4	1505	1,21,901	32,252	6
2021	5	1935	1,56,759	41,467	8
2031	7	2454	1,98,735	52,589	11
2041	8	3077	2,49,276	65,940	12
2051	10	3830	3,10,221	82,077	15

Source:- CPCB annual report 2020

Table 4 illustrates the connection between the creation of trash and the cultivation of compost, the manufacture of biofuel, and the generation of electricity. This data covers the years 2011 through 2051. It displays the amount of garbage in tonnes per day and per year, the amount of compost available in tonnes per year, the amount of biofuel available in cubic meters per year, and the amount of electricity available in megawatts per day.

❖ **Conversion of non-recyclable waste into electricity or fuel**

Kanpur generates approximately 1,500 metric tons of waste daily, with 20–25% classified as non-recyclable and combustible. This fraction of waste, which includes low-grade plastics, soiled paper, and other non-biodegradable materials, has significant potential for energy recovery. Technologies such as Waste-to-Energy (WTE) incineration and Refuse-Derived Fuel (RDF) production can be employed to convert this waste into electricity or industrial-grade fuel. A proposed WTE plant in Kanpur, with the capacity to process 600 metric tons of waste daily, could generate up to 15–18 megawatts of electricity, addressing a portion of the city's energy demand. Similarly, RDF plants can process non-recyclable waste into high-calorific-value pellets for use in cement kilns and other industries. To maximize efficiency, it is critical to establish robust waste segregation systems and ensure that recyclable materials are diverted away from the waste stream. By adopting these technologies, Kanpur can reduce landfill dependence, cut greenhouse gas emissions, and contribute to a sustainable urban energy model.

Incentives for recycling plastics and metals

Introducing incentives for recycling plastics and metals in Kanpur can significantly enhance resource recovery and reduce environmental pollution.. For instance, collection centers could offer cash or coupons in exchange for segregated plastics and metals, encouraging citizens to recycle. Businesses and industries that adopt sustainable practices, such as using recycled materials or contributing to Extended Producer Responsibility (EPR) schemes, could be granted tax benefits or certifications that enhance their market reputation. Establishing partnerships with scrap dealers and recycling companies can streamline the process, ensuring the efficient collection and processing of materials. Additionally, awareness campaigns and community recycling drives could further motivate participation. By creating a financial and social value for recycling, Kanpur can reduce its waste burden, conserve natural resources, and promote a culture of environmental responsibility.

Proposed Model for Sustainable Waste Treatment

Segregation at Source	**Mandatory Segregation**
	Awareness Campaigns
Door-to-Door Collection	**Fleet of Vehicles**
	Uniformed Sanitation Workers
Processing and Treatment Facilities	**Composting Units**
	Material Recovery Facilities (MRFs)
	Waste-to-Energy (WTE) Plant

	Bio methanation Plants
Technology Integration	**GPS and RFID Tracking**
	GIS Mapping
	Automation in Sorting
Community Involvement	**Citizen Engagement**
	NGO and Private Sector Partnerships
Financial Model	**User Fees**
	Revenue Streams
Policy and Governance	**Strict Enforcement**
	Transparent Monitoring
	Updating dashboard

With special reference to Kanpur there is 45% of all household has segregation at source (wet, dry & domestic hazardous) in practice and continuous programs being conducted to practice waste generator to minimize through 4R concept and to achieve 100% segregation practice. Kanpur Nagar Nigam has provided a vendor for the door-to-door collection of waste through tender process. The tender for D2D is covering 110 wards of municipal corporation and this process achieved 90% of target. For door-to-door work at present 294LCV & 109 tricycle is involved.

Conclusion

Kanpur's sustainable development is closely tied to its ability to manage solid waste effectively. By adopting innovative technologies, promoting community participation, and implementing robust policy frameworks, the city can address its waste management challenges and set an example for other urban centers.Incentive-based programs could include monetary rewards, tax rebates, or discounts on utility bills for individuals, households, and businesses that actively participate in segregation and recycling efforts. The integration of environmental, economic, and social sustainability in waste management practices will ensure a cleaner, healthier, and more prosperous future for Kanpur.

Declarations:
Conflicts of interest: There is not any conflict of interest associated with this study
Consent to participate: There is consent to participate.
Consent for publication: There is consent for the publication of this paper.
Authors' contributions: Author equally contributed the work.

References

1. Ramanathan, J. S. (2010). Solid Waste Management: Present & Future Challenges. I. K. Internationl Publishing House Pvt. Limited.
2. Central Pollution Control Board (CPCB). "Status of Solid Waste Management in Urban Areas." Annual Report, 2020.
3. Singh, J., and Gupta, S. "Composting as a Sustainable Method for Urban Organic Waste Management in India." Environmental Science and Pollution Research, vol. 27, no. 5, 2020, pp. 4237–4249.
4. Reddy, M.V., et al. "Potential of Waste-to-Energy Technologies in India: Current Status, Challenges, and Future Directions." Renewable and Sustainable Energy Reviews, vol. 128, 2020, pp. 109873.
5. United Nations Department of Economic and Social Affairs (UNDESA). "The Role of Waste Management in Achieving SDG 12: Responsible Consumption and Production." 2020
6. Ministry of Housing and Urban Affairs (MoHUA). "Swachh Bharat Mission (Urban): Status Report." New Delhi: Government of India, 2021.
7. NITI Aayog. "Strategy for Resource Efficiency in India: Circular Economy of Municipal Solid Waste." New Delhi, 2021.
8. United Nations Environment Programme (UNEP). "Waste Management Outlook for Asia: Towards Circular Economy and Sustainable Cities." UNEP, 2021.
9. Ghosh, P., et al. "Biogas Production from Municipal Solid Waste Using Anaerobic Digestion: A Review on Indian Perspectives." Journal of Cleaner Production, vol. 287, 2021, pp. 125003.
10. United Nations. "Progress towards the Sustainable Development Goals: Report of the Secretary-General." 2022.
11. Bhargava, A. M. (2022). Sustainable Municipal Solid Waste Management: A Case Study of Kanpur City. Journal of New Development in Chemistry.
12. Shukla, A. D. (2022). Changing Scenario of Municipal Solid Waste Management in Kanpur City. A Journal of Material Cycle & Waste Management.

13. Debashish Sengupta, B. K. (2022). Treatment & Disposal of Soid and Hazardous Waste.
14. Rishabh Chaudhary, D. M. (8). Assessment of Solid Waste Management in Kanpur City. Journal of Emerging Technologies and Innovative Research (JETIR).
15. Swara Bambade, D. J. (n.d.). Solid Waste Management. Tech-Neo Publications.