Techno Economic Comparison of Various Technologies Used for Solid Waste Management

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***Abstract*—The rapid growth of population, urbanization, and industrialization has led to a significant increase in the generation of municipal solid waste (MSW), creating serious environmental, social, and economic challenges. Effective solid waste management (SWM) has become essential for sustainable urban development and resource conservation. This project presents a techno-economic comparison of various technologies used for solid waste management, including landfilling, composting, anaerobic digestion, incineration, refuse-derived fuel (RDF) production, pyrolysis, and gasification. The study evaluates these technologies based on technical parameters such as waste processing capacity, energy recovery potential, operational efficiency, environmental impact, and suitability for different waste compositions. Economic aspects including capital investment, operation and maintenance costs, revenue generation, payback period, and overall cost-effectiveness are also analyzed. Comparative assessment is carried out using available literature, case studies, and performance data from existing waste treatment facilities.**

The findings indicate that the selection of an appropriate waste management technology depends on factors such as waste characteristics, local environmental regulations, land availability, financial resources, and energy demand. While landfilling remains the most economical short-term solution, advanced technologies such as anaerobic digestion, RDF production, and waste-to-energy systems offer greater long-term environmental and economic benefits through resource recovery and reduced landfill dependency. The study highlights the importance of adopting an integrated solid waste management approach that combines multiple technologies to maximize waste utilization and sustainability. This project provides valuable insights for policymakers, urban planners, and waste management authorities in selecting suitable technologies for efficient, environmentally sound, and economically viable solid waste management systems.

***Index Terms*—solid waste, Reuse, waste Management, Cost efficient**

I. INTRODUCTION

Solid waste management has become one of the major environmental concerns in rapidly urbanizing and industrializing countries. The increase in population, changing lifestyles, economic growth, and urban development have resulted in a significant rise in the quantity and complexity of solid waste generation. Improper handling and disposal of waste create serious environmental and public health problems such as air pollution, water contamination, land degradation, and spread of diseases. Effective solid waste management is essential for maintaining environmental sustainability, conserving natural resources, and improving the quality of life in urban and rural areas. Modern waste management practices focus not only on waste disposal but also on waste reduction, reuse, recycling, energy recovery, and environmentally safe treatment technologies. Different technologies such as landfilling, composting, recycling, biomethanation, incineration, pyrolysis, and waste-to-energy systems are currently used for managing solid waste. Each technology has its own technical, economic, environmental, and social implications. Therefore, selecting the appropriate technology is necessary for achieving sustainable and cost-effective waste management.

II. LITRATURE REVIEW

Czekała W. et al. (2023) Czekała and co-authors studied modern technologies used in solid waste management and their role in sustainable development. The paper discussed recycling, waste-to-energy systems, composting, and intelligent waste management technologies. The study highlighted that modern technologies help in reducing environmental pollution and improving resource recovery. Researchers emphasized the importance of circular economy principles in waste management. The paper also focused on public awareness and technological innovations for efficient waste handling. It concluded that integrated waste management systems are essential for future sustainability. The study suggested that smart technologies can improve waste collection and recycling efficiency. Techno Economic Comparison of Various Technologies used for Solid Waste Management - Awino F.B. et al. (2024) Awino and researchers reviewed global solid waste management practices based on waste hierarchy and circular economy concepts. The study compared waste management systems in developed and developing countries. It was found that improper waste segregation and poor recycling practices increase landfill dependency. The paper highlighted the importance of stakeholder participation and public awareness. Researchers concluded that sustainable waste management requires better policies, recycling systems, and environmental regulations. The study also identified barriers such as weak governance and lack of infrastructure. The paper recommended integrated and environmentally sustainable waste management strategies.

Alam S. et al. (2024) Alam and co-authors carried out a techno-economic and environmental analysis of organic municipal solid waste for energy production. The research focused on anaerobic digestion technology for biogas generation from organic waste. The study found that biogas plants reduce waste quantity and greenhouse gas emissions significantly. Researchers observed that energy recovery from organic waste can support renewable energy production. Economic analysis showed that the technology is feasible for urban areas with high organic waste generation. The study concluded that biomethanation is an environmentally sustainable waste management option. Paneru B. et al. (2024) Paneru and co-researchers studied solid waste generation and techno-economic assessment of waste management systems. The paper focused on recycling strategies and the concept of Reduce, Reuse, and Recycle (3Rs). Researchers identified major challenges such as poor segregation, increasing waste generation, and lack of public awareness. The study suggested that recycling and composting can significantly reduce landfill load. Economic analysis indicated that sustainable waste management practices can reduce long-term operational costs. The paper recommended proper policy implementation and community participation for effective waste management. Suryavanshi A.V. et al. (2023) Suryavanshi and co-authors performed energy, economic, and environmental analysis of waste-to-energy technologies. The study compared different waste-to-energy systems based on energy efficiency and environmental impact. Researchers found that incineration and gasification can Techno Economic Comparison of Various Technologies used for Solid Waste Management 11 significantly reduce waste volume while generating electricity. The study highlighted that waste-to-energy plants require high initial investment and pollution control systems. Environmental assessment showed reduction in landfill dependency and methane emissions. The paper concluded that waste-to-energy systems are suitable for metropolitan cities with high waste generation. Kasem N.F. et al. (2025) Kasem and co-authors studied techno-economic impacts of solid waste collection optimization in smart cities. The research focused on artificial intelligence, GIS, IoT, and optimization algorithms for efficient waste collection. The study found that traditional collection systems increase operational costs and carbon emissions. Researchers concluded that smart waste management technologies improve route optimization and resource efficiency. The study also emphasized the role of digital technologies in achieving sustainable development goals. It recommended adoption of intelligent systems for future urban waste management.

Hossain T. et al. (2025) Hossain and researchers analyzed techno-economic and life cycle assessment of municipal solid waste sorting and decontamination technologies. The study compared waste management systems in urban, suburban, and rural regions. Researchers found that recycling and sanitary landfill combinations are economically feasible for many areas. Environmental assessment indicated that integrated waste management systems reduce greenhouse gas emissions. The study highlighted the importance of tailoring waste management technologies according to population density and waste quantity. The paper concluded that proper planning improves sustainability and economic performance. Rokonuzzaman M. et al. (2024) Rokonuzzaman and co-authors carried out a technoeconomic and environmental analysis of municipal solid waste for biogas production in Bangladesh. The study designed decentralized anaerobic digestion systems for urban waste management. Researchers observed that biogas plants can produce renewable energy while reducing landfill waste. Economic analysis showed a short payback period for investment in biogas systems. The study also highlighted reduction in carbon emissions through energy recovery.

Researchers concluded that decentralized Techno Economic Comparison of Various Technologies used for Solid Waste Management 12 biomethanation systems are effective for sustainable urban waste management. Langley A. et al. (2024) Langley and co-authors reviewed computer vision and deep learning technologies for construction and demolition waste management. The study focused on automation and artificial intelligence for waste sorting and material recovery. Researchers found that AI-based systems improve recycling efficiency and reduce manual labor requirements. The paper discussed the role of sensors, robotics, and deep learning in identifying mixed waste materials. The study concluded that advanced technologies can improve sustainability and economic returns in waste management industries. It also highlighted challenges in implementation and data management.

Bello A. et al. (2025) Bello and co-authors studied the social impact of waste generation prediction tools and technology adoption in waste management. The research focused on policy gaps and the use of predictive technologies for sustainable waste management. Researchers observed that AI-based prediction systems improve waste planning and resource allocation. The study highlighted challenges such as lack of infrastructure and policy implementation gaps in developing countries. The paper emphasized the importance of integrating technology with public policies for efficient waste management. Researchers concluded that predictive technologies can improve environmental sustainability and waste management efficiency.

III. METHODOLOGY

The methodology adopted for this project involves systematic collection, analysis, and comparison of information related to various solid waste management technologies. Different treatment methods are evaluated based on technical performance, economic feasibility, environmental impact, and social aspects. Secondary data from journals, reports, and government publications are used for analysis. The study helps in identifying suitable and sustainable waste management technologies for different conditions.

3.1. STEPWISE METHODOLOGY

Step 1: Collection of Data and Literature

- Collect information related to solid waste management technologies from journals, research papers, books, government reports, and online sources.
- Study recent developments and sustainable practices used in solid waste treatment and disposal systems.

Step 2: Identification of Solid Waste Management Technologies

- Identify different waste management methods such as composting, vermicomposting, biomethanation, recycling, sanitary landfill, and waste-to energy systems.
- Understand the working principle, advantages, limitations, and applications of each technology.

Step 3: Technical Analysis of Technologies

- Analyze technical parameters such as treatment efficiency, waste reduction capacity, land requirement, and energy recovery potential.
- Study operational requirements and maintenance needs of different waste management systems.

Step 4: Economic Analysis

- Evaluate environmental impacts such as air pollution, water pollution, greenhouse gas emissions, and resource recovery.
- Study the environmental benefits of recycling, composting, and energy recovery systems.

Step 5: Environmental Sustainability Assessment

- Evaluate environmental impacts such as air pollution, water pollution, greenhouse gas emissions, and resource recovery.
- Study the environmental benefits of recycling, composting, and energy recovery systems. Techno Economic Comparison of Various Technologies used for Solid Waste Management

Step 6: Social Impact Assessment

- Analyse social aspects such as public acceptance, employment generation, and health impacts associated with waste management systems.
- Study the role of public participation and awareness in successful waste management practices.

Step 7: Comparative Evaluation

- Compare all technologies based on technical, economic, environmental, and social parameters.
- Identify the advantages, disadvantages, and suitability of each technology for different conditions.

Step 8: Result Analysis and Conclusion

- Interpret the collected data and comparative findings systematically.
- Draw conclusions and provide recommendations for suitable and sustainable solid waste management technologies.

IV. TECHNO-ECONOMIC ANALYSIS

4.1. GENERAL INTRODUCTION

Techno-economic analysis is an important process used to evaluate the technical performance and economic feasibility of different solid waste management technologies. It helps in comparing various systems based on operational efficiency, installation cost, environmental impact, and long-term sustainability. Different waste treatment technologies require different levels of investment, land area, manpower, and maintenance. Proper techno-economic analysis helps government authorities, municipalities, and industries in selecting suitable waste management systems according to waste quantity and local conditions. This analysis also supports sustainable development by identifying environmentally friendly and cost-effective technologies. Parameters such as capital cost, operation and maintenance cost, land requirement, energy recovery, treatment efficiency, lifespan, and skilled manpower requirement are considered for comparison. Understanding these parameters is essential for developing efficient and sustainable solid waste management systems.

4.2. PARAMETERS CONSIDERED

4.2.1.CAPITAL COST

Capital cost refers to the initial investment required for establishing a solid waste management system. It includes expenses related to land acquisition, construction work, machinery installation, equipment purchase, transportation facilities, and infrastructure development. Different waste management technologies require different levels of capital investment depending on their complexity and capacity. Simple compost pits require very low capital investment, whereas waste-to-energy plants and incineration systems require very high installation costs. Technologies involving advanced machinery, automation, and pollution control systems are generally more expensive. Capital cost also includes expenses related to electrical connections, pipelines, storage tanks, and safety arrangements. Proper estimation of capital cost is important for financial planning and project feasibility analysis. Low-cost systems are suitable for small communities, while high-investment systems are generally adopted in large urban Techno Economic Comparison of Various Technologies used for Solid Waste Management
areas.

4.2.2.OPERATION AND MAINTENANCE COST

Operation and maintenance (O&M) cost refers to the recurring expenses required for running and maintaining the waste management system efficiently. It includes labor charges, electricity consumption, fuel cost, repair and maintenance of equipment, transportation expenses, and monitoring activities. Technologies such as composting and vermicomposting have lower operational costs compared to incineration and waste to-energy systems. Advanced technologies require regular technical supervision and maintenance of machinery. O&M cost also depends on waste quantity, system capacity, and operational efficiency. Proper maintenance is necessary to ensure continuous operation and avoid system failure. Poor maintenance may lead to reduced efficiency, odor problems, and environmental pollution. Therefore, operation and maintenance cost are an important factor in evaluating the long-term economic feasibility of waste management technologies.

4.2.3.LAND REQUIREMENT

Land requirement refers to the amount of land needed for installation and operation of the waste management facility. Different technologies require different land areas depending on their design, waste handling capacity, and processing method. Composting and sanitary landfill systems generally require large land areas due to storage and decomposition processes. Waste-to-energy plants and incineration systems require comparatively smaller land areas because of compact machinery and faster processing. Availability of land is a major challenge in urban areas due to high land cost and limited space. Proper land selection is important to minimize environmental and social impacts. The selected site should be accessible, environmentally safe, and away from residential areas. Land requirement directly affects the economic feasibility and scalability of waste management projects.

4.2.4.ENERGY RECOVERY

Energy recovery refers to the generation of useful energy from solid waste through biological or thermal treatment processes. Technologies such as biomethanation, incineration, pyrolysis, gasification, and waste-to-energy systems recover energy in the Techno Economic Comparison of Various Technologies used for Solid Waste Management form of biogas, electricity, or heat. Organic waste can produce methane-rich biogas through anaerobic digestion in biogas plants. Thermal technologies convert waste into electricity and fuel energy.

Energy recovery reduces dependence on fossil fuels and supports renewable energy production. It also minimizes landfill usage and greenhouse gas emissions. The amount of energy recovered depends on waste composition, calorific value, and process efficiency. Energy recovery technologies are particularly useful in urban areas with high waste generation. Therefore, energy recovery is an important parameter in techno-economic analysis.

4.2.5.TREATMENT EFFICIENCY

Treatment efficiency refers to the ability of a waste management system to reduce waste quantity, remove pollutants, and recover useful resources effectively. High treatment efficiency indicates better waste processing performance and reduced environmental impact. Composting and biomethanation systems efficiently treat biodegradable waste, while recycling systems recover reusable materials. Incineration significantly reduces waste volume through high-temperature combustion. Treatment efficiency depends on factors such as waste composition, segregation quality, operational conditions, and technology used. Efficient systems reduce landfill dependency and improve resource recovery. Poor treatment efficiency may result in incomplete waste processing and environmental pollution. Therefore, treatment efficiency is essential for evaluating the technical performance of waste management technologies.

4.2.6.LIFESPAN

Lifespan refers to the expected operational life of a waste management system or facility before major replacement or reconstruction is required. Different technologies have different service lives depending on material quality, maintenance practices, and operational conditions. Simple composting systems have shorter infrastructure life compared to engineered waste-to-energy plants. Proper maintenance increases the operational lifespan of equipment and facilities. Technologies involving advanced machinery require periodic replacement of mechanical and electrical components. Long lifespan reduces long-term investment burden and improves economic sustainability. Environmental exposure, corrosion, and operational stress can affect system durability. Lifespan assessment is important for planning future maintenance and infrastructure Techno Economic Comparison of Various Technologies used for Solid Waste Management development. Therefore, lifespan is a key factor in techno-economic evaluation.

4.2.7.SKILLED MANPOWER REQUIREMENT

Skilled manpower requirement refers to the need for trained personnel to operate, monitor, and maintain the waste management system effectively. Simple systems such as compost pits require less technical expertise, whereas advanced technologies such as incineration and waste-to-energy plants require highly skilled operators and engineers. Skilled manpower is necessary for equipment handling, safety monitoring, process control, and maintenance activities. Lack of trained workers can reduce system efficiency and increase operational risks. Advanced technologies also require knowledge of pollution control systems and energy recovery operations. Training and awareness programs help in improving operational performance and safety standards. Availability of skilled manpower influences the successful implementation of waste management projects. Therefore, manpower requirement is an important consideration in selecting suitable technologies.

IMAGES

Fig..1 separation

	Principle of the Division of Labour	Attribute of Comparative Efficiency	Required External Conditions	Path of Economic Growth	Mode of Institutional Arrangement
Paradigm I	Detailed	Allocative efficiency	(Atomistic) perfect competition	Steady-state growth path	Markets
Paradigm II	Detailed	Economies of scale	(Static) imperfect competition	Transitory multiple growth paths	Hierarchies
Paradigm III	Social	Economies of scope	(Dynamic) imperfect competition	Non-converging multiple growth paths	Networks

Table 1 summarises the main features of three different techno-economic paradigms.

Fig.2 Comparison

V. COMPARATIVE ANALYSIS

5.1. GENERAL

Comparative evaluation of solid waste management technologies is essential for identifying the most suitable, economical, and environmentally sustainable waste treatment system. Different technologies have different advantages, limitations, operational requirements, and environmental impacts. Proper comparison helps municipalities, industries, and government agencies in selecting appropriate technologies based on waste quantity, land availability, economic conditions, and environmental regulations. The evaluation includes technical, economic, environmental, and social parameters for effective decision-making. Technologies such as landfill, composting, biomethanation, incineration, and recycling are widely used for solid waste management. Each system performs differently depending on waste characteristics and local conditions. Comparative analysis helps in understanding the strengths and weaknesses of each technology. Integrated waste management systems often provide better results than a single treatment method. Therefore, comparative evaluation is important for achieving sustainable and efficient solid waste management.

5.2. COMPARISON BASED ON CAPITAL COST

Capital cost is one of the most important factors considered while selecting a waste management technology. It includes expenses related to land development, construction, machinery, equipment installation, transportation systems, and infrastructure. Composting and landfill methods require relatively low capital investment because of their simple setup and operation. Biomethanation plants require medium investment due to the need for digesters, gas holders, and piping systems. Recycling units also require moderate investment for segregation and material processing equipment. Incineration and waste-to-energy plants involve very high capital cost because of advanced machinery, combustion chambers, pollution control systems, and energy generation equipment. High capital investment may create financial Techno Economic Comparison of Various Technologies used for Solid Waste Management challenges for small municipalities and rural areas. Therefore, low-cost technologies are generally preferred for small-scale waste management systems.

5.3. COMPARISON BASED ON OPERATION AND MAINTENANCE COST

Operation and maintenance cost refers to the recurring expenses needed for smooth functioning of waste management systems. It includes labor wages, electricity, fuel consumption, machinery repair, maintenance, transportation, and monitoring costs.

Composting and landfill systems have lower operational costs due to simple processes and limited machinery use. Biomethanation systems require moderate operational expenses for maintaining anaerobic conditions and gas collection systems. Recycling systems involve sorting, cleaning, and processing costs, resulting in moderate maintenance expenses. Incineration plants require high operational costs because of fuel requirements, skilled manpower, and pollution control maintenance. Regular monitoring and technical supervision are essential for advanced systems. Technologies with lower operational costs are generally more economical for long-term implementation. Therefore, O&M cost plays a significant role in technology selection.

5.4. COMPARISON BASED ON LAND REQUIREMENT

Land requirement is an important parameter, especially in urban areas where land availability is limited and expensive. Landfill systems require very large land areas because waste is continuously accumulated and stored for long periods. Composting systems also require moderate to large land areas for waste decomposition and curing processes. Biomethanation plants require moderate land because digestion occurs in compact closed tanks. Recycling systems generally require less land for segregation and storage of recyclable materials. Incineration and waste-to-energy plants require comparatively smaller land areas because of compact processing units and rapid waste reduction. High land requirement may increase project cost and create environmental concerns. Selection of suitable technology depends on availability and cost of land. Therefore, land requirement is a critical factor in waste management planning.

VI. RESULT AND DISCUSSION

6.1. GENERAL

This chapter presents the results obtained from the techno-economic comparison of different solid waste management technologies. The study compares various methods such as landfill, composting, biomethanation, recycling, and incineration based on technical, economic, environmental, and social parameters. The analysis helps in understanding the advantages, limitations, and suitability of each technology under different waste management conditions. Parameters such as capital cost, operation and maintenance cost, land requirement, energy recovery, treatment efficiency, environmental impact, and skilled manpower requirement are considered in the evaluation. The findings obtained from the study are discussed systematically to identify sustainable and economically feasible waste management technologies. Comparative analysis indicates that integrated waste management systems provide better environmental and operational performance than single-method systems. The chapter also discusses the suitability of technologies for urban, semi-urban, and rural conditions.

6.2. RESULTS OF TECHNO-ECONOMIC ANALYSIS

The techno-economic analysis showed significant variation among different waste management technologies. Landfill systems require low initial investment but involve high land consumption and environmental risks. Composting systems were found to be economical and suitable for biodegradable waste generated from households and agricultural activities. Biomethanation systems showed moderate investment cost but provided additional benefits through renewable energy generation in the form of biogas. Recycling systems were effective in recovering valuable materials such as plastic, paper, metal, and glass, thereby reducing the burden on landfills. Incineration and waste-to energy technologies showed high treatment efficiency and energy recovery potential but required high capital and operational costs. The study indicated that advanced technologies require skilled manpower and regular maintenance for efficient performance. The results suggest that technology selection should depend on waste quantity, composition, land availability, and economic conditions.

6.3. DISCUSSION ON CAPITAL COST

The comparative analysis revealed that composting and landfill systems have the lowest capital cost among all technologies studied. These systems require minimal infrastructure and equipment, making them suitable for small municipalities and rural areas. Biomethanation and recycling systems involve moderate investment due to the need for processing units and waste segregation facilities. Incineration systems showed the highest capital cost because of advanced machinery, combustion chambers, pollution control devices, and energy generation units. High capital investment limits the adoption of incineration technology in developing regions with limited financial resources. However, in metropolitan cities with large waste generation, high-investment technologies can provide long-term benefits through energy recovery and waste reduction. Therefore, financial feasibility plays an important role in technology selection.

6.4. DISCUSSION ON OPERATION AND MAINTENANCE COST

Operation and maintenance cost analysis indicated that composting systems have lower recurring expenses due to simple operation and limited equipment usage. Landfill systems involve moderate maintenance costs associated with waste covering, monitoring, and leachate management. Biomethanation systems require regular maintenance of digesters, gas holders, and pipelines, leading to moderate operational expenses. Recycling facilities require labor and machinery for segregation and processing activities. Incineration plants showed the highest operation and maintenance cost because of fuel consumption, pollution control equipment maintenance, and technical supervision requirements. The study observed that high operational cost may reduce the economic feasibility of advanced technologies in smaller regions. Efficient maintenance practices are essential to improve system performance and reduce environmental risks.

6.5. DISCUSSION ON LAND REQUIREMENT

Land requirement analysis showed that landfill systems require very large land areas because waste accumulation continues over long periods. Composting systems also need moderate land area for decomposition and curing processes. Biomethanation systems require comparatively less space because waste treatment occurs inside compact digesters. Recycling plants occupy smaller land areas mainly for segregation, storage, and processing units. Incineration systems require the least land area due to compact infrastructure and rapid waste volume reduction. Urban areas with limited land availability prefer compact technologies such as biomethanation and incineration. High land requirement increases project cost and environmental concerns in densely populated regions. Therefore, land availability is a major factor influencing technology selection.

6.6. DISCUSSION ON ENERGY RECOVERY

The study found that biomethanation and incineration systems provide significant energy recovery benefits. Biomethanation plants generate methane-rich biogas from biodegradable waste, which can be used for cooking, heating, and electricity generation. Incineration and waste-to-energy systems convert waste into electricity and thermal energy through controlled combustion processes. Recycling indirectly conserves energy by reducing the demand for raw material extraction and manufacturing. Composting systems do not produce direct energy but generate nutrient-rich compost beneficial for agriculture. Landfill systems produce limited landfill gas, which can sometimes be utilized for energy generation. Energy recovery technologies support renewable energy production and reduce dependence on fossil fuels. Therefore, technologies with energy recovery capability are considered more sustainable.

6.7. DISCUSSION ON TREATMENT EFFICIENCY

Treatment efficiency analysis showed that incineration provides maximum waste volume reduction among all technologies. Biomethanation systems effectively treat biodegradable waste and produce renewable energy simultaneously. Composting systems efficiently convert organic waste into useful manure for agricultural applications. Recycling systems recover reusable materials and reduce environmental pollution caused by improper disposal. Landfill systems mainly store waste and provide comparatively lower treatment efficiency. The study found that segregation of waste at source significantly improves treatment performance and resource recovery. Technologies with high treatment efficiency reduce landfill dependency and environmental risks. Therefore, treatment efficiency is an important criterion in selecting sustainable waste management systems.

6.8. DISCUSSION ON ENVIRONMENTAL IMPACT

Environmental analysis indicated that composting, biomethanation, and recycling are environmentally sustainable technologies with lower pollution potential. Composting improves soil fertility and reduces biodegradable waste disposal. Biomethanation reduces greenhouse gas emissions by converting organic waste into biogas. Recycling conserves natural resources and reduces energy consumption in manufacturing industries. Poorly managed landfill systems can cause groundwater contamination, methane emissions, and foul odor problems. Incineration systems may generate harmful emissions if proper pollution control measures are not implemented. Modern emission control technologies help in minimizing air pollution from thermal treatment systems. Therefore, environmentally friendly technologies are essential for sustainable waste management and public health protection.

6.9. OVERALL DISCUSSION

The overall analysis indicates that each waste management technology has specific advantages and limitations. Composting is economical and suitable for biodegradable waste in rural and community-level applications. Biomethanation provides additional benefits through renewable energy generation and efficient organic waste treatment. Recycling systems are highly effective in resource conservation and reduction of landfill burden. Incineration systems offer high waste reduction and energy recovery but require high investment and technical expertise. Landfills remain necessary for disposal of residual waste but have environmental limitations. The study concludes that integrated solid waste management systems combining segregation, recycling, composting, and energy recovery provide the most sustainable solution. Proper technology selection should consider local conditions, waste characteristics, environmental regulations, and economic feasibilit.

VII. CONCLUSION

The present study focused on the techno-economic comparison of various technologies used for solid waste management. Different waste treatment methods such as landfill, composting, biomethanation, recycling, and incineration were analyzed based on technical, economic, environmental, and social parameters. The study revealed that each technology has its own advantages, limitations, and suitability depending on waste quantity, composition, land availability, and financial conditions. Composting and vermicomposting were found to be economical and environmentally friendly methods suitable for biodegradable waste management, especially in rural and community-level applications. Biomethanation technology showed significant benefits through renewable energy generation and efficient treatment of organic waste. Recycling systems proved highly effective for resource conservation and reduction of landfill burden by recovering reusable materials such as plastic, paper, glass, and metals. Incineration and waste-to-energy technologies demonstrated high treatment efficiency and maximum waste volume reduction. However, these systems require high capital investment, skilled manpower, and pollution control measures. Landfill systems, although widely used, were observed to have major environmental limitations such as groundwater contamination, methane emissions, and large land requirement. The comparative evaluation indicated that no single technology can completely solve solid waste management problems under all conditions. Integrated solid waste management systems combining segregation, recycling, composting, biomethanation, and scientific disposal methods provide the most sustainable and effective solution. Proper waste segregation at source plays a major role in improving treatment efficiency and resource recovery. The study concludes that selection of suitable waste management technology should be based on technical feasibility, economic viability, environmental sustainability, and local conditions. Adoption of modern and sustainable waste management practices can help in reducing pollution, conserving natural resources, generating renewable energy, and improving public health. Therefore, integrated and scientifically managed solid waste systems are essential for achieving sustainable urban and rural development.

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