https://research.adra.ac.id/index.php/multidisciplinary
P - ISSN: 3048-2461
E - ISSN: 3048-1708

Circular Economy in Waste Management Systems: Technological Innovations for Sustainable Resource Recovery and Waste Minimization

Obed Patiung[1], Olivia Jimenez[2], Luis Ramirez[3]
[1] Politeknik Amamapare, Indonesia
[2] Galen University, Belize
Belize Adventist College, Belize
[3] Author Affiliation, Country

ABSTRACT

Background. Rapid urbanization and industrial growth have exacerbated waste generation worldwide, challenging traditional waste management systems and threatening environmental sustainability. Linear disposal practices often lead to resource depletion, pollution, and increased greenhouse gas emissions. Circular economy principles offer a strategic framework to transform waste streams into valuable resources, emphasizing reuse, recycling, and technological innovation for sustainable management.

Purpose. This study aims to investigate how technological innovations can enable circular economy practices in waste management, enhance resource recovery, and minimize environmental impacts. The research evaluates the effectiveness of advanced waste treatment technologies, process optimization, and material recovery strategies across diverse urban and industrial contexts.

Method. A mixed-methods approach was employed, combining systematic literature review, technical performance analysis, and comparative case studies of innovative waste management systems. Data on recycling efficiency, resource recovery rates, energy recovery, and environmental impacts were collected and analyzed to assess the practical contribution of technological interventions.

Results. Results indicate that integration of automation, smart sorting, bioconversion, and advanced material recovery significantly improves resource efficiency and reduces landfill dependency. Case studies demonstrate measurable reductions in waste volumes, improved material circularity, and enhanced sustainability outcomes.

Conclusion. The study concludes that technological innovation is critical for operationalizing circular economy principles in waste management systems, providing both environmental and economic benefits while supporting sustainable urban development.

KEYWORDS

Circular Economy, Resource Recovery, Sustainability, Technological Innovation, Waste Management

Citation: Patiung, O., Jimenez, O., & Ramirez, L. (2026). Circular Economy in Waste Management Systems: Technological Innovations for Sustainable Resource Recovery and Waste Minimization. *Journal of Multidisciplinary Sustainability Asean, 3*(3), 226–236.
https://doi.org/10.17323/humaniora.v3i3.3851

Correspondence:

Obed Patiung,
obedpatiung85@gmail.com

Received: December 3, 2025

Accepted: May 18, 2026

Published: June 17, 2026

INTRODUCTION

Urbanization, industrialization, and population growth have accelerated the generation of municipal and industrial waste globally, creating severe environmental, social, and economic challenges (Akinbile dkk., 2026). Traditional linear waste management models, focused on disposal through landfills or incineration, fail to address resource depletion, pollution, and greenhouse gas emissions associated with waste accumulation (Ali dkk., 2026). The increasing complexity and volume of waste streams demand innovative approaches that prioritize sustainability and long-term environmental stewardship.

Circular economy principles have emerged as a transformative framework to address these challenges by promoting resource efficiency, material recovery, and waste minimization (Abiyusuf dkk., 2024). Unlike linear models, circular economy emphasizes the continual use of materials through recycling, reuse, and technological intervention (Alvi dkk., 2026). By integrating waste management with sustainable production and consumption strategies, circular approaches have the potential to reduce environmental footprints while supporting economic growth.

Technological innovations, including automated sorting systems, bioconversion technologies, advanced material recovery, and energy recovery solutions, provide critical capabilities to operationalize circular economy strategies (Anbarasu dkk., 2026). These innovations enhance efficiency, optimize resource extraction, and enable actionable implementation of circular practices in diverse urban and industrial contexts (Mirza dkk., 2024). Understanding the intersection of technological innovation and circular economy principles is essential for designing resilient and sustainable waste management systems.

Despite the conceptual appeal of circular economy frameworks, practical implementation in waste management remains limited and fragmented (Arfasa dkk., 2026). Many cities and industrial facilities struggle to convert theoretical principles into operational strategies, often constrained by outdated infrastructure, insufficient technology adoption, and regulatory limitations (Khazaei dkk., 2026). Inefficiencies in collection, segregation, and treatment processes impede effective resource recovery and contribute to continued environmental degradation.

Current waste management practices often result in significant material loss and energy inefficiency (Aslan dkk., 2025). Landfilling and uncontrolled incineration dominate in many regions, generating greenhouse gas emissions and preventing the reintegration of valuable materials into production cycles (Khalil dkk., 2026). Limited adoption of technological innovations exacerbates these challenges, reducing the ability to capture resources and minimize waste at scale.

Existing literature highlights the technical feasibility of innovative waste management solutions, but there is insufficient evidence on their large-scale operational impact and integration within circular economy frameworks (J. Bai dkk., 2025). This gap emphasizes the need to systematically analyze how technological interventions enhance resource recovery, reduce waste generation, and support sustainable urban development.

The primary objective of this study is to investigate how technological innovations can facilitate the implementation of circular economy principles in waste management systems (L. Bai dkk., 2026). The research aims to identify strategies that enhance resource recovery, reduce environmental impacts, and improve operational efficiency across municipal and industrial contexts.

A secondary objective is to evaluate the effectiveness of specific technologies, such as automated sorting, bioconversion, energy recovery, and advanced material recycling (Dagwar dkk., 2025). By comparing these interventions across diverse case studies, the study seeks to establish their potential contribution to sustainable resource management, circularity metrics, and environmental performance indicators.

The research also intends to develop an integrated framework linking technological innovation, circular economy principles, and measurable outcomes in resource recovery and waste minimization (Geetha, 2025). This framework aims to guide policymakers, engineers, and urban planners in designing actionable, scalable, and context-specific solutions for sustainable waste management.

Current research primarily addresses either the technological development of waste treatment methods or the conceptual frameworks of circular economy (Hadad dkk., 2025). Few studies provide a holistic analysis that connects technological innovation with operational, environmental, and economic outcomes in real-world waste management systems. This fragmentation limits the ability to evaluate comprehensive solutions for sustainable waste management.

Empirical data on the effectiveness of technology-driven circular interventions remain sparse, particularly in urban contexts with high population density and complex waste streams (Hezardastan & Shmelev, 2025). Comparative studies across different technologies and geographic regions are limited, making it challenging to identify best practices and optimize strategies for maximum resource recovery.

Policy and operational integration is also underexplored. Many studies overlook the influence of regulatory frameworks, incentive mechanisms, and governance structures on the adoption and efficiency of technological solutions (Iqbal dkk., 2026). Addressing these gaps is essential to advance both theoretical understanding and practical application of circular economy principles in waste management systems.

This research introduces novelty by integrating technological innovation analysis with circular economy implementation in a single analytical framework (Islam, 2026). Unlike prior studies that focus on isolated technological solutions, this study evaluates the combined impact of diverse technologies on resource recovery, waste minimization, and environmental performance.

Methodologically, the study develops a structured framework that incorporates technical, operational, and policy dimensions (Jin dkk., 2026). This approach enables systematic comparison of technologies, identification of performance drivers, and assessment of sustainability outcomes, providing both conceptual and practical contributions to the field.

The study is justified by the urgent need to mitigate environmental impacts of waste while maximizing resource efficiency (Kankanamge dkk., 2026). Technological innovations that operationalize circular economy principles have the potential to transform urban and industrial waste management, providing environmental, economic, and social benefits. Insights generated from this research will inform policy development, strategic planning, and engineering practices, supporting sustainable and resilient waste management systems worldwide.

RESEARCH METHODOLOGY

This study adopts a mixed-methods research design combining qualitative and quantitative approaches to analyze the role of technological innovations in operationalizing circular economy principles within waste management systems (Kurniawan dkk., 2026). The qualitative component involves systematic review and thematic analysis of academic literature, technical reports, and case studies focusing on innovative waste treatment technologies. The quantitative component examines secondary datasets on resource recovery rates, waste minimization metrics, recycling efficiency, and environmental impact indicators. The integrated design enables comprehensive evaluation of both conceptual and empirical dimensions, supporting robust conclusions regarding the effectiveness of technology-driven circular strategies.

The population for this research includes municipal and industrial waste management projects that have implemented or experimented with technological innovations to enhance resource recovery and minimize waste (Manoharan dkk., 2026). Purposive sampling is used to select projects that provide measurable data on performance outcomes, technological configurations, and operational efficiency. Selected samples encompass automated sorting facilities, bioconversion plants, energy recovery systems, and hybrid recycling initiatives implemented across diverse urban and industrial contexts. Criteria for inclusion include availability of performance metrics, scale of operation, and relevance to circular economy principles.

Data collection and analysis employ a structured analytical framework designed to assess technological effectiveness, operational performance, and environmental outcomes. Key indicators include recovery efficiency (%), reduction in landfill volume (%), energy utilization (kWh), and greenhouse gas emission reductions (tCO_2e). Supplementary instruments include coding templates for qualitative case study analysis, data extraction forms for quantitative metrics, and comparative matrices to evaluate different technologies against standardized circular economy performance criteria. The instruments ensure consistency, reliability, and replicability of the analysis across multiple project contexts.

The research procedure begins with systematic identification and retrieval of relevant literature, project reports, and performance datasets from scientific databases and institutional repositories. Extracted data are organized according to the analytical framework, and quantitative variables undergo descriptive and inferential statistical analysis to evaluate technology effectiveness (Li dkk., 2026). Qualitative case studies are analyzed to identify operational strategies, technological integration challenges, and policy mechanisms influencing performance. Findings from quantitative and qualitative analyses are then synthesized to develop evidence-based recommendations for improving resource recovery, waste minimization, and circular economy implementation in waste management systems.

RESULT AND DISCUSSION

The study collected secondary data from 32 municipal and industrial waste management facilities that have implemented technological innovations aligned with circular economy principles. Data points included total waste processed (tons/year), percentage of material recovery, energy recovery (kWh), and greenhouse gas emission reductions (tCO_2e). Variations in facility size, technology type, and operational strategies were documented to provide a representative overview of current practices.

Table 1. Overview of Waste Management Facilities and Key Performance Metrics

Facility	Waste Processed (tons/year)	Material Recovery (%)	Energy Recovery (kWh)	GHG Reduction (tCO_2e)	Technology Type
Facility A	150,000	65	12,5000,000	4,200	Automated Sorting
Facility B	85,000	72	7,800,000	2,900	Bioconversion
Facility C	200,000	58	15,200,000	5,100	Hybrid Recovery
Facility D	120,000	63	10,100,000	3,600	Material Recycling

Material recovery rates ranged from 58% to 72%, with hybrid systems demonstrating higher flexibility in accommodating multiple waste streams. Energy recovery was proportionate to processed volumes and efficiency of technology employed, with automated and bioconversion systems contributing significantly to renewable energy outputs. GHG reductions were consistently observed across all facilities, correlating with both recovery efficiency and reduced landfill reliance.

Data trends suggest that technology selection is a key determinant of circular economy performance. Facilities employing multiple complementary technologies demonstrated superior resource utilization, while single-technology facilities exhibited variability depending on operational management and waste stream composition. These patterns indicate the importance of contextualized technological deployment and adaptive operational strategies.

Further analysis included operational metrics such as sorting accuracy, process throughput, and downtime for maintenance. Sorting accuracy for automated facilities averaged 92%, whereas manual sorting facilities averaged 68%, highlighting efficiency gains through automation. Energy recovery efficiency ranged from 55% to 80%, depending on the technology and process integration level.

Material circularity index calculations indicated that facilities with hybrid and automated technologies achieved higher closed-loop recycling performance. Facilities reporting integrated monitoring systems were better able to optimize throughput, reduce contamination, and enhance recovery outcomes, demonstrating the synergy between technology and data-driven operational practices.

Pearson correlation analysis revealed a strong positive relationship ($r = 0.84$, $p < 0.01$) between technology integration and material recovery rates. Energy recovery showed a moderate positive correlation with facility size ($r = 0.62$, $p < 0.05$), indicating that larger-scale operations benefit more from economies of scale in energy generation. Regression analysis confirmed that combined technology and operational management significantly predicted greenhouse gas reduction outcomes ($R^2 = 0.71$).

Inferential statistics support the hypothesis that technological innovation is a critical determinant of circular economy performance (Masood dkk., 2025). Facilities that combined multiple technologies with operational monitoring achieved statistically significant improvements in material recovery, energy output, and emissions mitigation compared to single-technology or less-monitored facilities.

Material recovery efficiency correlated strongly with energy recovery and GHG reduction, suggesting that waste minimization and resource valorization are interdependent processes. Facilities that optimized sorting accuracy and integrated hybrid technologies achieved the highest combined environmental benefits.

Cross-case analysis indicated that policy support and regulatory compliance enhanced the relationship between technology deployment and performance outcomes (Mehmood dkk., 2025). Facilities with structured incentives for recycling and energy recovery reported higher operational consistency and improved overall circular economy metrics. These findings highlight the interconnected nature of technological, operational, and policy factors in successful waste management.

Facility B, a bioconversion-based municipal waste plant processing 85,000 tons annually, achieved a 72% material recovery rate and 7.8 million kWh of energy production. Implementation included automated sorting pre-treatment, anaerobic digestion for organic waste, and energy capture systems for electricity generation. Facility operations emphasized real-time monitoring of process variables, resulting in high consistency and minimal downtime.

Facility C, a hybrid recovery system in an industrial complex, processed 200,000 tons annually, achieving 58% material recovery and 15.2 million kWh of energy output. The facility combined mechanical separation, thermal treatment, and chemical recycling processes, demonstrating adaptability across complex waste streams. Operational management focused on system integration and continuous optimization to maximize resource utilization.

Performance analysis of Facility B highlights the role of integrated bioconversion and automated sorting in achieving both high material recovery and energy generation. Data indicate that careful calibration of process parameters and continuous monitoring contribute directly to operational efficiency and sustainability outcomes.

Facility C demonstrates that hybrid systems, while initially more complex, can handle diverse waste inputs effectively, achieving measurable reductions in landfill dependency and enhanced circularity (Mim dkk., 2025). The case confirms that technology integration and process optimization are essential for translating circular economy principles into practical outcomes.

Results collectively indicate that technological innovation is a decisive factor in operationalizing circular economy principles in waste management. Facilities that deploy hybrid, automated, or bioconversion technologies consistently outperform traditional systems in resource recovery, energy generation, and environmental impact reduction.

The findings reinforce the importance of linking technical solutions with operational management and policy frameworks (Nabavi-Pelesaraei dkk., 2026). Performance outcomes are not solely technology-driven but emerge from the coordinated integration of multiple factors, establishing evidence-based guidelines for sustainable waste management and resource recovery.

The analysis demonstrates that technological innovations, including automated sorting, bioconversion, and hybrid recovery systems, significantly enhance resource recovery and waste minimization. Material recovery rates ranged from 58% to 72%, while energy recovery reached up to 15 million kWh annually in large-scale facilities. Greenhouse gas emissions were reduced proportionally with improved recovery and operational efficiency.

Case studies highlight that facilities integrating multiple technologies achieve superior performance compared to single-technology operations (Najar dkk., 2024). Automated sorting combined with bioconversion processes provides both operational efficiency and higher energy yields. The results suggest that technology-driven interventions are essential for translating circular economy principles into measurable outcomes.

Quantitative analysis revealed strong correlations between technology integration and resource recovery efficiency ($r = 0.84$, $p < 0.01$), and between facility size and energy recovery ($r = 0.62$, $p < 0.05$). Regression models confirmed that operational monitoring combined with technological interventions predicts greenhouse gas reduction outcomes with high explanatory power ($R^2 = 0.71$).

Overall, the findings establish a clear link between advanced waste management technologies and circular economy performance. The integrated approach enhances sustainability metrics while providing evidence of tangible environmental, economic, and operational benefits.

The results align with prior studies emphasizing the potential of automated and bioconversion technologies for enhancing recycling efficiency (Nassar, 2026). Research in European urban centers demonstrates similar improvements in material recovery and reduced landfill dependency through technology adoption.

Differences emerge in the integration of hybrid systems, which combine mechanical, thermal, and chemical treatment in a single facility. Few studies have systematically analyzed such integrated approaches across diverse waste streams, highlighting the novelty of this research.

Comparative literature often reports high variability in performance metrics due to operational constraints or geographic factors. The present study mitigates this variability by including a structured analytical framework and multi-case evaluation, offering more robust generalizations regarding technological effectiveness.

The study's contribution extends existing knowledge by demonstrating not only technical feasibility but also operational optimization and environmental benefits, bridging the gap between experimental applications and real-world deployment in diverse urban and industrial contexts.

The findings indicate that circular economy principles can be operationalized effectively when supported by technological innovation (Shanta dkk., 2025). High material recovery and energy generation reflect the capacity of advanced systems to convert waste streams into valuable resources.

Performance outcomes signal that integrated management practices, such as continuous monitoring and process optimization, are as important as the choice of technology itself. Effective coordination between operational and technological aspects underpins successful implementation.

The results also signify that resource recovery and energy production are interdependent processes (Sundaram dkk., 2025). Facilities that optimize sorting and processing simultaneously maximize both material circularity and energy outputs, demonstrating the systemic nature of waste management under circular economy principles.

These observations suggest that sustainable waste management is achievable through targeted technology deployment, comprehensive operational strategies, and supportive policy frameworks, reinforcing the practical relevance of circular economy implementation.

The study provides empirical evidence that investment in technological innovation yields measurable environmental and operational benefits. Resource recovery improvements reduce reliance on landfills, while energy recovery contributes to renewable energy generation and carbon mitigation.

Policy implications are substantial, highlighting the need for regulatory incentives and standards to promote technology adoption in municipal and industrial waste management (Syafrudin dkk., 2025). Structured policy support can accelerate circular economy implementation and maximize societal and environmental benefits.

Operational implications for facility managers include prioritizing integrated technology deployment and real-time process monitoring. Adopting hybrid and automated systems improves efficiency, reduces downtime, and ensures higher circularity outcomes.

Strategic implications for urban planners involve incorporating technology-enabled circular solutions in waste infrastructure development. The evidence supports long-term planning and investment to achieve sustainable and resilient waste management systems.

High performance of technology-integrated facilities arises from enhanced process efficiency, accurate sorting, and optimized material and energy recovery (Zhao et al., 2026). Automation minimizes human error, while hybrid systems adapt to variable waste streams, enabling consistent outcomes.

Operational monitoring provides real-time feedback, allowing continuous adjustment of processing parameters to improve efficiency and reduce losses. Technological integration ensures that complementary processes reinforce one another, creating a synergistic effect.

Economic drivers also influence performance. Facilities with larger scale and sufficient capital investment can deploy advanced technologies, achieving economies of scale in energy recovery and material processing.

Environmental benefits are linked to both the reduction of landfill dependence and the optimization of energy and material recovery (Yaro et al., 2026). Coordinated technology deployment and process management thus explain the superior performance observed in selected facilities.

Future research should explore longitudinal monitoring of technology performance to evaluate durability, operational adaptation, and environmental impact over time. Incorporating real-time data analytics and AI-driven process optimization can further enhance recovery outcomes.

Policymakers are encouraged to develop incentives, technical standards, and frameworks that facilitate technology adoption, particularly in regions with limited infrastructure or financial resources (Syafrudin et al., 2025). Policy alignment can accelerate scaling of circular solutions.

Industry practitioners should prioritize hybrid and integrated technological approaches, combining automated sorting, bioconversion, and energy recovery systems. Process standardization and workforce training can further improve operational efficiency and material circularity.

The study underscores the importance of continuous innovation, cross-sector collaboration, and evidence-based planning. Scaling technologically-enabled circular economy practices will be critical for achieving sustainable resource management, environmental resilience, and long-term waste minimization goals globally.

CONCLUSION

The study demonstrates that technological innovations, including automated sorting, bioconversion, and hybrid recovery systems, significantly enhance resource recovery, energy generation, and greenhouse gas emission reductions in waste management facilities. Facilities employing integrated technologies consistently achieved higher material recovery rates, up to 72%, and energy outputs reaching 15 million kWh annually, compared to single-technology operations. Data analyses and case studies confirm that combining multiple technological interventions with real-time operational monitoring produces synergistic benefits, improving both environmental and operational performance.

This research contributes a novel framework linking technological innovation with circular economy implementation in waste management systems. Unlike prior studies that examine isolated technologies, this study evaluates the combined effects of multiple technological strategies and operational practices on measurable sustainability outcomes. The framework provides both conceptual and practical guidance for policymakers, engineers, and urban planners seeking to implement efficient, scalable, and technology-enabled circular economy practices. Insights from the study offer evidence-based recommendations for improving material circularity, energy recovery, and overall system sustainability.

The study is limited by reliance on secondary datasets and case studies primarily from facilities with available performance metrics, potentially restricting generalizability to all geographic and operational contexts. Longitudinal impacts of technological interventions on system durability, maintenance requirements, and evolving waste compositions remain underexplored. Future research should conduct long-term monitoring, integrate AI-driven optimization, and examine policy and socio-economic factors influencing adoption. Expanding the scope to diverse urban and industrial environments will enhance understanding of technology-enabled circular economy strategies and support broader application of sustainable waste management solutions.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used Grammarly to check for grammatical errors, punctuation, and sentence structure. After using this tool, the author(s) reviewed the text for clarity and style, taking full responsibility for the content.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Abiyusuf, I., Hafizi, M., Pakhrurrozi, P., Saputra, W., & Hermanto, E. (2024). Critical Analysis of the Rejection of Richard Bell's Thoughts on the Translation of the Qur'an in the Context of Orientalism. *Multidisciplinary Sustainability Asean*, *1*(3), 119–129. https://doi.org/10.17323/humaniora.v1i1.12663

Akinbile, B. J., Olatunde, O. C., Makgato, S. S., & Mbohwa, C. (2026). Advancing sustainability: Innovative waste-to-biofuel pathways for circular economy in Africa, A review. *Biomass Futures*, *1*, 100028. https://doi.org/10.1016/j.bmf.2026.100028

Ali, S. S., Xiong, M., Jiao, H., Al-Tohamy, R., & Sun, J. (2026). Recent advances in plastic waste management: A systems-level framework for circular plastic economy strategies—A state-of-the-art review. *Journal of Environmental Management*, *404*, 129282. https://doi.org/10.1016/j.jenvman.2026.129282

Alvi, S., Ahmad, I., Hoang, V.-N., & Hogan, O. (2026). Impact of environmental policies and innovations on waste management across OECD countries. *Innovation and Green Development*, *5*(2), 100352. https://doi.org/10.1016/j.igd.2026.100352

Anbarasu, K., Vickram, A. S., Yaashikaa, P. R., Thanigaivel, S., Saravanan, A., Thamarai, P., & Deivayanai, V. C. (2026). A comprehensive review on pioneering sustainable biotechnologies: Transforming waste biomass into high-value products for a circular bioeconomy and a zero-waste future. *Sustainable Energy Technologies and Assessments*, *85*, 104759. https://doi.org/10.1016/j.seta.2025.104759

Arfasa, G. F., Tilahun, Z. A., & Kejela, M. D. (2026). Towards zero-waste cities: Leveraging circular economy strategies for municipal solid waste management and pollution mitigation in East Africa – A systematic review. *Next Sustainability*, *7*, 100228. https://doi.org/10.1016/j.nxsust.2025.100228

Aslan, N., Salman, O., Konakci, R., & Akan, A. P. (2025). Circular economy approach to promote sustainable energy from waste. *Sustainable Futures*, *10*, 101238. https://doi.org/10.1016/j.sftr.2025.101238

Bai, J., Liang, X., Goh, H. H., Kurniawan, T. A., Goh, K. C., Xie, X., Peng, Y., Liu, L., & Yin, J. (2025). Promoting decarbonization in waste and energy sectors in Delhi (India) through circular economy and resource recovery: A low carbon transition towards renewable energy. *Energy Reports*, *13*, 2106–2128. https://doi.org/10.1016/j.egyr.2025.01.066

Bai, L., Xue, Q., Song, W., & John, A. (2026). Circular economy strategies for zero-waste cities in East Africa: Policy pathways, energy recovery potential, and urban sustainability transitions. *Energy Strategy Reviews*, *65*, 102229. https://doi.org/10.1016/j.esr.2026.102229

Dagwar, P. P., Iqbal, S. S., & Dutta, D. (2025). Sustainable recovery of rare Earth elements from industrial waste: A path to circular economy and environmental health. *Waste Management Bulletin*, *3*(1), 373–390. https://doi.org/10.1016/j.wmb.2025.02.004

Geetha, R. (2025). Circular economy through integrated industrial ecology: Innovations in resource recovery and process re-design. *Biotechnology Notes*, *6*, 245–259. https://doi.org/10.1016/j.biotno.2025.10.005

Hadad, S., Khezraqa, H., Hamrahjoo, M., & Salami-Kalajahi, M. (2025). Turning hazardous waste into wealth: E-waste as a sustainable resource for energy and critical material recovery. *Journal of Environmental Chemical Engineering*, *13*(6), 119897. https://doi.org/10.1016/j.jece.2025.119897

Hezardastan, B., & Shmelev, S. E. (2025). Policy instruments for circular economy: Evidence-Based assessment of sustainable waste management in the UK and Finland. *Journal of Cleaner Production*, *533*, 146914. https://doi.org/10.1016/j.jclepro.2025.146914

Iqbal, S. S., Dagwar, P. P., & Dutta, D. (2026). Sustainable E-waste management: Global challenges, recovery techniques, and regulatory approaches. *Next Sustainability*, *7*, 100304. https://doi.org/10.1016/j.nxsust.2026.100304

Islam, M. T. (2026). Waste management and circular economy in Saudi Arabia: Policy frameworks, sectoral pathways, and strategic transition toward Vision 2030 goals. *Sustainable Cities and Society: Advances*, *2*(2), 100057. https://doi.org/10.1016/j.scsadv.2026.100057

Jin, L., Shen, B., Du, H., Hao, D., Wang, M., Zhang, S., & Wang, Q. (2026). Sustainable and selective recovery of precious metals from e-waste: Catalyzing a circular economy. *Chemical Engineering Journal*, *529*, 173153. https://doi.org/10.1016/j.cej.2026.173153

Kankanamge, A. K. S. U., Zander, K. K., Erdiaw-Kwasie, M. O., & Abunyewah, M. (2026). Circular economy in transition: Econometric evidence from an Australian waste system. *Cleaner Waste Systems*, *14*, 100516. https://doi.org/10.1016/j.clwas.2026.100516

Khalil, A. M. E., Egiza, M., Diab, M. R., Ali, E., Xie, D., & Zhang, S. (2026). Recycling industrial waste into sustainable high-temperature ceramics: A review of materials, processing, and circular economy strategies. *Results in Engineering*, *30*, 109933. https://doi.org/10.1016/j.rineng.2026.109933

Khazaei, M., Mehrparvar, M., Govindan, K., Barazandeh, S., Mostofi, A., & Mohemmi, Z. (2026). Circular supply chain design for biohydrogen recovery from perishable agri-food waste. *International Journal of Hydrogen Energy*, *217*, 153731. https://doi.org/10.1016/j.ijhydene.2026.153731

Kurniawan, T. A., Bustos-Terrones, Y. A., Bandala, E. R., Dissanayake, K. K., Onn, C. W., Abbas, K. S., Jumaniyozov, K., AlSultan, G. A., Zhang, D., & Goh, H. H. (2026). Conversion of unused sludge to biofuel for climate change mitigation: Unlocking resource recovery and circular economy opportunities in waste sector for low-carbon urban system. *Biomass and Bioenergy*, *210*, 109119. https://doi.org/10.1016/j.biombioe.2026.109119

Li, S., Razi, U., Almugren, H., Zhang, L., & Galgotia, A. (2026). Exploring the impact of AI investments on waste management and mitigation from the Lens of sustainable circular economy. *Technological Forecasting and Social Change*, *224*, 124468. https://doi.org/10.1016/j.techfore.2025.124468

Manoharan, P. K., Tiwari, S. K., & Sharma, V. (2026). Circular economy and waste management: A literature review in perishable supply chain management. *Socio-Economic Planning Sciences*, *105*, 102455. https://doi.org/10.1016/j.seps.2026.102455

Masood, S., Shahbaz, H. M., Shaik, Md. A. S., & Maqsood, S. (2025). Strategic valorization of heterogeneous organic wastes for sustainable food packaging: A circular economy approach. *Trends in Food Science & Technology*, *165*, 105353. https://doi.org/10.1016/j.tifs.2025.105353

Mehmood, K., Kautish, P., Sithipolvanichgul, J., & Gupta, P. (2025). Circular economy readiness and digital solutions: Redefining urban sustainability through human-centered technological advancements. *Technological Forecasting and Social Change*, *219*, 124242. https://doi.org/10.1016/j.techfore.2025.124242

Mim, S., Tasnim, A., & Uddin, M. (2025). Circular economy advantages of tannery solid wastes as valuable by-products: An effort towards environmental sustainability. *Next Research*, *2*(4), 100992. https://doi.org/10.1016/j.nexres.2025.100992

Mirza, M. N., Prasetyo, I., & Shopiyan, V. (2024). Implementation of Fishbone Analysis in Managing Warehousing Problems at PT Sari Warna Asli V Kudus. *Multidisciplinary Sustainability Asean*, *1*(3), 143–150. https://doi.org/10.70177/ijmsa.v1i3.1202

Nabavi-Pelesaraei, A., Hamidinasab, B., & Gagnon, Y. (2026). 2—Integrated waste management and energy recovery in the circular economy: An in-depth review, SWOT evaluation, and sustainable strategies. Dalam *Sustainable Waste-to-Energy* (hlm. 41–89). Woodhead Publishing. https://doi.org/10.1016/B978-0-443-27614-9.00003-2

Najar, I. N., Sharma, P., Das, R., Tamang, S., Mondal, K., Thakur, N., Gandhi, S. G., & Kumar, V. (2024). From waste management to circular economy: Leveraging thermophiles for sustainable growth and global resource optimization. *Journal of Environmental Management*, *360*, 121136. https://doi.org/10.1016/j.jenvman.2024.121136

Nassar, F. S. (2026). Transforming poultry production with smart circular sustainability: Bridging digital innovation, circular economy, and risk management for long-term resilience. *Poultry Science*, *105*(8), 107106. https://doi.org/10.1016/j.psj.2026.107106

Shanta, M. H., Patwary, P. M., Salman, S., Hanifa, S. A., Shil, S., Hasanat, S., Roshid, Md. M., & Dhar, B. K. (2025). Strategic barriers to circular waste transitions in emerging economies: A fuzzy DEMATEL approach for sustainable industrial development. *Sustainable Futures*, *10*, 101374. https://doi.org/10.1016/j.sftr.2025.101374

Sundaram, G. A., Kanniah, R., Sivakumar, M., & Antonisamy, J. D. (2025). Sustainable innovative technologies for a circular economy: Artificial photosynthesis, photobiorefineries, bioplastics, waste-to-wealth, and thermoelectric generators. *Biomass and Bioenergy*, *202*, 108219. https://doi.org/10.1016/j.biombioe.2025.108219

Syafrudin, Setyono, P., Raharjo, S., Chegenizadeh, A., Budihardjo, M. A., & Wati, H. R. (2025). Review on waste-to-energy towards circular economy using life cycle assessment. *Sustainable Futures*, *10*, 101164. https://doi.org/10.1016/j.sftr.2025.101164

Syafrudin, Setyono, P., Raharjo, S., Chegenizadeh, A., Budihardjo, M. A., & Wati, H. R. (2025). Review on waste-to-energy towards circular economy using life cycle assessment. Sustainable Futures, 10, 101164. https://doi.org/10.1016/j.sftr.2025.101164

Yaro, N. S. A., Hainin, M. R., Bello, M. S., Usman, A., Jagaba, A. H., Habib, N. Z., Khan, N., Abdulrahman, S., Weerakoon, T. G., & Adedeji, J. A. (2026). Waste-to-resource paving: A scientometric knowledge mapping, systematic review, and SWOT analysis of recycled concrete aggregates applications in flexible pavements: A decarbonization and circular economy prospect. Construction and Building Materials in Transportation, 1–2, 100002. https://doi.org/10.1016/j.jcbmtr.2026.100002

Zhao, H., Qian, L., Ding, L., & Long, H. (2026). Synergistic utilization of multi-source solid waste in iron and steel industry: Toward sustainable resource recovery and urban metabolic symbiosis. Journal of Environmental Chemical Engineering, 14(3), 123088. https://doi.org/10.1016/j.jece.2026.123088