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CIRCULAR ECONOMY IN ENVIRONMENTAL MANAGEMENT: EVALUATING THE ROLE OF WASTE-TO-RESOURCE TECHNOLOGIES IN URBAN SUSTAINABILITY

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ABSTRACT

The rapid pace of urbanization in the 21st century has intensified the demand for sustainable solutions to manage growing volumes of urban waste while reducing the environmental footprint of cities. Traditional linear economic models based on the "take-make-dispose" paradigm are increasingly proving inadequate to meet the ecological, economic, and social demands of modern urban environments. This research examines the emerging role of waste-to-resource technologies within the framework of the circular economy, with a focus on their contributions to urban sustainability and efficient environmental management. Circular economy principles advocate for the regeneration of natural systems, the design of out-of-waste cycles, and the continuous reuse of materials through strategies such as recycling, remanufacturing, and industrial symbiosis. The research explores how waste-to-resource technologies, including advanced composting systems, anaerobic digestion, materials recovery facilities (MRFs), pyrolysis, and chemical recycling, enable cities to transform waste streams into valuable inputs, such as renewable energy, construction materials, and agricultural supplements. These technologies are not merely tools for waste reduction but act as transformative mechanisms that redefine waste as an economic asset, thereby fostering resource efficiency and resilience. The study employs a mixed-methods approach, combining quantitative data analysis of urban waste generation and recovery rates with qualitative interviews from municipal authorities, technology providers, and sustainability experts across selected metropolitan cities. The findings indicate a strong correlation between the deployment of waste-to-resource infrastructure and improvements in waste diversion rates, urban air and soil quality, and overall material efficiency. Moreover, cities that have embedded these technologies within policy frameworks and public-private partnerships have shown marked improvements in circularity metrics and citizen engagement. However, the study also highlights key barriers to the widespread adoption of such technologies, including capital intensity, lack of regulatory coherence, and inadequate public awareness. To address these challenges, the research recommends integrated policy mechanisms, targeted fiscal incentives, and capacity-building programs aimed at local governments and stakeholders. The broader implication of this research lies in establishing a roadmap for cities to transition from waste management systems to resource recovery ecosystems that are aligned with global climate goals and the UN Sustainable Development Goals (SDGs). In conclusion, the integration of waste-to-resource technologies within urban planning is not only feasible but essential for the realization of circular, sustainable, and resilient urban systems. This research contributes to the evolving discourse on circular urbanism by offering empirical insights and actionable strategies that can shape the future of environmental management in urban landscapes.

KEYWORDS: *Circular Economy; Waste-to-Resource Technologies; Urban Sustainability; Environmental Management; Resource Efficiency.*

Article History

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