

Education drives circular waste management.

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Introduction

The journey towards a circular economy (CE) is fundamentally reshaping waste management paradigms, moving away from linear models towards systems that maximize resource recovery and minimize waste. Central to this transition is the valorization of food waste. One study comprehensively explores the multifaceted role of food waste valorization within the circular economy framework, scrutinizing current policies and practical applications. It pinpoints key drivers and challenges, emphasizing that effective policy integration and technological innovation are essential for shifting from a linear to a circular system in food waste management. The insights gathered suggest crucial areas for improving regulatory frameworks and operational strategies to maximize resource recovery [1].

Building on this, a comprehensive review offers an in-depth analysis of policies, technologies, and challenges related to food waste valorization within a circular economy. This review highlights the potential of various valorization methods, including composting, anaerobic digestion, and biorefining, to transform food waste into valuable resources. It identifies the need for integrated policy approaches, robust infrastructure, and consumer engagement as vital steps to overcome existing barriers and unlock the full potential of food waste in circular systems [9].

Specifically addressing European efforts, another paper examines the opportunities and challenges for valorizing food waste through composting within the European circular economy. Composting emerges as a crucial strategy for nutrient recovery and carbon sequestration, aligning well with circular principles. However, the study also highlights hurdles such as varying national policies, concerns over compost quality control, and the ongoing need for greater public acceptance, underscoring that policy harmonization and technological standardization are essential for widespread adoption across the continent [6].

Beyond food waste, circular economy principles extend to other significant waste streams. A systematic review provides a comprehensive mapping of the barriers and opportunities involved in implementing circular economy principles in organic waste management. It highlights challenges like insufficient infrastructure, regulatory gaps, and low public awareness. Concurrently, it identifies

opportunities such as technological advancements in composting and anaerobic digestion, along with supportive policy instruments. This review emphasizes the necessity for integrated strategies to overcome hurdles and leverage the full potential for a more circular approach to organic waste [3].

Similarly, the transition towards a circular economy for plastic packaging waste presents distinct challenges and opportunities. One review delves into the policies, technologies, and challenges involved, examining current global and regional policies aimed at reducing plastic waste, promoting recycling, and fostering design for circularity. While advanced recycling technologies show promise, significant challenges persist in collection infrastructure, market demand for recycled content, and managing complex material streams, necessitating coordinated efforts across various sectors for effective implementation [4].

A fundamental aspect of sustainable waste management involves understanding and influencing human behavior through education. Research investigates how environmental education influences sustainable waste management, particularly household waste sorting, in rural China. It demonstrates a significant positive correlation between effective environmental education programs and increased participation in waste sorting behaviors. These findings underscore the importance of targeted educational initiatives in fostering environmental consciousness and practical skills among residents, ultimately contributing to broader waste management goals [2].

Further studies reinforce this link, exploring the mediating role of perceived responsibility between environmental education and pro-environmental behavior in sustainable waste management. This work reveals that environmental education significantly enhances an individual's sense of responsibility towards the environment, which in turn motivates them to adopt pro-environmental actions like waste reduction and recycling. The findings highlight that fostering a strong sense of personal accountability is key to effective waste management strategies [5].

The impact of environmental education on waste separation behavior in residential communities has also been explored, utilizing a social cognitive theory perspective. Educational interventions are shown to significantly improve residents' knowledge, self-efficacy,

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and outcome expectations regarding waste separation, leading to more consistent pro-environmental actions. This research emphasizes that understanding psychological factors alongside educational content is crucial for promoting effective waste management practices [8].

Looking forward, developing circular economy competencies through higher education is crucial for sustainable waste management. A systematic literature review identifies the critical skills, knowledge, and attitudes needed by future professionals to design and implement circular waste solutions. It suggests that universities play a pivotal role in integrating circular economy principles into curricula, fostering interdisciplinary approaches, and promoting experiential learning to prepare a workforce capable of driving the transition to circularity [10].

The implementation of a circular economy extends globally, presenting unique opportunities and challenges, particularly in developing countries. A review analyzes these aspects for sustainable waste management in such regions. It highlights how circular models can effectively address pervasive environmental degradation and resource scarcity. However, key challenges include inadequate infrastructure, the prevalence of informal waste sectors, and limited financial resources. The paper stresses the importance of robust policy frameworks, technological adoption, and capacity building to facilitate a successful transition, emphasizing the need for context-specific strategies [7].

Conclusion

The available research collectively highlights the critical importance of transitioning towards a circular economy for sustainable waste management. These studies delve into various waste streams, including food waste, organic waste, and plastic packaging, examining the policies, technologies, challenges, and opportunities involved. Food waste valorization is recognized as a key strategy, with emphasis on composting, anaerobic digestion, and biorefining, requiring integrated policy approaches and robust infrastructure. Significant challenges persist across different waste types, such as insufficient infrastructure, regulatory gaps, low public awareness, and the need for greater market demand for recycled content. A recurring theme is the pivotal role of environmental education in promoting pro-environmental behavior and effective waste management practices. Studies show a strong positive correlation between educational programs and increased participation in waste sorting, fostering environmental consciousness and practical skills.

Education also enhances perceived responsibility, motivating individuals towards waste reduction and recycling. Furthermore, developing circular economy competencies through higher education is vital for future professionals to design and implement sustainable solutions. The global context, especially in developing countries, presents unique challenges like inadequate infrastructure and limited financial resources, underscoring the necessity of strong policy frameworks and capacity building. Overall, the literature underscores that a successful transition to a circular economy demands coordinated efforts across policy, technology, education, and public engagement to maximize resource recovery and address environmental degradation.

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