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Bibliometric Analysis of Research Dynamics of Circular Economy in Plastic Management

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ABSTRACT

The circular economy has emerged as a transformative approach to addressing the global plastic waste crisis by emphasizing resource recovery, recycling, and sustainability. This study presents a bibliometric analysis of research dynamics in circular economy and plastic management, utilizing data exclusively from the Scopus database and analyzed with VOSviewer. Key findings reveal significant growth in research activity over the past two decades, with central themes such as "circular economy," "waste management," and "plastic waste" dominating the field. The analysis identifies strong international collaborations, with countries like the United Kingdom, China, and India serving as key contributors. Emerging topics, including "pyrolysis" and "sustainable development," indicate a shift toward innovative technologies and broader sustainability goals. Despite advancements, gaps remain in understanding the socioeconomic implications of circular economy practices and consumer behavior's role in driving sustainability. This study provides critical insights into the research landscape, guiding future studies and policy frameworks toward effective and equitable plastic management solutions.

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1. INTRODUCTION

The escalating crisis of plastic waste accumulation poses significant challenges to global sustainability, particularly in light of the rapid growth in plastic production and its pervasive use across various industries. As plastics infiltrate every corner of the globe, their management has become a central focus in environmental sustainability discussions. This concern is driven by the material's durability and resistance to degradation, which, while beneficial for product longevity, result in severe environmental consequences when disposed of improperly [1]. The persistence of plastic waste in ecosystems has led to devastating impacts on wildlife and human health, highlighting an urgent need for effective management strategies [2].

In response to this environmental challenge, the concept of a circular economy has emerged as a transformative approach to

resource management, promoting a systemic shift towards reuse, recycling, and resource recovery. Unlike the traditional linear economy, which follows a 'take-make-dispose' pattern, a circular economy aims to redesign the material flows to form a closed-loop system, thus minimizing waste and extending the lifecycle of resources [3]. In the context of plastic management, the circular economy model encourages innovations in recycling technologies, product design for recyclability, and alternative materials that can ease the transition from a linear to a circular flow of plastic materials [4].

Despite the growing advocacy for circular economy practices in plastic management, there is a considerable gap in the comprehensive understanding and quantification of the research dynamics within this field. Bibliometric analysis serves as a potent tool in this regard, providing a systematic method to evaluate the development and focus areas of research over time. By analyzing publication patterns, citation networks, and thematic evolutions, bibliometric studies can offer valuable insights into the prevailing trends, influential studies, and emerging themes in circular economy research related to plastic management [5].

However, while the body of literature on circular economy and plastic management is expanding, it is often fragmented, spanning multiple disciplines and lacking a cohesive framework that integrates various aspects of plastic reuse, recycling, and recovery within a circular economy paradigm. This fragmentation presents significant challenges for policymakers, researchers, and practitioners striving to implement effective strategies that align with circular economy principles [6].

Given the critical environmental impact of plastic waste and the potential of circular economy strategies to mitigate these effects, it is imperative to synthesize and analyze the existing research to identify key trends, gaps, and future directions. This study aims to address the lack of a comprehensive, systematic analysis of the research dynamics in circular economy practices within the context of plastic management. The fragmented nature of the current literature necessitates a bibliometric study to map the intellectual landscape, assess the contributions from various disciplines, and pinpoint areas requiring further investigation or immediate action.

The objective of this study is to conduct a bibliometric analysis of the literature on circular economy approaches to plastic management. By mapping the research landscape, this study aims to uncover the developmental trajectories, key themes, and influential works in the field. The insights derived from this analysis will aid in understanding the evolution of the research, the interconnectivity of themes, and the most impactful contributions, thereby providing a foundational framework to guide future research initiatives and policy formulations in the realm of sustainable plastic management.

2. LITERATURE REVIEW

2.1 The Crisis of Plastic Waste

The ubiquity of plastic waste has become one of the most pressing environmental issues of the 21st century. The global production of plastic has surpassed 300 million tons per year, with a significant portion destined for single-use applications, resulting in substantial waste generation [7]. The durability of plastics, while advantageous for product longevity, poses severe environmental challenges when it comes to disposal. Plastics are resistant to natural degradation processes, leading to their accumulation in natural habitats, waterways, and urban areas [8]. The environmental impact is profound, affecting marine life, wildlife, and human communities alike, as microplastics and plastic

pollutants make their way through the food chain [9].

2.2 *Circular Economy as a Paradigm Shift*

In response to the unsustainable consumption of resources characteristic of the linear economy, the circular economy model has been proposed as a sustainable alternative. The circular economy emphasizes the importance of rethinking design, consumption, and waste management to create closed-loop systems that minimize resource input, waste, emissions, and energy leakage [10]. This model extends the lifecycle of products through strategies such as reuse, repair, refurbishing, and recycling, aiming to keep resources in use for as long as possible [11]. Specifically in plastic management, the circular economy approach advocates for the redesign of plastic products to enhance their recyclability, the development of new recycling technologies, and the substitution of traditional plastics with biodegradable or more easily recyclable materials [12]. These strategies are intended to decrease the dependency on virgin plastic production and reduce the volume of plastic waste generated.

2.3 *Bibliometric Studies on Circular Economy*

Bibliometric analysis has been widely used to assess the growth and focus areas of research within various scientific domains, including the circular economy. These studies utilize data-driven approaches to map out the intellectual landscape, revealing the most influential studies, authors, and journals, as well as the relationships between various research themes [5]. For instance, a bibliometric review by [13] identified that research on the circular economy has been rapidly expanding, with significant contributions focusing on sustainability metrics, business models, and system design. However, the integration of plastic waste management within the circular economy literature remains underexplored, indicating a gap in research that integrates these two critical areas.

2.4 *Plastic Management within Circular Economy Frameworks*

Research on plastic management within the circular economy framework often discusses various strategies that could potentially mitigate the impact of plastic waste. One common theme is the innovation in recycling technologies that can accommodate diverse types of plastics and improve the efficiency of resource recovery [14]. Moreover, policy-driven approaches, such as extended producer responsibility (EPR), have been suggested to incentivize producers to design products with better end-of-life recyclability [10]. Furthermore, the role of consumer behavior and societal attitudes towards plastic use and recycling practices cannot be overlooked. Studies have highlighted the necessity of enhancing public awareness and participation in recycling programs as essential components of effective waste management strategies [15]. These elements are crucial for the success of circular economy initiatives, as public buy-in is

necessary for the widespread adoption of new practices and technologies.

3. METHODS

This study utilizes a bibliometric analysis focused exclusively on literature related to circular economy approaches to plastic management, sourced from the Scopus database. The selection of Scopus as the sole database is driven by its extensive coverage of peer-reviewed literature and its comprehensive indexing which enhances the reliability of the analysis. The search strategy was developed using specific keywords including "circular economy," "plastic management," "plastic waste," and "recycling technologies." These terms were combined using Boolean operators to filter and refine the search to capture the most relevant studies from the year 2000 to 2025. This period was chosen to track the evolution and trends in the field over 25 years, providing a longitudinal perspective on the research dynamics. The data extraction included information on the number of citations, authors, publication years, and geographic distribution, which are critical for understanding the impact and scope of the research conducted in this domain. For the data analysis, this study employs VOSviewer, a tool specifically designed for constructing and visualizing bibliometric networks. This includes networks of co-authorship, citation, co-citation, and keyword co-occurrence. VOSviewer will be used to create visual maps that illustrate the links between various research areas within the circular economy and plastic management fields, highlighting the most influential studies and identifying clusters of research activity.

4. RESULTS AND DISCUSSION

4.1 Keyword Co-Occurrence Network

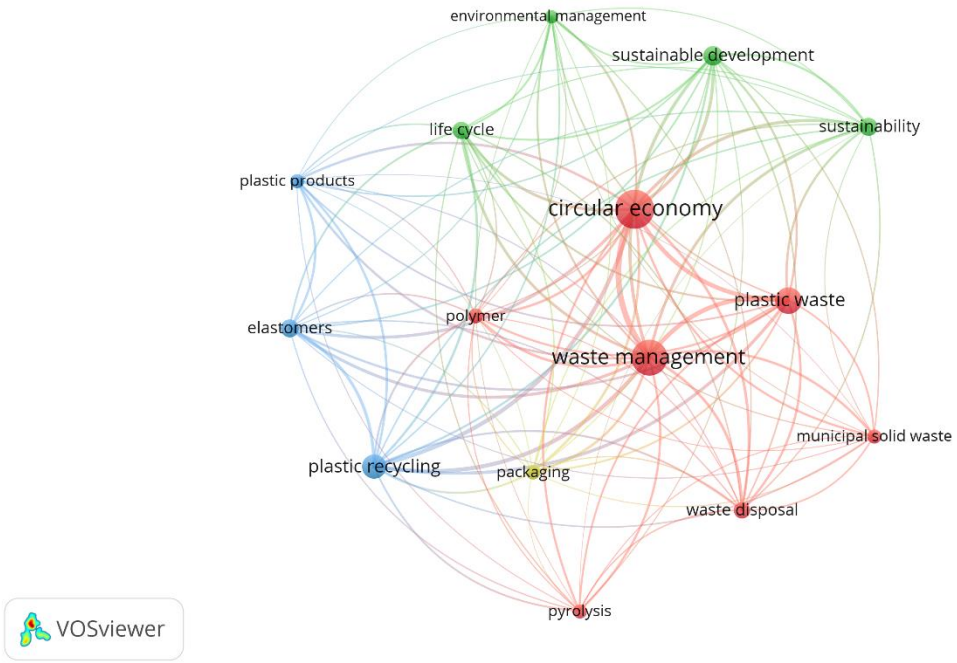

Figure 1. Network Visualization
Source: Data Analysis Result, 2025

The bibliometric map visualizes key research themes and their interconnections within the field of circular economy and plastic management. The central nodes represent dominant topics, such as "circular economy," "waste management," and "plastic

waste," which are strongly interlinked. This indicates that these topics are the primary focus of research in this domain and often co-occur in the literature. The prominence of "circular economy" as the largest node suggests its pivotal role in addressing plastic waste issues and guiding research efforts toward sustainable practices. The map also reveals distinct clusters representing subthemes in the field. The green cluster is associated with "sustainability," "sustainable development," and "environmental management," highlighting the alignment of circular economy practices with broader environmental goals. This cluster underscores the importance of integrating circular economy principles with sustainable development objectives, emphasizing the role of lifecycle assessments and environmental considerations in plastic management strategies.

The red cluster focuses on "waste management," "waste disposal," and "municipal solid waste," illustrating the operational and systemic aspects of managing plastic waste. This cluster signifies the practical challenges and technical solutions involved in reducing, reusing, and recycling plastics. It also points to the critical role of policy and infrastructure in improving waste management practices within a circular economy framework. The blue cluster centers on "plastic recycling," "elastomers," and "plastic products," emphasizing technological and material innovations. This cluster reflects ongoing research into advanced recycling technologies, polymer reuse, and the development of alternative materials to replace conventional plastics. The interconnectedness of this cluster with others highlights the multidisciplinary nature of the field, bridging technological advancements with sustainability and waste management strategies. These clusters collectively illustrate the diverse and interconnected research directions in the circular economy and plastic management domain

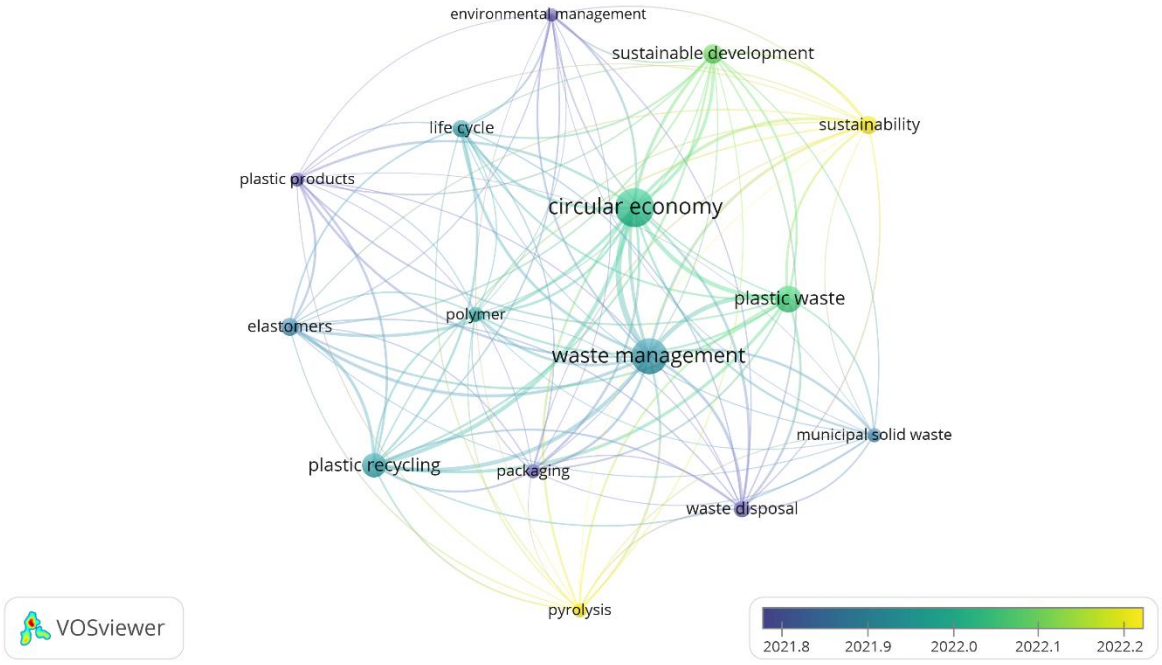

Figure 2. Overlay Visualization
Source: Data Analysis Result, 2025

This bibliometric map visualizes the research landscape of circular economy and plastic management with a temporal overlay. The color gradient, ranging from blue (earlier research) to yellow (more recent research), reveals the evolution of focus areas within the field. Central themes such as "circular economy," "waste management," and "plastic waste" are positioned prominently, signifying their pivotal role as foundational topics. The interconnectedness of these themes highlights their multidisciplinary nature, where environmental sustainability, technological innovation, and systemic waste management converge. The green to yellow nodes, such as "sustainability," "sustainable development," and "pyrolysis," indicate emerging and recent areas of research. This progression suggests a growing emphasis on advanced recycling technologies and the alignment of plastic management with broader sustainability goals. The visibility of "pyrolysis" as a newer topic reflects increasing interest in chemical recycling methods as a solution for managing non-recyclable plastics, while "sustainable development" showcases efforts to integrate plastic management into global environmental strategies. In contrast, blue nodes like "plastic recycling" and "life cycle" represent earlier research directions that have established foundational knowledge in the field. These earlier studies likely laid the groundwork for the current focus on circular economy principles. The temporal progression from blue to yellow across clusters reflects the dynamic evolution of research priorities, shifting from traditional recycling and lifecycle assessment toward innovative technologies and sustainability-oriented solutions.

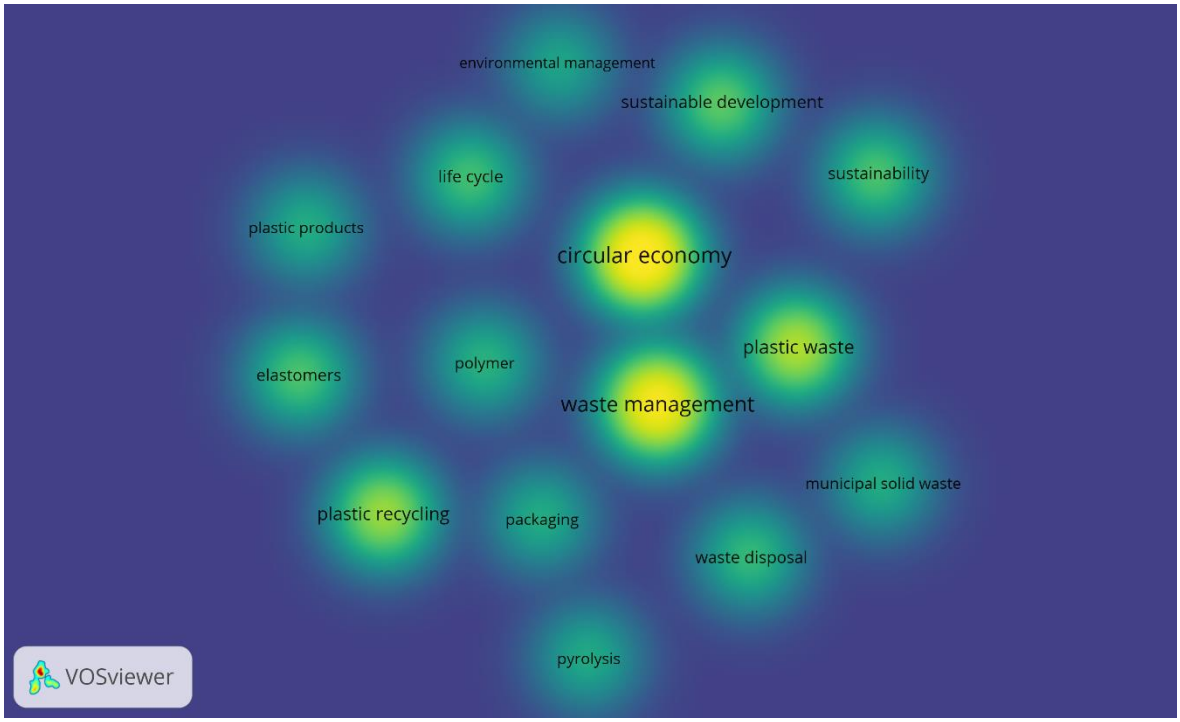

Figure 3. Density Visualization
Source: Data Analysis, 2025

This heatmap visualization highlights the intensity and prominence of research themes within the domain of circular economy and plastic management. The bright yellow nodes, such as "circular economy," "waste management," and "plastic waste," represent the most frequently discussed and influential topics in the field. These central themes indicate the core focus of research, emphasizing the intersection of systemic waste management strategies with the principles of the circular economy. The

interconnectedness of these bright nodes suggests that these topics are highly relevant and interrelated, forming the foundation for advancing research in plastic management. Surrounding the central themes are green nodes such as "plastic recycling," "sustainable development," and "life cycle," which signify secondary yet significant areas of focus. The visibility of terms like "plastic recycling" and "pyrolysis" reflects the emphasis on technological innovations and alternative methods for managing plastic waste. Meanwhile, the presence of "sustainability" and "environmental management" underscores the alignment of plastic management strategies with broader environmental objectives.

4.2 Co-Authorship Network

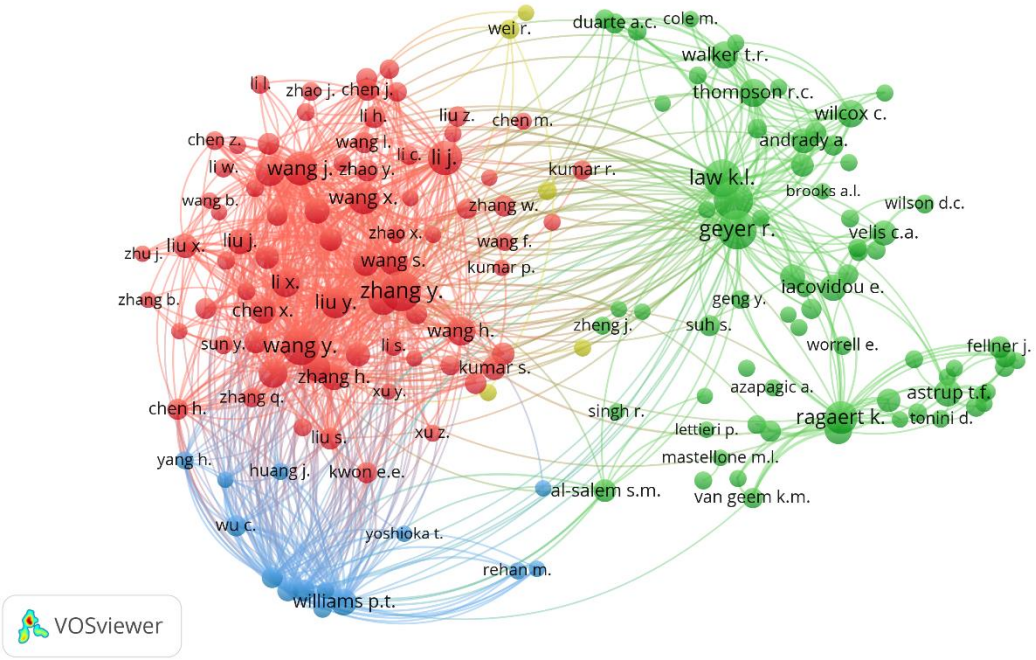

Figure 4. Author Collaboration Visualization

Source: Data Analysis, 2025

This co-authorship network map highlights key contributors and collaborative relationships in the field of circular economy and plastic management. The clusters are color-coded, representing distinct groups of researchers frequently collaborating with one another. The red cluster, dominated by authors such as "Wang J.," "Zhang Y.," and "Liu J.," indicates a dense and closely connected network of researchers likely focused on specific aspects of plastic management. Similarly, the green cluster, featuring prominent names such as "Law K.," "Geyer R.," and "Wilcox C.," reflects another group of highly influential researchers, potentially addressing sustainability and systemic waste management. The blue cluster, led by authors like "Williams P.T.," suggests a focus on technological innovations such as advanced recycling techniques.

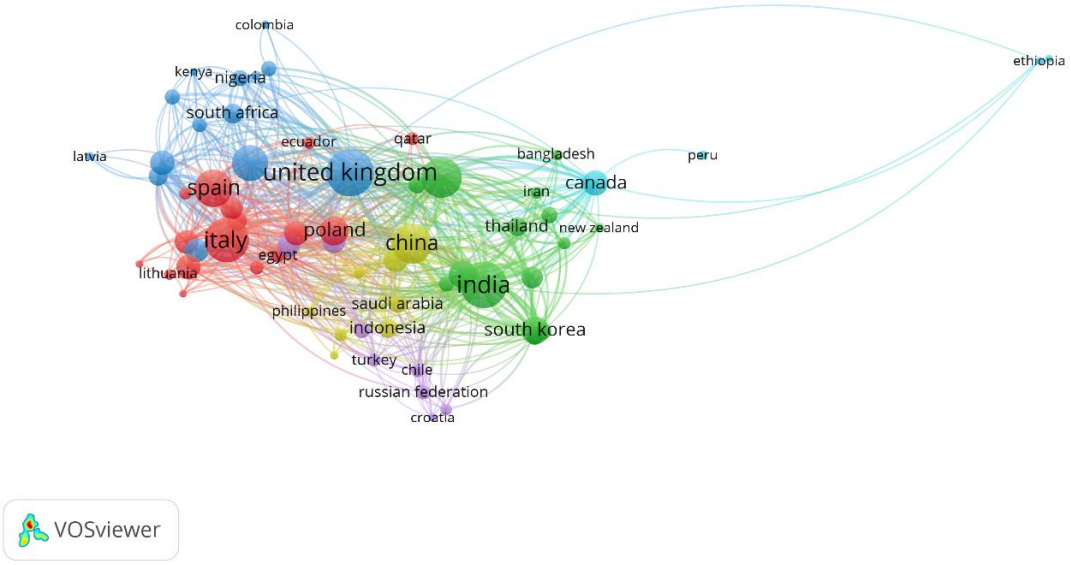

Figure 5. Country Collaboration Visualization

Source: Data Analysis, 2025

This collaboration network map displays the global distribution and interconnections of countries actively contributing to research in circular economy and plastic management. The clusters represent groups of countries with frequent collaborations, with the size of the nodes indicating research activity levels. The United Kingdom, China, and India stand out as central nodes, reflecting their significant contributions and extensive collaborative networks across various regions. Clusters like the red group, including Spain and Italy, and the green group, featuring India and South Korea, suggest regional partnerships fostering focused research efforts. The map also highlights smaller but impactful connections, such as Ethiopia's collaborations, which extend across continents, emphasizing the growing global interest in tackling plastic management challenges.

4.3 **Citation Analysis**

Table 2. Top Cited Research

Citations	Authors and year	Title
898	[16]	Bioplastics for a circular economy
632	[17]	Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context: A business model proposal
608	[18]	The Chinese import ban and its impact on global plastic waste trade
478	[19]	Challenges and strategies for effective plastic waste management during and post COVID-19 pandemic
465	[20]	The circular bioeconomy: Its elements and role in European bioeconomy clusters
441	[21]	Pyrolysis of plastic waste: Opportunities and challenges
428	[22]	Waste biorefineries: Enabling circular economies in developing countries

Citations	Authors and year	Title
418	[23]	Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions
390	[24]	Food packaging in the circular economy: Overview of chemical safety aspects for commonly used materials
369	[25]	Human health and ocean pollution

Source: Publish or Perish Output, 2025

Discussion

1. Research Trends and Evolution

The analysis reveals a substantial increase in research activity related to the circular economy and plastic management over the past two decades. This growth aligns with the global recognition of plastic pollution as a pressing environmental challenge, driven by increasing public awareness, regulatory pressures, and advances in technology. The predominance of "circular economy," "waste management," and "plastic waste" as central themes underscores their foundational role in this field. These topics are interconnected with various subthemes, such as recycling technologies, sustainability, and lifecycle assessments, which indicate the multidisciplinary nature of this research domain.

The temporal overlay in the bibliometric analysis illustrates a clear evolution in research priorities. Early studies focused predominantly on traditional waste management practices and lifecycle analyses. More recent research, as indicated by emerging themes like "pyrolysis" and "sustainable development," reflects a shift toward innovative recycling technologies and the integration of circular economy principles into broader sustainability frameworks. This progression demonstrates the field's responsiveness to emerging challenges and opportunities, particularly the need for advanced methods to manage non-recyclable plastics and align with global sustainability goals.

2. Collaborative Networks and Key Contributors

The co-authorship network analysis highlights the collaborative nature of research in circular economy and plastic management. Prominent authors, such as those in the red and green clusters, play central roles in advancing knowledge through partnerships and interdisciplinary collaborations. For example, researchers like "Wang J." and "Zhang Y." in the red cluster are closely linked with studies on recycling technologies and plastic reuse. Similarly, "Law K." and "Geyer R." in the green cluster contribute significantly to understanding sustainability metrics and policy frameworks. The analysis also underscores the importance of international collaboration, as seen in the country-level network map. Nations like the United Kingdom, China, and India emerge as hubs of research activity, fostering extensive partnerships across regions. European countries, such as Spain and Italy, exhibit strong regional collaborations, while emerging economies like Ethiopia highlight the increasing involvement of developing countries in addressing plastic waste challenges. These findings emphasize the need for continued international cooperation to leverage diverse expertise and resources for sustainable solutions.

3. Integration of Circular Economy Principles

The integration of circular economy principles into plastic management is evident from the clustering of related topics in the bibliometric maps. Concepts like "sustainability," "life cycle," and "waste disposal" are strongly linked to the central theme of the circular economy, reflecting a systemic approach to resource management. This integration is crucial for achieving long-term environmental and economic benefits, as it shifts the focus from linear production and

disposal models to circular systems that emphasize reuse, recycling, and resource recovery. However, the analysis also reveals gaps in the literature. While there is significant research on recycling technologies and waste reduction strategies, there is limited focus on the socioeconomic implications of circular economy practices. Understanding the impact of these practices on communities, industries, and economies is essential for developing equitable and effective solutions. Furthermore, the role of consumer behavior in adopting circular economy practices remains underexplored, despite its importance in driving demand for sustainable products and participation in recycling programs.

4. Emerging Technologies and Innovations

The emergence of topics like "pyrolysis" and "advanced recycling" in the analysis highlights the growing interest in innovative technologies to address plastic waste challenges. Pyrolysis, for instance, offers a promising solution for converting non-recyclable plastics into valuable resources, aligning with circular economy objectives. These technologies, however, require significant investment in research and development, as well as supportive policy frameworks to scale their implementation. In addition to technological advancements, the analysis underscores the need for innovations in product design and material substitution. Designing plastics for recyclability and developing alternatives to traditional plastics, such as biodegradable materials, are critical for reducing plastic waste and improving resource efficiency. These innovations must be accompanied by robust supply chain systems and effective waste collection infrastructure to maximize their impact.

5. Policy Implications and Recommendations

The findings from this study have important policy implications. The clustering of topics related to "municipal solid waste," "waste disposal," and "packaging" suggests a strong focus on regulatory and policy-driven approaches to plastic management. Extended producer responsibility (EPR), for example, is a policy mechanism that encourages manufacturers to design products with end-of-life considerations and take responsibility for their recycling or disposal. Such policies are crucial for promoting circular economy practices and incentivizing sustainable product design. Moreover, international collaborations evident in the network analysis highlight the need for harmonized global policies to address plastic pollution. Developing countries, in particular, require support to build infrastructure and capacity for effective waste management. This can be achieved through knowledge-sharing initiatives, funding mechanisms, and technology transfer programs that enable these nations to adopt circular economy practices.

6. Limitations and Future Directions

While the bibliometric analysis provides valuable insights, it is not without limitations. The reliance on the Scopus database, although comprehensive, may exclude relevant studies indexed in other databases, potentially limiting the scope of the analysis. Additionally, bibliometric methods focus on quantitative measures such as citation counts and co-occurrence frequencies, which may not fully capture the qualitative aspects of research contributions. Future research should address these limitations by incorporating additional databases and employing mixed-method approaches that combine bibliometric analysis with qualitative reviews. There is also a need for longitudinal studies that examine the long-term impacts of circular economy practices on plastic management, as well as comparative analyses across different regions and sectors.

5. CONCLUSION

This study provides a comprehensive bibliometric analysis of research dynamics in the circular economy and plastic

management, shedding light on key trends, collaborations, and emerging themes in this critical field. The findings reveal the growing emphasis on circular economy principles as a sustainable solution to the global plastic waste crisis, with significant research focusing on recycling technologies, waste reduction strategies, and sustainability integration. The analysis highlights the central role of international collaborations and the contributions of leading researchers and institutions in advancing the field. However, gaps remain in addressing socioeconomic impacts, consumer behavior, and the scalability of innovative technologies. By identifying these gaps and providing insights into the evolving research landscape, this study underscores the need for interdisciplinary approaches, global cooperation, and policy support to develop equitable and effective solutions for plastic management within a circular economy framework.

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