CATRA RESEARCH INSTITUTE
ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
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INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
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CIRCULAR ECONOMIC MODEL OF WASTE BANK BASED ON TECHNOLOGICAL INNOVATION: A COMPREHENSIVE BIBLIOMETRIC INSIGHT

Volume: 7
Number: 2
Page: 382 - 394

Article History:
Received: 2026-01-24
Revised: 2026-02-20
Accepted: 2026-03-28

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Abstract:
The circular economy contributes to increasing environmental resilience and the social welfare of society. This analysis aims to identify the development of an effective waste bank circular economy model through technological innovation. The method used is bibliometric analysis with VOSviewer software. The research results show that the main challenges faced are a lack of infrastructure, public awareness, and inadequate regulations in several countries. However, this research also highlights the enormous opportunities offered by circular economy models, such as the creation of new jobs, reduced dependence on non-renewable resources, and increased global competitiveness. The implications of implementing a circular economy model for sustainable development support increased resource utilization efficiency, new job creation, and strengthened economic resilience. The implementation of circular economy models in China, Germany, Australia, and Indonesia demonstrates distinct advantages and challenges. China focuses on recycling with subsidies, but still faces challenges in law enforcement and infrastructure. Germany has succeeded in recycling waste with renewable energy, but focuses more on technological innovation than on social innovation.

Keywords: Circular Economy Model, Technology Innovation, Waste Bank

INTRODUCTION

One economic approach that is beginning to be widely adopted is the circular economy model, which focuses on the principle of sustainable resource management (Palle et al., 2022). This term was first introduced in a relevant and relevant way by British economist Kenneth Boulding in his book, "The Economics of the Coming Spaceship Earth" (1966), which describes the limitations of planet Earth's ability to provide unlimited resources. From an environmental perspective, the circular economy highlights sustainability issues related to resource use, waste management, and emission reduction (Dwiningsih et al., 2022). In this model, consumed products are not simply thrown away but are instead reprocessed through a series of efforts such as reducing, reusing, recycling, replacing, and repairing (Reduce, Reuse, Recycle, Replace, and Repair), which support the sustainability of product lifespans (Purwanti, 2021).

Based on these conditions, waste generation can be minimized, reducing negative impacts on the environment. Used products can be remanufactured into new products or used as raw materials for other products, thereby extending the life cycle of goods and optimizing resource use. The focus on product recycling through the 5Rs can increase resource efficiency, promote active participation from various stakeholders, and build integrated production and consumption patterns (Hidayati et al., 2021). The implementation of a circular economy can contribute to increased environmental resilience and social welfare, reduce the impact of environmental damage, and encourage the creation of new value-added products. Furthermore, a circular economy also supports green economic growth, which aligns with sustainable development goals (Sitinjak, 2024).

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The implications of implementing a circular economy model for sustainable development support increased resource utilization efficiency, new job creation, and strengthened economic resilience. However, challenges such as shifting business paradigms, the need for supporting infrastructure, and the development of appropriate regulations must also be addressed (Sitinjak, 2024). Various potential challenges and obstacles that arise from implementing a circular economy model involve production patterns, consumption patterns, and the role of technological innovation related to waste banks as waste management facilities.

Research by Siregar (2023) states that challenges to implementing a circular economy model in Indonesia are related to limited infrastructure, lack of public awareness and understanding, inadequate regulations, and a business paradigm that needs to be adjusted. Meanwhile, potential opportunities in implementing a circular economy model include new job creation, reduced dependence on non-renewable resources, increased global competitiveness, and green economic growth. Accelerating the implementation of a circular economy model can be achieved through effective waste management. One crucial aspect of waste management is the circular economy, particularly in creating more efficient product cycles and reducing waste ending up in landfills.

In this context, sustainable waste management includes the process of sorting, recycling, and processing organic waste to produce new products, energy, or fertilizer. For example, waste banks in several cities in Indonesia play a crucial role in collecting and managing economically valuable inorganic waste for reprocessing into industrial raw materials. An effective approach to environmentally friendly and efficient waste management involves implementing various strategies and technologies to manage, reduce, and utilize waste generated by human activities. This approach aims to transform waste into valuable resources for both the environment and society. One effective implementation is through Waste Banks, where communities can exchange sorted waste for recyclable materials, thereby generating economic benefits while reducing environmental impacts. Waste Banks not only support waste reduction but also empower communities by providing economic incentives and raising awareness of the importance of sustainable waste management (Desty Febrian & Solihin, 2024).

This article discusses circular economy models implemented in various countries to identify patterns of distribution and development of discussions on the circular economy. This paper is expected to provide findings on circular economic models that are relevant to the concept of waste banks, as well as the effective implementation of technological innovations.

METHODS

Bibliometric analysis was applied in this study. The purpose of bibliometric analysis is to identify the annual distribution of articles based on volume, topic distribution, level of collaboration between authors, authorship patterns, and institutional affiliation patterns. Furthermore, this analysis reveals the written communication process and its development within a scientific discipline. There are several benefits to using bibliometric methods, including their ability to estimate the completeness of secondary literature and identify subjects or fields within a scientific discipline.

The stages of bibliometric analysis are as follows:

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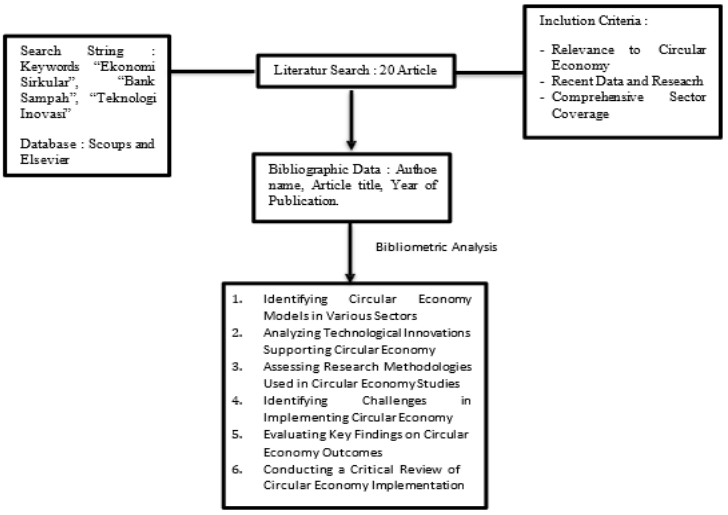
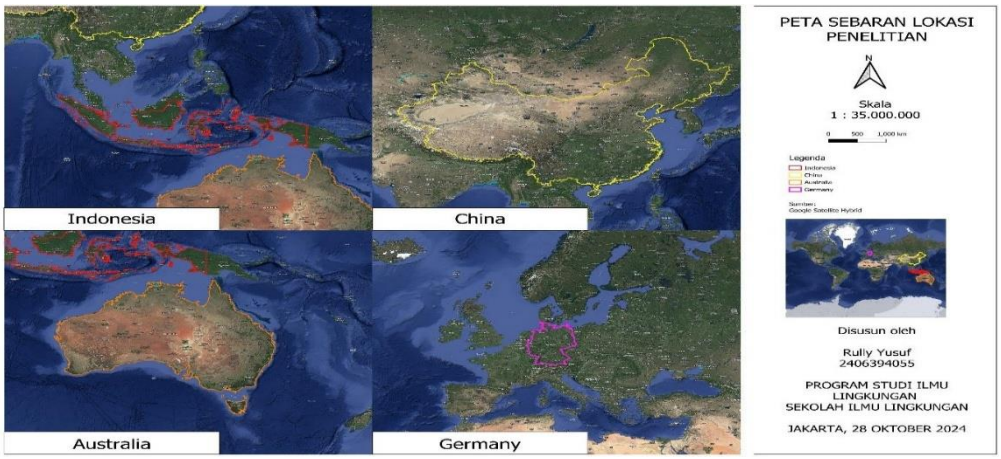


Figure 1. The stages of bibliometric analysis

The first stage was to determine search keywords, which in this study included "Circular Economy," "Waste Bank," and "Technological Innovation." In addition to these keywords, the year of publication of the articles was also considered, with the publication deadline being 2019-2024 in the Scopus database. The second stage was to review the initial search results based on articles within the 2019-2024 time period related to bibliometric data such as citation information, abstracts, keywords, and reference information. The third stage was to filter the search results, tailoring them to the research focus, namely the circular economy model of waste banks based on technological innovation. By using the Scopus database from Elsevier, more recent data is expected to provide a more accurate picture of current trends and challenges. The fourth stage was the process of compiling data that aligns with the related search results and the data clustering process. The data can then be further analyzed using VOSviewer 1.6.20. The fifth stage of bibliometric analysis uses VOSviewer 1.6.20 software to interpret and identify relationships between keywords, journals, articles, countries, and institutions related to a database of 20 articles in CSV format with the keywords "Circular Economy Model, Waste Bank, and Technological Innovation."

This research was conducted in four countries: Indonesia, China, Germany, and Australia.



Source: Created using Google Earth

Figure 2. Research Location

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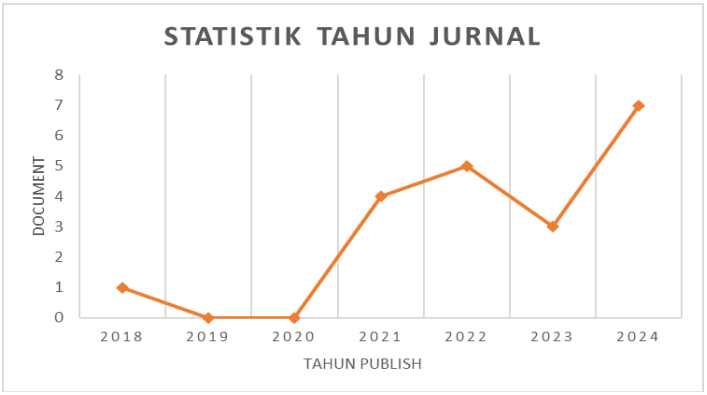
RESULT AND DISCUSSION

Journal Publication Analysis. From 2018 to 2024, articles related to the circular economy model were published, analyzed using tools in the Scopus database based on keyword searches for "Circular Economy Model," "Waste Bank," and "Technological Innovation." The data used in the article were 20 articles representing the implementation of the circular economy model in various countries. The article analysis graph per year shows the development in the number of publications from 2018 to 2024. This graph represents the number of documents published each year and shows a clear trend in publication activity. The graph shows a fluctuating pattern, with a decrease in 2019, followed by a consistent upward trend in the number of publications. The significant spike in 2024 indicates intensive efforts to increase research and publication productivity.

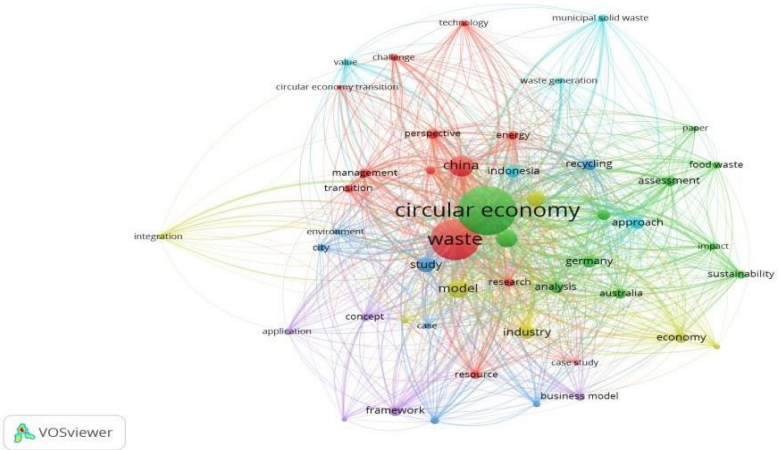


Source: Researcher, 2024

Figure 3. Publication Year

Factors such as institutional support, research collaborations, and regulatory changes may be the main drivers of this pattern. Overall, this trend reflects positive growth in the number of publications during the period under review, although there were some fluctuations in the middle. The surge in 2024 suggests the potential for continued publication growth in the future.

Keyword Relatedness Analysis.



Source: Researcher, 2024

Figure 4. Networking Analysis by VosViewer

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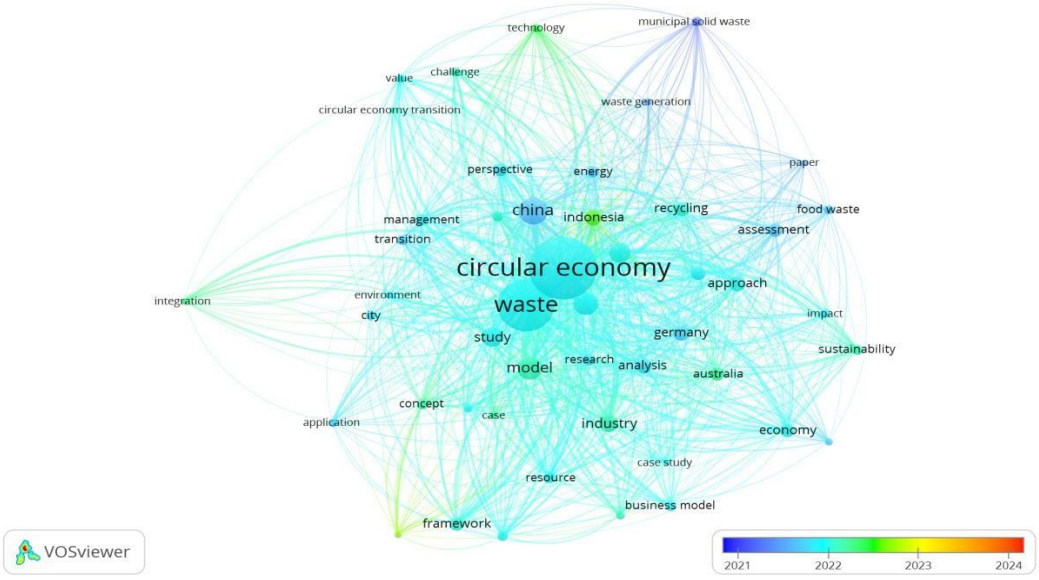
Bibliometric analysis using VosViewer revealed several related keywords between articles, demonstrating a shared meaning. These keywords include "Waste, Circular Economy, Recycling, Food Waste, and Technology," which serve as a strong link. "Waste" is directly related to the main topic of "Circular Economy," with its interconnected perspectives, management, technology, and energy. However, implementation challenges involve various technical, social, economic, and environmental aspects that must be considered simultaneously to achieve sustainability goals (Marsh et al., 2022). It explains that waste, closely related to the circular economy model, is closely linked to discussions of stakeholder perspectives, production management, and technological innovation that support the implementation of the circular economy model. The implementation of the circular economy model aligns with sustainable practices that support technological innovation for resource optimization, waste management, and material recycling (Rabbi et al., 2024). Networking analysis of Indonesian keywords relates to recycling, waste generation, study, and value. It indicates that Indonesia is in the educational stage for waste management and increasing the value of products from waste.

Keyword Recency Analysis.



Source: Researcher, 2024

Figure 5. Overlay Analysis

Based on an overlay analysis of articles on the Circular Economy, the focus of discussion is on the relationship between the circular economy, waste, recycling, and perspective. The discussion of these keywords spans from 2021 to 2022. Analysis related to the development of circular economy models has evolved with keywords such as model, concept, industry, and sustainability. The development of a sustainable circular economy model requires effective governance that is tailored to the context of the activities and resources held by the stakeholders involved (Minoja et al., 2024). Based on the analysis, the discussion of these keywords increased in mid-2022. The circular economy subsequently evolved into a circular economic principle in 2023. Discussion of this principle can be part of addressing implementation challenges, such as the lack of accountability in implementing the circular economy model in industry due to a lack of tax regulations and public awareness, as in Australia (Milios, 2021).

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Analysis of Circular Economy Model Research Articles. This research content analysis focuses on publications related to the circular economy from various countries, with a primary focus on sustainability issues, waste management, and the challenges and opportunities faced in implementing a circular economy in countries such as China, Germany, Australia, and Indonesia. Each article highlights the specific context of its respective country and provides insights into the potential and obstacles faced in achieving sustainability goals through a circular economy approach.

Table 1. Literature analysis content article

No	Title	Authors	Source	Country	Year
1	Barriers tosustainabl- e food consumption and production in China: A fuzzy DEMATEL analysis from a circular economy perspective	Yanping Liu, Venkatesh, Lincoln C. Wood, V.G. Zhang, Farooque	Elsevier, Journal Sustainable Production and Consumption Page 1114 - 1129	China	2021
2	Impact of subsidies on innovations of environmental protection and circular economy in China	Xiaofeng Xu, Tao Wang, Yi Xu, Huanzheng,	Elsevier Journal of Environmental Management	China	2021
3	The affecting factors of circular economy information and its impact on corporate economic sustainability: Evidence from China	Lopin Kuo, Bao-Chang	Elsevier, Journal Sustainable Production and Consumption	China	2021
4	Toward the construction of a circular economy ecocity: An emergy-based sustainability evaluation of Rizhao city in China	Junli Li, Wei Sun, Ruiping Li, Junqing Hao, Huaming,	Elsevier, Journal Sustainable Cities and Society	China	2021
5	The circular economy in China: Achievements, challenges and potential implications for decarbonization	Raimund Bleischwitz, Miying Yang, Beijia Huang, Xiaozhen XU, Jie Zhou, Will McDowall, Philip Andrews- Speed, Zhe Liu, Geng Yong	Elsevier, Journal Resources Conservation and Recycling	China	2022
6	Insight into Plastic Food Packaging Waste Sorting Behavior: A Focus group study among consumers in Germany	Ellen Meilinger, Romana	Elsevier Journal Waste Management	Germany	2024

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7	The Circular Economy and The Bio-Based Sector Perspective of Europe and German Stakeholders	Sina Leipold, Anna Petit	The Journal of Cleaner Production	Germany	2018
8	Challenges and Perspectives of the Circular Economy in the European Union: A Comparative Analysis of the Member States	Francisco Jose Castillo Diaz, Belmonte Urena, Fernando Dianzer Martinez, Luis J.	Elsevier Journal Ecological Economics	Germany	2024
9	Unpacking Pathways to a Circular Economy : A Study of Packaging	Machteld Catharina Simoens	ElSevier Sustainable Production and Consumption	Germany	2024
10	Understanding the effect of market orientation on circular economy practices: The mediating role of closed-loop orientation- in German SMEs	Corinna, Bastian, Cassian, Tessa	Journal Faculty Business and Economics University Dortmund	Germany	2021
11	Circular economy barriers in Australia: How to translate theory into practice?	Jessica, Sarah King, Matthew, Tristan, Helwig, Hannah, Paulomi (Polly)	Elsevier, Journal Sustainable Production and Consumption 45 Page 582-597	Australia	2024
12	Circular Economy: A Sustainable Management Strategy For- Rare Earth Elements Consumption in Australia	Mejame Palle Paul Mejame, Zsuzsa Banhalmi- zakar, Yinghe King,	Elsevier, Journal Current Research in Environmental Sustainability Page 100 -157	Australia	2022
13	Empirical Evidence on Circular Economy Adoption in Australian Small and Medium Enterprises	Ayon, Fabiane Leticia, O'Loughlin, Andrew, Harpeet S. Kandra	Elsevier, Journal of Cleaner Production 467	Australia	2024
14	Full circle: Challenges and prospects for plastic waste management in Australia to achieve a circular economy	Rumana Hossain, Md Tasbirul Islam, Anirban Ghose, Veena Sahajwalla	Elsevier, Journal of Cleaner Production 368	Australia	2022
15	Transformation towards a circular economy in the Australian construction and demolition waste management system	Salman Shooshtarian, Tayyab Maqsood, Savindir Caldera, Tim Ryley	Elsevier, Sustainable Production and Consumption	Australia	2022

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16	A Sustainable Circular Economy Approach for Smart Waste Management System to Achieve Sustainable Development Goals: Case Study in Indonesia	Yun, Kannan Govindan, Agus Setiawan, Rochiyati	Journal Of Cleaner Production	Indonesia	2020
17	Toward a Circular Economy: A System Dynamic Model of Recycling Framework-work for Aseptic Pa-Per Packaging Waste in Indonesia	Tsai Kuo, Ni- Ying, I-Hsuan Hong, Chin- Jung, Reza	Journal Of Cleaner Production	Indonesia	2021
18	Circular Economy and The Hospitality Industry: A Comparison of The Netherlands and Indonesia	Nina Bittner, Thomas B. Long, Nicole Bakker,	Journal Of Cleaner Production	Indonesia	2024
19	Unlocking Synergies Between Waste Management and Climate Change Mitigation to Accelerate Decarbonization Through Circular Economy Digitalization in Indonesia	Tonni K, Abdelkader, Praskash Sarangi, Buntora Pasaribu, Imran Ali, Christina Meidiana, Hui Goh, Dongdong Zhang, Mohd Dzarfan Othman, Faissal	Journal Sustainable Production and Consumption	Indonesia	2024
20	Reverse Logistic Toward a Circular Economy: Consumer Behavioral Intention Toward Polyethylene Terephthalate (PET) Recycling in Indonesia	Yuniar, Siswanto, Iwan Vanany	Case Studies in Chemical and Environmental Engineering	Indonesia	2024

(Source: Scopus Database Analysis)

Based on a literature analysis of 20 articles representing five countries, it was identified that discussions of circular economy models regarding waste management through waste bank practices are more prevalent in Indonesia, while China has implemented circular economy models for sustainability in various sectors that support industry in China.

Table 2. Literature analysis comprising four countries

Aspect	China	Germany	Australia	Indonesia

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Circular Economy Model	The circular economy model in China is implemented through a 3R approach with a focus on recycling and efficient resource utilization, both in the food and industrial sectors, and through government policies supported by subsidies.	Circular economy for retired wind turbines, plastic waste recycling, circular economy for household waste, bio-based CE for resource management	The implementation of a circular economy model is currently in the stage of strengthening commitment and regulations. Special incentives from the government are needed. It will support material efficiency through industrial sectors with production designs that prioritize waste reduction.	The implementation of the Circular Economy Model has a focus on waste reduction, resource reuse, and achieving a more sustainable system.
Technology Innovation	The technological innovations used are technology, processing waste into energy, and renewable energy technology.	waste sorting tools, wind turbine recycling systems, bioplastics, plastic waste, and fossil fuels to bio-based	Limitations of technological innovation in recycling facilities and complex circular economy models	The use of the Internet of Things (IoT) enables more efficient monitoring and management of waste,
Method	The methods used in the five journals include content analysis, Fuzzy DEMATEL, emergy analysis, literature review, expert interviews, and multivariate regression.	Qualitative and participatory, LCA, material flow analysis and secondary data	The methods used in the analysis of the circular economy case model include a systematic literature review and a questionnaire survey method.	The method used is the Case Study Approach, while the dynamic system simulation and survey methods.
Challenge	Challenges in implementing a circular economy in China include a lack of environmental law enforcement and limited infrastructure in rural areas.	lack of models that best contribute to a sustainable economy, infrastructure for processing recycled materials, increased emissions and separation.	Challenges in implementing a circular economy in Australia include: inadequate regulations and policies, a lack of industry priority, and low productivity. recycling rate	The main challenges in implementing a circular economy in Indonesia include a lack of adequate infrastructure, low community participation with consumers, and weak coordination among stakeholders.

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Finding	Key findings indicate that the circular economy has successfully driven increased productivity and resource recycling in China. However, key challenges remain, particularly in terms of law enforcement and reliance on non-renewable resources.	Focusing more on technological models than on social or organizational innovation, optimizing source separation can increase recycling rates from 38% to 50%. Focusing more on the circular economy of biogeochemistry.	Findings from the analyzed articles show that various sectors, such as plastic waste and construction, found that low recycling rates, high costs, non-supportive policies, and inadequate infrastructure were the main obstacles.	Findings from the articles analyzed the use of smart technology to increase efficiency in the role of consumer attitudes in recycling. The use of IoT and ICT has been shown to improve waste management significantly.
Critical Review	A critical review shows that although China's circular economy has shown significant progress, there are still weaknesses in the integration of long-term strategies, decarbonization policies, and local innovation.	The need to define which cycles are more critical to future economic sustainability remains. Challenges remain in achieving higher material recycling targets.	Based on a conditional analysis of the implementation of the circular economy model in Australia, it is still in the initial implementation stage due to regulations that are not yet comprehensive, limited infrastructure and a lack of priority in various industrial sectors.	Based on an analysis of how the circular economy and digitalization can be a long-term solution for waste management in Indonesia.

Based on a literature analysis comprising four countries, differences exist in the implementation of the circular economy model across the four countries analyzed. For example, a comparison between the implementation of the circular economy in Australia still requires strengthening commitment and regulations, as well as building recycling habits at the consumer level. Meanwhile, the implementation of the circular economy model in China demonstrates the success of the circular economy in increasing industrial productivity, supported by effective recycling technology. Cross-sector collaboration and increased attention to domestic technology also need to be strengthened. Training and monitoring programs in waste management can be integrated with technology to support sustainable waste management (Del et al. 2020). This comparison of the implementation of the circular economy model can provide an overview of further development related to its implementation in Indonesia. Currently, Indonesia is still focusing on waste reduction and community education to establish a system that focuses on material reuse. While both have advantages in offering new approaches, challenges faced in policy implementation, infrastructure, and public awareness are barriers that need to be overcome. With the right strategy, collaboration between government, industry, and society will be crucial to achieving a successful transition.

CONCLUSION

A bibliometric analysis of circular economy models and technological innovations used VOSviewer software to map publication trends, collaborations between authors, and topic

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developments across countries. This analysis found that circular economy models are increasingly developing through the use of innovative technologies, particularly in waste management and emissions reduction.

The implementation of circular economy models in China, Germany, Australia, and Indonesia demonstrates distinct advantages and challenges. China focuses on recycling with subsidies, but still faces challenges in law enforcement and infrastructure. Germany has succeeded in recycling waste with renewable energy, but focuses more on technological innovation than on social innovation. Combining various strategies for plastic management still faces challenges with material-efficiency trade-offs. The interconnectedness between circular and bio-based economies needs further exploration for sustainability priorities. Australia is strengthening regulations, but recycling rates and infrastructure remain low. Indonesia is still in its early stages, with infrastructure challenges and low public participation. To adopt best practices, Indonesia needs to improve infrastructure, public education, and intersectoral collaboration to support a more sustainable circular economy transition.

In the context of waste banks, technology plays a crucial role in increasing the efficiency of recycling and waste management. The research findings indicate that the main challenges faced are a lack of infrastructure, public awareness, and inadequate regulations in several countries. These obstacles are exacerbated by a lack of public education and awareness, as well as a reliance on traditional waste management methods. However, the study also highlights the significant opportunities offered by the circular economy model, such as creating new jobs, reducing dependence on non-renewable resources, and increasing global competitiveness.

To support the development of a circular economy through technological innovation-based waste banks in Indonesia, several solutions can be implemented. Integration of waste banks with the recycling industry should be enhanced through digital platforms that connect suppliers and recycling plants, thereby accelerating the recycling process. Public education about sorting and the economic benefits of recycling should be strengthened through campaigns utilizing digital and social media.

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