A Bibliometric Evaluation Based on Web of Science Database for Waste Management Studies within the Framework of Circular Economy

Döngüsel Ekonomi Çerçevesinde Atık Yönetimi Çalışmalarına Yönelik Web of Science Veri Tabanına Dayalı Bibliyometrik Bir Değerlendirme

İlay TİLKİ TOMAY[1]

Abstract

Purpose: This study aims to reveal the general overview and trends of the international scientific literature in the fields of circular economy and waste management.

Design/Methodology: In the study, 1095 articles retrieved from the Web of Science database were examined using bibliometric analysis based on the PRISMA method. VOSviewer and Microsoft Excel programs were utilized for the analysis of the obtained data.

Findings: The analysis findings reveal that academic interest in the subject has increased over the years and that the studies have been published in high-impact journals. According to the keyword analysis, the most frequently encountered terms in the literature are (1) circular economy, (2) waste management, (3) recycling, (4) sustainability, and (5) life cycle assessment. Another result of the study shows that, in country-based evaluations, the United Kingdom holds a leading position in terms of both the number of publications and citations.

Limitations: The study is limited to articles that are indexed in the Web of Science database, published in English, and released between the years 2014 and 2024.

Originality/Value: It has been determined that bibliometric studies focusing on the circular economy and waste management literature are relatively limited. This study was conducted on a relatively large sample, covering the years 2014–2024 and analyzing 1095 articles. Therefore, the study holds potential for presenting an overall picture of the relevant literature and is expected to contribute to the academic field.

Keywords: Circular Economy, Waste Management, Bibliometrics, PRISMA Method, VOSviewer

Öz

Amaç: Bu çalışma, döngüsel ekonomi ve atık yönetimi alanındaki bilimsel literatürün genel görünümünü ve eğilimlerini ortaya koymayı amaçlamaktadır.

Tasarım/Yöntem: Araştırmada PRISMA yöntemi kullanılarak Web of Science veri tabanında taranan 1095 makale bibliyometrik analiz yöntemi ile incelenmiştir. Elde edilen verilerin analizinde VOSviewer ve Microsoft Excel programlarından yararlanılmıştır.

Bulgular: Analiz bulguları, konuya yönelik akademik ilginin yıllar içinde artış gösterdiğini ve çalışmaların yüksek etkili dergilerde yayımlandığını ortaya koymaktadır. Anahtar kelime analizine göre literatürde en sık karşılaşılan terimlerin (1) circular economy, (2) waste management, (3) recycling, (4) sustainability ve (5) life cycle assessment olduğu belirlenmiştir. Çalışmanın bir başka sonucuna göre ise ülke bazlı değerlendirmelerde hem yayın sayısı hem de atıf sayısı açısından İngiltere'nin lider konumda yer aldığı görülmüştür.

Sınırlılıklar: Çalışmada yalnızca Web of Science veri tabanında yer alan, yayın dili İngilizce olan ve 2014-2024 yılları arasında yayınlanan makalelerin ele alınması çalışmanın sınırlılıklarını oluşturmaktadır.

Özgünlük/Değer: Döngüsel ekonomi ve atık yönetimi literatürüne yönelik bibliyometrik inceleme çalışmalarının oldukça sınırlı olduğu tespit edilmiştir. Bu çalışma, 2014-2024 yıllarını kapsayan ve 1095 makalenin incelendiği oldukça geniş bir örneklem üzerinden gerçekleştirilmiştir. Dolayısıyla çalışma, ilgili literatüre yönelik genel durumu ortaya koymak açısından potansiyel taşımakta ve literatüre katkı sunması beklenmektedir.

Anahtar Kelimeler: Döngüsel Ekonomi, Atık Yönetimi, Bibliyometri, PRISMA Yöntemi, VOSviewer

---

[1]Arş. Gör., Muğla Sıtkı Koçman Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, Uluslararası Ticaret ve Finansman, ilaytilki@mu.edu.tr, ORCID: 0000-0002-7289-3755

1. INTRODUCTION

The increasing negative impacts of human activities have accelerated the depletion of natural ecosystems, resulting in persistent global environmental problems. Damage to natural resources and ineffective waste management have become central issues in achieving sustainability targets required for long-term development goals. High levels of waste generated from industrial processes highlight the need for a critical assessment of environmental sustainability requirements. Therefore, there is a growing need to transition to a novel approach capable of ensuring the sustainable use of high-impact natural resources. The conventional economic model, based on a take–make–dispose structure, does not offer adequate solutions to sustainability challenges (Michelini et al., 2017, p. 2). These limitations create the rationale for integrating circular economy principles with waste management strategies.

The concept of the circular economy represents an alternative economic model that emphasizes the reduction of waste and pollution throughout production and consumption cycles. It aims to promote the long-term use of materials and resources while protecting the ecosystems in which these processes occur (Upadhayay et al., 2024, p. 1). Waste management is a vital component of environmental sustainability, and as an integral part of the circular economy, it requires reintegrating waste materials into the system rather than disposing of them. Approaches such as recycling and reuse, instead of disposal, demonstrate the increasing necessity of combining circular economy and waste management principles. This growing need has led numerous studies to examine the potential benefits of integrating both approaches to support environmental sustainability.

The primary purpose of this study is to investigate existing literature on circular economy and waste management within the Web of Science database. The study employs the PRISMA methodology to define inclusion and exclusion criteria, ensuring transparency in the data selection process. The dataset consists of 1,095 academic articles related to the field.

Within the scope of this research, international literature on circular economy and waste management is systematically examined using bibliometric analysis. The study comprehensively evaluates prevailing trends in the literature, identifies key academic contributors, analyzes the distribution of research areas, and explores potential future research directions. By doing so, the study aims to contribute to academic knowledge in the field and provide meaningful implications for the development of circular economy and waste management processes.

2. CONCEPTUAL FRAMEWORK

2.1. Circular Economy

According to the definition of the Ellen MacArthur Foundation, the concept of circular economy is defined as "an economic model that eliminates waste and pollution from the design of the product, keeps products and materials in use, and renews natural systems" (Ellen MacArthur Foundation, 2013: 7). According to the definition of the European Commission (2015: 2), circular economy is defined as "an economy that aims to preserve the value of products, materials and resources (water, energy, etc.) in the economy for as long as possible and to minimize waste generation". According to the definition of the United Nations Environment Programme, circular economy is defined as "a model that promotes sustainable economic growth through the efficient use of resources, reducing waste and minimizing environmental impacts throughout the life cycle of products" (UNEP, 2017).

The concept of circular economy offers an alternative approach to the inadequacy of the take-make-use-dispose approach of the so-called linear economy. The basic understanding of the circular economic model is based on increasing the value of scarce resources, utilizing waste from production and consumption processes, and using renewable energy sources (Didenko et al., 2018: 1). At this point, circular economy is an economic system that opposes the term "end-of-life" and adopts the reduction, reuse, recycling and recovery of materials used in production and consumption stages (Kirchherr et al., 2017: 229). Therefore, while products in a linear economy finish their life cycle as waste, a circular economy aims to reintroduce those products to the natural environment. Based on this idea, three core principles have been introduced to clarify the concept of circular economy. These principles, known as 3Rs, consist of the initials of the English words Reduce, Reuse and Recycle, and are listed as reduction, reuse and recycling. Reduction aims to minimize resource consumption and waste generation. Reuse

encourages the continued use of products and materials by prolonging their lifespan. Recycling ensures the circulation of resources by transforming waste into new products (Ghisellini et al., 2016: 11-30). The principles of the 3Rs are one of the fundamentals of sustainability efforts and play an important role in waste management. In line with these principles, the concept of circular economy has become increasingly important in recent years. Circular economy is regarded as a practical and reliable approach by academics and policymakers to effectively implement waste management, increase resource efficiency, and overcome global sustainability challenges (Sohal & De Vass, 2022: 595). In this context, adopting the 3R principles and implementing circular economy practices are among the key elements of building a sustainable future.

2.2. Waste Management

Wastes are categorized according to certain criteria such as source, physical structure, or chemical content. Generally, wastes are classified as solid wastes, liquid wastes, gas wastes, and packaging wastes. According to traditional definitions, solid waste refers to substances originating from domestic, commercial, or industrial activities that are no longer needed by their owners and must be disposed of regularly to prevent adverse effects on human health and the environment. Wastes are defined as materials that lose their financial value for individuals by losing their functionality after the use of raw materials, fuel and water (Gündüzalp & Güven, 2016: 2). Although waste and waste generation have existed since the earliest periods of human history, it has become more complex over time due to rapid population growth, industrialization, increased consumption activities and demand, and limited resources. This situation has revealed the increasing importance of waste management. The concept of waste management is traditionally defined as a system that covers the process from generation to disposal of waste (O'leary et al. 2002: 3). In this traditional model, wastes are collected, transported, processed and disposed of. However, the disposal of wastes without employing methods such as recycling and recovery results in significant losses of valuable resources. Therefore, today, the waste hierarchy model has gained prominence over the traditional model (UNEP, 2019). The items in this hierarchy are listed as prevention, reduction, reuse, recycling, recovery and disposal (Ali et al., 2021: 9; Geyer et al., 2017; Gharfalkar et al., 2015: 307-308; UNEP, 2019):

- Prevention: The prevention stage, which is the first stage in the hierarchy, includes activities to prevent waste generation before waste is generated. For example, it refers to the reduction of material use in production processes, efficient design processes and the acquisition of sustainable consumption habits.
- Minimization: In cases where waste generation is inevitable, the amount of waste should be minimized.
- Reuse: It means using waste materials again for the same or another purpose without any processing.
- Recycling: Refers to the processing of wastes and their re-inclusion in production processes.
- Energy Recovery: In cases where recycling is not possible, it refers to the way of energy production from waste. At this stage, waste is processed to produce waste-derived fuel and biogas.
- Disposal: The final stage in the hierarchy, final disposal, involves the safe disposal of waste that can no longer be recycled or utilized through energy recovery.

As seen in the waste management hierarchy, waste management is a comprehensive process that does not only consist of the disposal of wastes, but also aims to increase resource efficiency and minimize negative environmental impacts. Considering the rapidly increasing population and consumption habits, the adoption of an integrated waste management system under the responsibility of all stakeholders, from individuals to policymakers, is a serious necessity both environmentally and economically.

3. LITERATURE REVIEW

The concepts of circular economy and waste management are becoming increasingly important in terms of achieving sustainable development goals. The limitation of natural resources, the rapid increase in the amount of waste in the world and the negative reflections of environmental problems on human life have made these issues a priority area for many stakeholders such as governments, industries

and researchers. In this context, academic studies on circular economy and waste management issues are of great importance in order to develop solution proposals in terms of both theory and practice. Below is a review of the relevant literature.

Tsai et al. (2020) conducted a bibliometric analysis of municipal solid waste management in circular economy. The study utilized 413 published articles to make inferences. The study reveals that apart from the conventional bibliometric analysis methods adopted, the use of the entropy weight approach to better enhance the key findings to establish new areas for further studies. The study further identified five indicators, such as solid waste segregation, plastic waste, incineration, sustainability, and life cycle assessment. The study's focus region was diverse, showing fewer studies existed in North America and Africa, respectively, based on the articles reviewed.

A total of 962 articles were examined by Ranjbari et al. (2021) over a period of 19 (2001-2020) years. The origin of these articles was the database of Web Science which also used the bibliometric analysis approach. Among these studies, seven major themes focused on waste management in relation to circular economy. These major themes include electronic waste, plastic waste, bio-based waste management, municipal waste, environmental impacts and life cycle assessment, circular economic transition, and the management of construction and demolition waste.

A systematic literature review coupled with bibliometric analysis was carried out by Boloy et al. (2021) using the PRISMA approach. The authors focused their ten article reviews on waste conversion to energy technologies in the circular economy. The study further revealed that the most used keywords are "municipal solid waste, incineration, combustion, waste management, gasification, anaerobic digestion, waste-energy, landfill gas, and sustainability".

According to Singh et al. (2021), who adopted the use of bibliometric analysis of literature articles for a period of 12 years, spanning from 2008 to 2020, with the main focus on e-waste concepts and circular economy. They analysed 326 articles from the Scopus database, and the studies focused on numerous factors such as reviews based on year and type of journal, the most cited works, the renowned authors in the area of circular economy, and the keywords used for the analysis. The study further showed that the major words connected to themes used were sustainability, e-waste, recycling, and reuse.

Negrete-Cardoso et al. (2022) adopted the use of descriptive statistics using over 416 articles that were published from 2007 to 2020. The key focus areas were circular economy and waste management using a bibliometric approach. The study further shows that leaders in these areas were countries like Spain, Italy, Brazil, India, and China. These countries have made up a 96 percent increase in annual scientific contributions over the past few years. Five research thematic areas were identified, which include circular economy, waste management and recycling, life cycle, waste processing, greenhouse gases, and anaerobic digestion and recovery.

González-Sánchez et al. (2023) evaluated the role of circularity in waste management in achieving the 2030 Agenda through bibliometric analysis using VOSviewer and SciMat software. According to the results of the study, sustainability, recycling, waste management and reuse were among the most used keywords in the literature. According to another result of the study, European countries (especially Germany and the Netherlands) are in a leading position in the implementation and development of circular economy policies and practices, while in developing countries, significant gaps in circular economy and waste management practices have been identified.

In their study, Reis et al. (2023) examined the studies published on solid waste management and circular economy between 2012 and 2022 with the data obtained from Scopus and Web of Science (WoS) databases by bibliometric analysis method. As a result of the study, the indicators that will facilitate the evaluation of solid waste management are determined as the volume of material collected, operating costs and recycling rates. According to the authors, another important result is that solid waste management and circular economy practices should be integrated with blockchain technology to reduce the level of waste generation.

Akomea-Frimpong et al. (2024) aimed to examine the barriers to the implementation of a circular economy in the context of solid waste management. In the study, 1709 articles obtained from

the Scopus database were analyzed. As a result of the study, China, the USA, Australia, Italy and the United Kingdom are the leading countries in funding research in this area. The most frequently used keywords in the literature are sustainability, reuse, waste management and recycling.

4. RESEARCH METHODOLOGY

### 4.1. Purpose of the Study and Research Questions

The main aim of this study is to comprehensively examine the international literature on circular economy and waste management and to present an overview of the literature. The sub-objectives of the study are to determine the trend of interest in the literature, to reveal in which research areas the subject stands out, to identify the effective actors within the scope of the subject, to reveal international collaborations on the basis of authors, institutions and countries, and to carry out a detailed examination of other bibliometric indicators. The research questions that emerged in line with these objectives are as follows:

- What is the distribution of the number of publications by years?
- What is the distribution of publications according to the journals in which they are published the most?
- What is the distribution of publications according to their indexes?
- What is the distribution of publications according to WoS categories?
- What are the most frequent keywords and what is the network map of common keywords?
- Which are the most cited papers, authors and countries?
- What is the distribution of the number of citations by year?
- Which organizations and countries publish the most?
- Which authors, institutions and countries have the most co-publications and what are their network maps?

4.2 Determination of the Data Set of the Study

The data set used in the study was obtained from the Web of Science database on 05.12.2024. The data set of the study consists of 1095 articles in which the words "circular economy" and "waste management" are mentioned together in the topic search criteria in the Web of Science database, the language of publication is English and published in the fields of social sciences and environmental sciences between 2014-2024. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram was used to select and systematically review the data sourced from the WoS database. A detailed presentation of the study sample and the inclusion criteria for the publications is provided in the PRISMA flow diagram displayed below.

Figure 1: PRISMA Flow Diagram
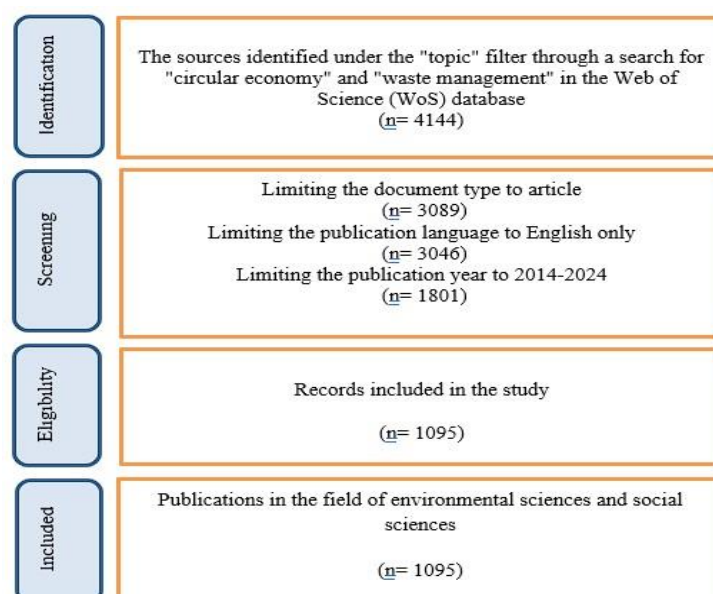
4.3. Method of Analysis

In this study, the bibliometric analysis method, one of the quantitative research methods, was used. Bibliometric analysis is a popular and widespread method that is particularly suitable for researching and analyzing large volumes of scientific data (Donthu et al., 2021: 285). In this context, the analysis of the data obtained from the WoS database was carried out using Excel and VOSviewer 1.6.20 programmes. VOSviewer software allows visualizing and clustering the frequency of co-occurrence of various elements such as words, authors, institutions and countries with network maps and is frequently preferred especially in bibliometric analysis studies (Van Eck & Waltman, 2010: 524).

5. FINDINGS

Figure 2: The most frequently used keywords in publications
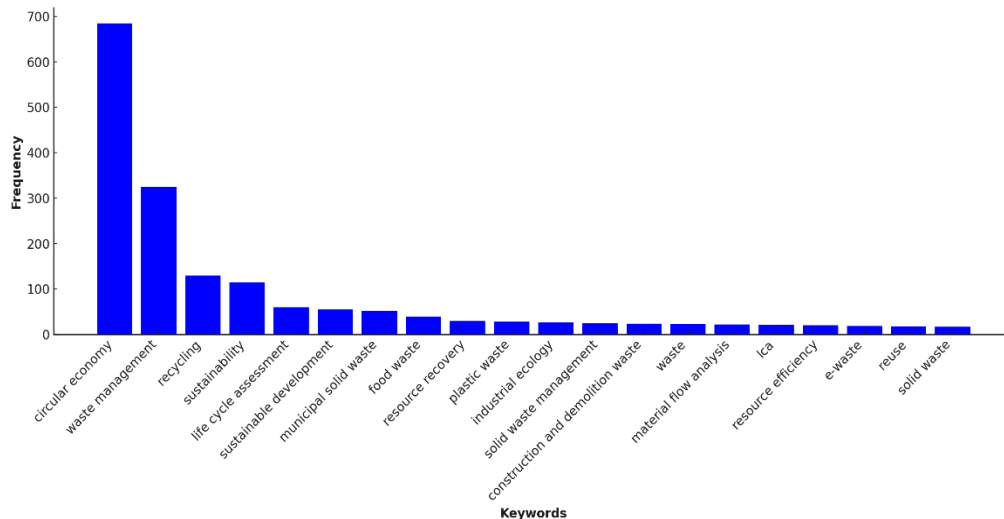

The graph shows the 20 most frequently used keywords in scientific articles in circular economy and waste management literature. Accordingly, the 5 most recurring keywords in the studies are (1) circular economy, (2) waste management, (3) recycling, (4) sustainability, and (5) life cycle assessment.

Figure 3: Keyword Co-occurrence Network Map
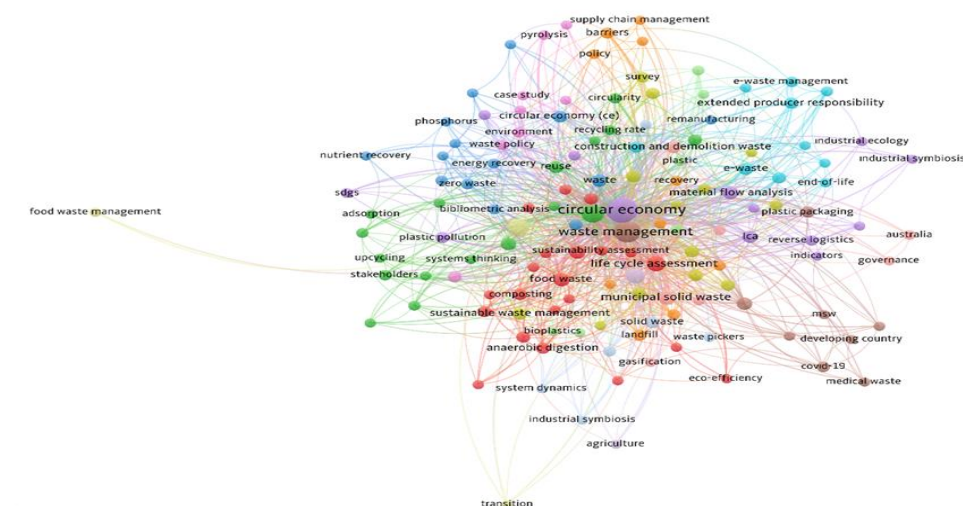
The map shows the diversity of the literature and key research concepts. Accordingly, circular economy, waste management and recycling are in a central position as expected. Upon reviewing the strong links in the map, it is seen that concepts such as sustainability, waste-to-energy and life cycle assessment show a high level of strong links. Apart from this, smaller nodes such as "nutrient recovery", "industrial symbiosis", "separate collection", "eco-efficiency", and "developing country" indicate relatively less studied areas and are considered to be potential study areas for researchers in the future.

Figure 4: Distribution of publications by the journals in which they were published
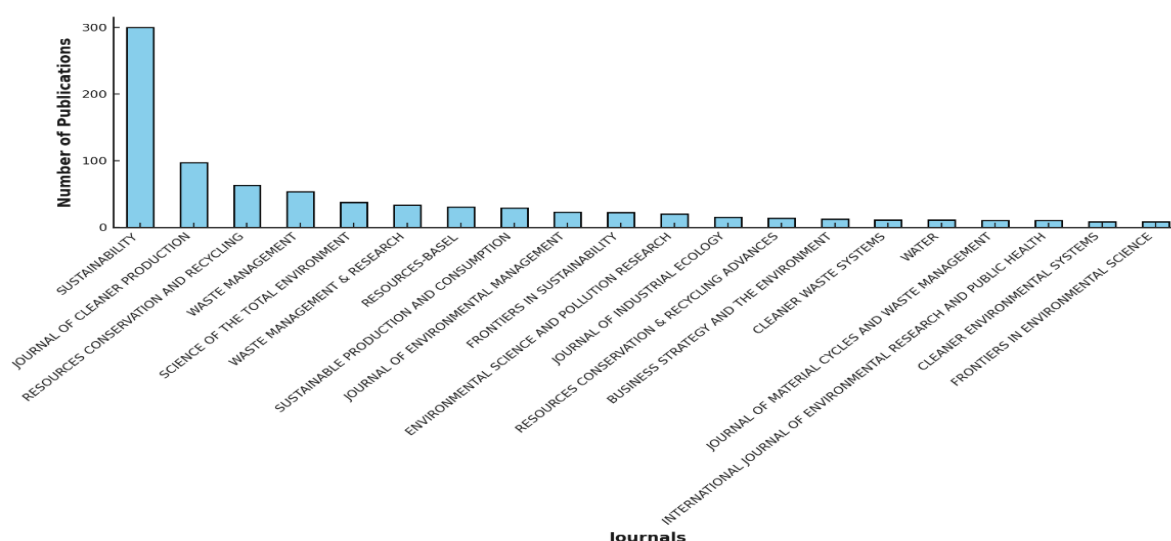
Articles in the related field were published in a total of 176 different journals. This graph shows the top 20 journals with the most publications. The first journal with the highest number of publications is Sustainability with 300 publications (32.85%). It is followed by the Journal of Cleaner Production with 97 publications (10.62%) and Resources Conservation and Recycling with 64 publications (7%). These journals are well-recognized in the field, particularly in topics such as environment, sustainability, resource efficiency, and waste management. Therefore, it can be said that numerous publications concentrate on these journals.

Table 1: Distribution of Publications According to Indexes of Journals

| Index	Number of Publications	Percentage (%)
Science Citation Index Expanded (SCI-EXPANDED); Social Science Citation Index (SSCI)	439	40.09
Science Citation Index Expanded (SCI-EXPANDED)	375	34.25
Emerging Sources Citation Index (ESCI)	218	19.91
Social Science Citation Index (SSCI)	59	5.39
Other	4	0.37

The analysis of the table reveals that the highest indexed rates belong to SCI-EXPANDED and SSCI. Notably, a significant portion of the journals (40.09%) are included in both the SCI EXPANDED and SSCI indexes. Furthermore, the table shows that an impressive 94% of the journals are indexed in SCI EXPANDED, SSCI, and ESCI. In this case, it can be said that the relevant literature is predominantly published in high-level indexes and the quality and academic impact of the publications related to the literature is strong.

Table 2: Distribution of publications according to Wos categories

Category	Number of Publications	Percentage (%)
Environmental Sciences	414	37.81
Green & Sustainable Science & Technology	238	21.74
Environmental Studies	192	17.53
Engineering, Environment	140	12.79
Governance	21	1.92
Economy	18	1.64
Business	17	1.55
Public, Environment & Occupational Health	6	0.55
Water Resources	6	0.55
Urban Studies	5	0.46
Other	38	3.47

Table 2 shows the distribution of publications according to WoS categories. When this distribution is analyzed, it is seen that 37.81% (414 publications) of the articles on circular economy and waste management are in the "Environmental Sciences" category. This was followed by the "Green & Sustainable Science & Technology" category with 21.74% (238 publications). It is followed by the category of "Environmental Studies" with a rate of 17.53% (192 publications). Apart from these categories, publications were also made in many other categories such as engineering, management, economics and business. However, the number of publications in these categories is relatively less compared to the first three categories. At this point, it can be stated that increasing the number of studies on categories with few publications will contribute to both the enrichment of the literature and the development of interdisciplinary approaches to circular economy and waste management.

Figure 5: Distribution of Publication Numbers by Years
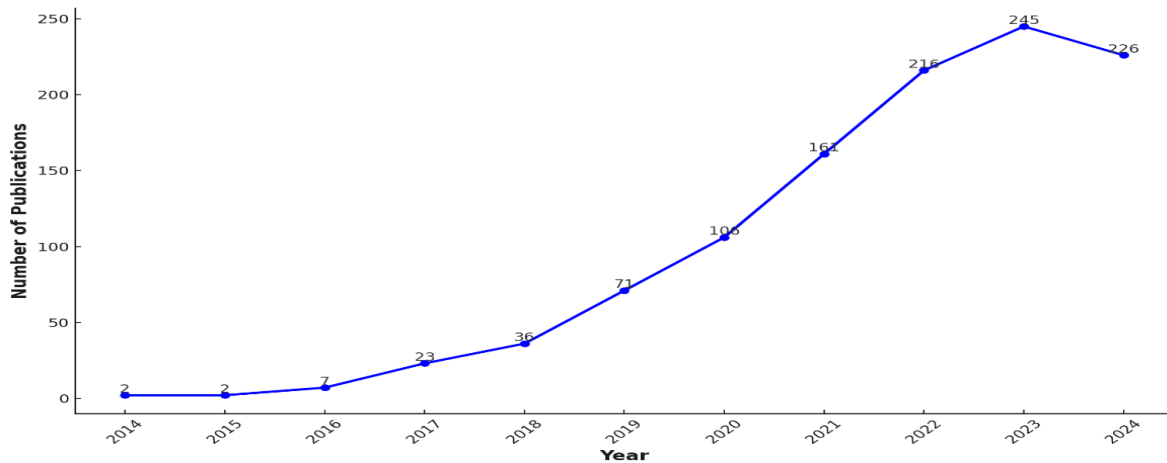
An analysis of the number of publications in the related field reveals that 2014 had the lowest number of publications, with only 2, while 2023 recorded the highest number of publications at 245. Analyzing the yearly changes in publication numbers indicates a consistent increasing trend since 2014. Therefore, this indicates a growing interest in the subject over the years. Furthermore, since the data collection for this study occurred before the end of 2024, the observed decline in the last year may be attributed to this timing.

Table 3: Countries with the Most Publications

No	Country	Number of Publications	Percentage (%)	No	Country	Number of Publications	Percentage (%)
1	United Kingdom	95	8.67	16	Romania	19	1.73
2	Italy	83	7.57	17	Canada	18	1.64
3	Spain	74	6.75	18	Scotland	18	1.64
4	Germany	50	4.56	19	Norway	16	1.46
5	People's Republic of China	49	4.47	20	Portugal	16	1.46
6	Poland	43	3.92	21	Malaysia	15	1.37
7	USA	40	3.65	22	Switzerland	15	1.37
8	Netherlands	35	3.19	23	Austria	14	1.28
9	Australia	33	3.01	24	South Africa	13	1.19
10	Denmark	28	2.55	25	Finland	13	1.19
11	India	27	2.46	26	Chile	12	1.09
12	Brazil	27	2.46	27	Taiwan	12	1.09
13	Sweden	26	2.37	28	Indonesia	12	1.09
14	France	21	1.92	29	Saudi Arabia	12	1.09
15	Belgium	19	1.73	30	Greece	11	1.0

A total of 109 different countries have published on circular economy and waste management. In this table, the top 30 countries with the highest number of publications are given. Accordingly, it is seen that 8.67% (95 publications) of the total publications were made by the UK and it stands out as the

country with the highest number of publications. The UK is followed by Italy with 7.57 percent (83 publications) and Spain with 6.75 percent (74 publications). It can be said that the fact that the UK ranks first showcases its responsibility and leadership in environmental issues such as circular economy and waste management as a developed country. Additionally, the UK's leading position in the number of publications can be associated with its strong research infrastructure, comprehensive state-sponsored funding programmes, and international cooperation (Thelwall et al., 2022).

Table 4: Publications with the Most Citations

No	Article Title	Author(s)	Citation Count	Journal Name
1	The circular economy: New or Refurbished as CE 3.0? - Exploring Controversies in the Conceptualisation of the Circular Economy through a Focus on History and Resource Value Retention Options	Reike et al. (2018)	809	Resources Conservation and Recycling
2	Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy	De Jesus and Mendonça (2018)	591	Ecological Economics
3	Construction and demolition waste management in China through the 3R principle	Huang et al. (2018)	585	Resources Conservation and Recycling
4	Construction and demolition waste best management practice in Europe	Galvez-Martos et al. (2018)	448	Resources Conservation and Recycling
5	Circular Economy Policies in China and Europe	Mcdowall et al. (2017)	395	Journal of Industrial Ecology

The table shows the top 5 most cited articles on circular economy and waste management. Based on the information contained in the Table, Reike et al.'s (2018) article had the most citations with a figure of 809. The findings focused on the evolution of the circular economy, and their in-depth analysis discovered three different stages. The stages consist of Circular Economy with 1) Concentration on waste management, 2) with a focus on Eco-efficiency strategies that combine both inputs and outputs, and 3) to maximize resource value and implement sustainable system changes.

De Jesus and Mendonça (2018) are also reported to have been cited 591 times. The attention of these authors was on the factors that affect transitioning to a circular economy, as there are both supporting and hindering factors that play major roles. The studies also identified the significance of eco-innovation initiatives with an impact on the transition to circular economy.

Huang et al. (2018) were ranked third with the most citations. The authors analysed the construction management and damages of waste in Asia's China. They further explore how circular economy implementation relates to construction management and damage of waste using the 3R principles.

The findings from the table reveal that waste management and circular economy are the two most cited articles due to their significant impact on the existing literature. There is a robust opinion by scholars in terms of practical applications, theoretical framework, and innovation process due to the number of existing citations on waste management and circular economy.

Table 5: Authors with the Most Citations

| No	Author	Total Citation	Number of Publications
1	Yong, Geng	1018	5
2	Bleischwitz, Raimund	986	3
3	Huang, Beijia	980	2
4	Vermeulen, Walter J. V.	821	2
5	Reike, Denise	809	1
6	Witjes, Sjors	809	1
7	Azapagic, Adisa	757	6
8	Styles, David	680	6
9	De Jesus, Ana	591	1
10	Mendonça, Sandro	591	1

Table 5 shows the most cited authors in this field, with Prof Yong Geng being ranked first with over 1018 citations and 5 publications. As a leading expert in the field of climate change, sustainable development, industrial ecology, and circular economy, his publications on the transition towards circular economy in China are among the most recognised on the subject. The scholar has contributed to policies in terms of sustainable development in his home country. Credit to his name with over 170 publications in reputable journals globally and recognised by Google Scholar to have garnered about 49,007 citations with a high index of 104. Prof. Dr. Raimund Bleischwitz is ranked second with 986 citations from 3 publications. He is a well-known economist in Germany and also a director in a research centre based in the city of Bremen called the Leibniz Centre for Tropical Marine Research (ZMT). He is a specialist in environmental and resource economics with an interest in research areas like governance on natural resources, blue economy, and circular economy (Leibniz Tropical Marine Research Centre, 2024). He had published more than 300 publications to his name, with 10,022 citations on Google Scholar and a high index of 49.

Table 6: Countries with the Highest Number of Citations

No	Country	Citation Count	No	Country	Citation Count
1	United Kingdom	6737	11	Sweden	1198
2	People's Republic of China	3811	12	France	1123
3	Netherlands	2677	13	Portugal	978
4	Spain	2583	14	Ireland	931
5	Italy	2547	15	Taiwan	871
6	Germany	2384	16	Poland	828
7	USA	1949	17	Finland	791
8	Australia	1711	18	Malaysia	776
9	Denmark	1537	19	Brazil	756
10	India	1481	20	Norway	743

The table lists the 20 countries with the highest number of citations in the international literature. The United Kingdom tops the list with 6,737 citations. Second to them is the People's Republic of China with 3,811, followed by the Netherlands with 2,677, while the least cited country is Norway with 743 citations. One of the advantages of the United Kingdom, being ranked first in the citation counts, is the existence of reputable universities such as Cambridge and Oxford. These institutions produce high-level and influential academic studies. Furthermore, the UK has a large number of highly influential researchers around the world. These researchers contribute to the production of highly cited studies by playing an active role in international collaborations and academic studies. Therefore, this indicates that the strong positions of countries like the UK, China, and the Netherlands may be due to their dedication to academic research, the number of publications, and the quality of those publications.

Figure 6: Distribution of Citation Numbers by Years
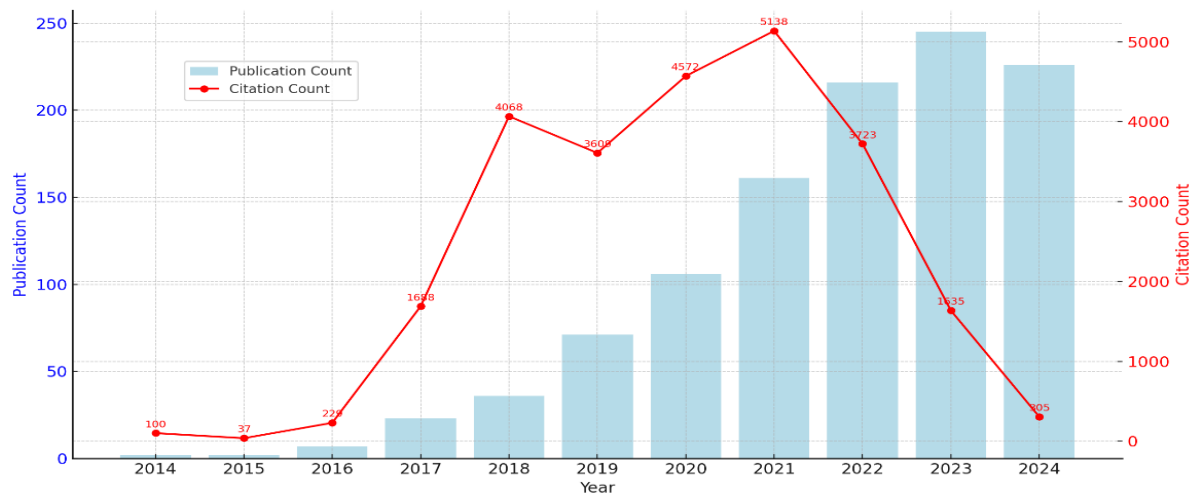
When the graph above is examined, it is seen that the least number of citations to the publications on the subject was made in 2015 with 37 citations, and the most citations were made in 2021 with 5138 citations. When the trend of the number of citations by year is analyzed, it is seen that although there

was a small decrease in 2019, the number of citations generally showed an increasing trend between 2015 and 2021. Since 2021, there has been a downward trend in the number of citations. This decline may be linked to factors such as increasing saturation in the research field or a tendency among authors to cite earlier foundational studies.

Figure 7: Cross-Country Coauthorship Network Map
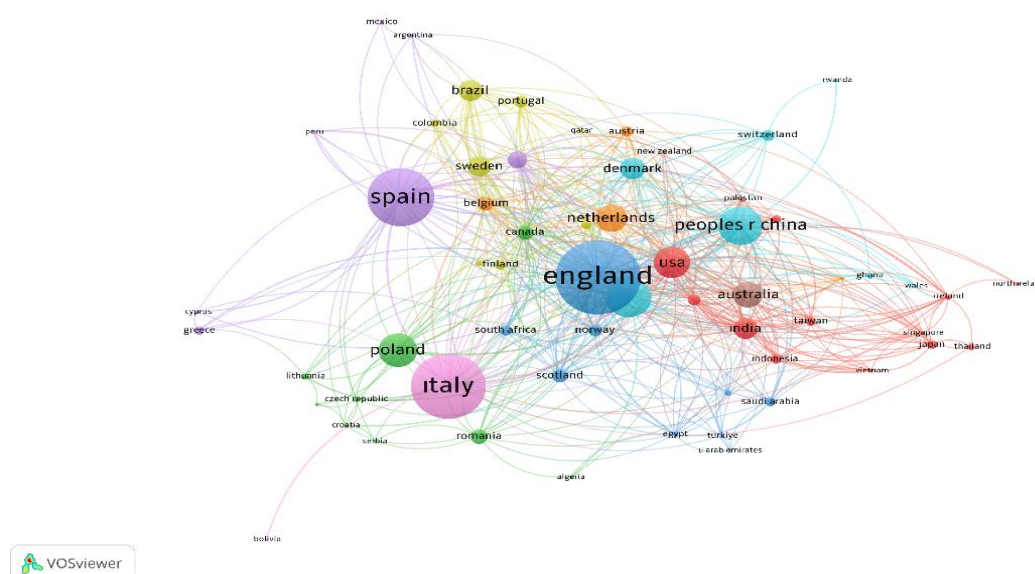
The cross-country network analysis presented above shows the co-authorship that takes place between countries. It is determined that there is a high level of co-authorship between countries such as Italy, Spain, China, Poland, the Netherlands and Denmark, especially the United Kingdom. The United Kingdom is the prime in terms of international collaboration based on pieces of literature and the illustrations of the map (Thelwall et al., 2022). The geographical locations of these countries play a huge part in the relationships between them. There is a linkage between European countries as illustrated in the map, which further depicts a huge impact on the co-authorship relationships with their neighboring countries, that is, Italy and Spain or Denmark, and the Netherlands. China and the United States, which are geographically far distance from each other, also play significant roles. This highlights that these two countries also have a high level of productivity in terms of academic degrees, as well as the maintenance of international relations. Thus, the relationship between countries and co-authors could be strongly influenced by economic conditions, academic development levels, and geographical location.

Table 7: Most Productive Institutions

No	Institution	Number of Publications
1	Delft University of Technology	18
2	European Commission	17
3	Technical University of Denmark	17
4	Coventry University	15
5	Royal Institute of Technology	14
6	University College London (UCL)	14
7	University of Leeds	12
8	Bucharest University of Economic Studies	11
9	Sapienza University of Rome	11
10	University of Manchester	11

Upon reviewing the institutions that have the highest number of publications in the relevant field, the Delft University of Technology is at the top with a total of 18 publications. The European Commission and the Technical University of Denmark come second, each with 17 publications. These institutions are known for their strong academic competencies as well as their established international research networks in fields like engineering, environmental sciences, and technology.

Figure 8: Inter-Institutional Co-Authoring Network Map
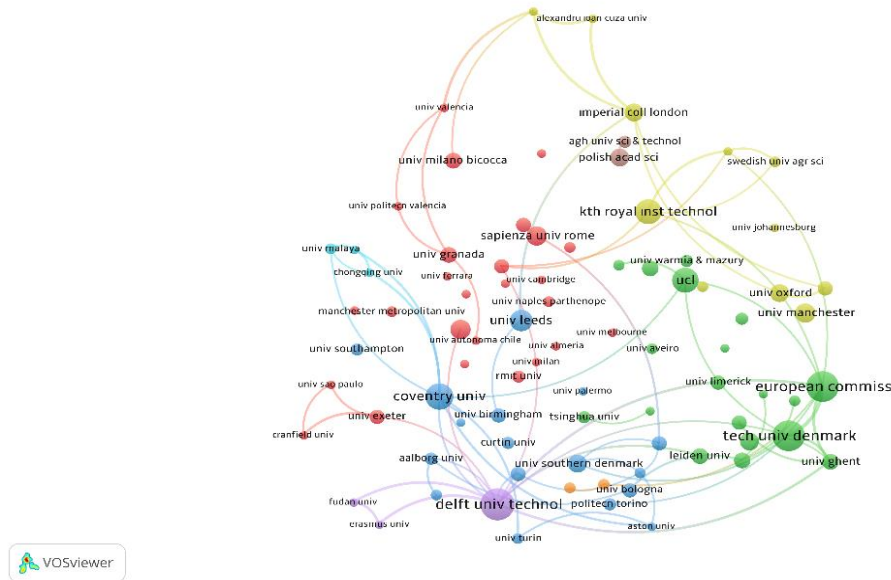
The map shown above illustrates the analysis of academic collaborations among different institutions. It depicts that reputable institutions, including the European Commission, Delft University of Technology, the Royal Institute of Technology and the Technical University of Denmark, have robust relationships that present a high degree of importance to this network. The maps identified a firm collaboration between the individual institutions involved based on the output produced. These institutions include the University College London, the Technical University of Denmark, and the European Commission. Furthermore, closely cooperating are Imperial College London and that of the Royal Institute of Technology.

Figure 9: Co-authorship Map Among Authors
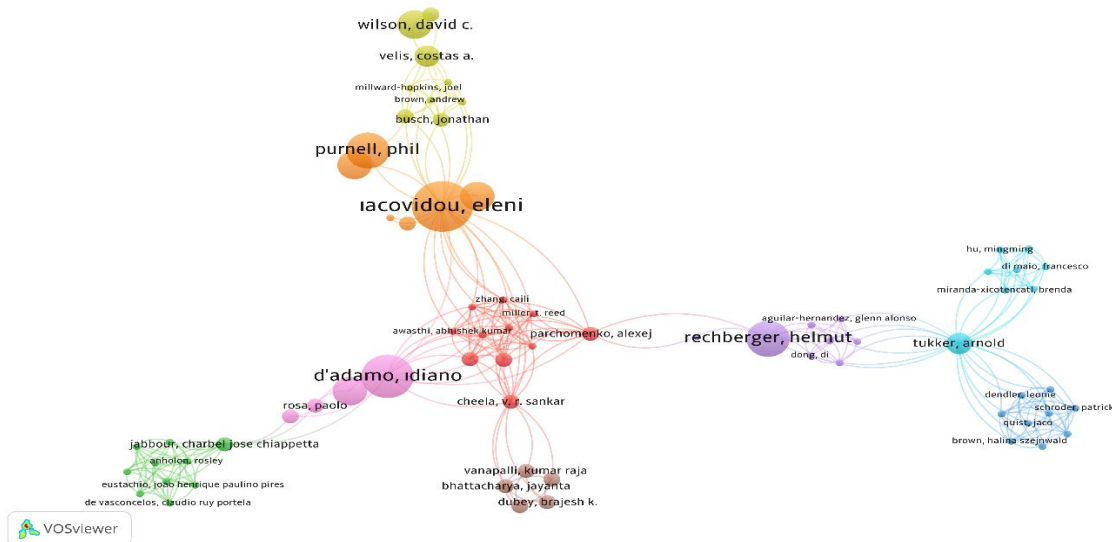
The map above shows the relationship that exists among different co-authors. Based on the illustration presented, five authors (i.e., Idiano D'Adamo, Eleni Iacovidou, Helmut Rechberger, Phil Purnell, and Arnold Tukker) together provide their valuable contributions on the subject matter, which shows their expertise in their various fields. There is a strong collaboration between Phil Purnell and Eleni Iacovidou, and also between Idiano D'Adamo and Paolo Rosa in the chart above. This indicates the benefit of collaborative research.

6. CONCLUSION AND RECOMMENDATIONS

The study retrieved 1,095 articles from the Web of Science database, indicating that the concepts of circular economy and waste management are gaining much attention in academia. From the analysis, five keywords were the most often used, consisting of circular economy, waste management, life cycle assessment, recycling, and sustainability. This indicates their significant presence in the literature.

The data on the number of publications depict a substantial increase in publications that are related to circular economy and waste management since 2014. The rise in the number of publications is associated with the growing interest in environmental sustainability among policymakers, researchers, and other stakeholders in response to the emerging global concerns. From the Web of Science (WoS) categories, the analysis of the study distribution that is conducted within the field shows that the environmental sciences category represented the largest share of publications, totaling a rate of 37%.

It can be concluded that these journals maintain their focus on issues such as sustainability, resource and waste management. They play a significant role in influencing the academic literature in this field. Another analysis of the study, when the indexes where these publications were scanned showed that 40% of publications were featured in the SCI-EXPANDED and SSCI indexes. The findings depicted that publications in the field usually have a substantial impact on the academic level.

The findings of the country-based analysis indicated that the United Kingdom, Italy and Spain are the countries that have the highest number of publications on the relevant subject. Other countries that ranked high in their number of publications are Germany and the People's Republic of China. Notably, the UK stands out with a leading position in academic literature that is related to the development and implementation of circular economy policies. These countries appear to demonstrate strong engagement in circular economy practices, supported by various national policies. The United Kingdom, for instance, holds a particularly ambitious position regarding plastic waste recycling targets (Ellen MacArthur Foundation, 2020). The country's NISP program promotes industrial by-product exchanges, generating approximately £1 billion in annual savings (International Synergies, n.d.), while the Extended Producer Responsibility (EPR) legislation enacted in 2023 places the cost burden of recycling on producers (GWP Group, 2024). At the European level, the EU Circular Economy Action Plan has mandated eco-design for products and set a target to recycle 70% of packaging waste by 2030 (EC, 2020). Italy, through its "supermarket surplus" law implemented in 2022, prevents around 500,000 tons of food waste annually (FAO, 2023), whereas Spain supports SMEs with grants covering up to 50% of costs under its Circular Economy 2030 strategy (EC, 2020). Germany stands out with a 68% packaging recycling rate, one of the highest in Europe (Eurostat, 2022, p. 24). In addition, China has successfully advanced circular economy policies through initiatives such as Eco-Industrial Parks (Zeng et al., 2021).

The citation score from the analysis shows that authors with the highest citation counts are Geng Yong, Raimund Bleischwitz, and Beijia Huang with 1018, 986, and 980 citations, respectively. The high citation counts were due to the relevant contributions of these researchers on circular economy and waste management. The historical evolution of circular economy and its related subjects was analyzed by the study of Reike et al. (2018), and it is observed as the most cited publication over a period. Another most cited scholar was De Jesus and Mendonça (2018), with much focus on circular economy transition, with more emphasis on the key roles of eco-innovations. The study concludes that three countries, which are the United Kingdom, the Netherlands, and the People's Republic of China have contributed more to the development in terms of circular economy and waste management based on citations from the literature.

Furthermore, network maps indicate a strong academic collaboration among these countries, institutions, and authors. Key authors such as Idiano D'Adamo, Eleni Iacovidou, Helmut Rechberger, Phil Purnell, and Arnold Tukker hold the central position in the network map and demonstrate significant collaborations. Therefore, this shows that their prominence is a result of their collaborative or co-authored research efforts. In terms of institutions, the European Commission, Delft University of Technology and the Technical University of Denmark were found to be the most productive institutions in the relevant field. Accordingly, it can be stated that these institutions have made a great contribution to the establishment of the scientific infrastructure of circular economy policies. In terms of countries, a high level of co-authorship has been identified among countries such as Italy, Spain, China, Poland,

the Netherlands and Denmark, and it has been revealed that these countries attach great importance to international co-operation.

The findings obtained in this study are broadly consistent with the theoretical frameworks widely recognized in the circular economy and waste management literature. The prominence of European countries in terms of publications and citations indicates that circular economy approaches are largely driven by strong policy-based transformations. This aligns with theoretical perspectives emphasizing that regulatory frameworks, national strategies, and institutional capacity play a critical role in supporting circular economy practices. The frequent use of keywords such as life cycle assessment, recycling, and sustainability is directly related to the core principles of the circular economy, including resource efficiency, the closing of material loops, and the valorization of waste. Moreover, the marked increase in publications after 2014 suggests that the circular economy and waste management have gained significant visibility on the international policy agenda, thereby strengthening the underlying theoretical foundations within the literature.

According to the overall findings of the study, academic research on circular economy and waste management tends to concentrate around specific themes, while interdisciplinary studies and those focusing on developing countries remain relatively limited. This situation highlights a significant opportunity for future research addressing different themes and country contexts. For instance, various policies and practices have been implemented in Turkey in the field of circular economy and waste management. Notable examples include the Zero Waste Regulation (Resmî Gazete, 2018), municipal waste-to-energy and composting projects (İBB, 2023), industrial applications such as the use of alternative fuels in the cement sector (TÇMB, 2021), and circular economy-oriented R&D initiatives supported by national agencies (TÜBİTAK, 2023). In this context, a more in-depth examination of such strategies in developing countries like Turkey is expected not only to contribute to the existing literature but also to guide future studies in this field. In addition, it is thought that academic studies in the field of circular economy and waste management can provide guidance to many stakeholders such as policymakers and the industrial sector. At this point, it is of great importance to implement waste management and circular economy principles more effectively and in coordination in order to achieve sustainable development goals at the global level.

Ethics Statement: In this study, no method requiring the permission of the "Ethics Committee" was used.
Etik Beyan: Bu çalışmada "Etik Kurul" izni alınmasını gerektiren bir yöntem kullanılmamıştır.

BIBLIOGRAPHY

Akomea-Frimpong, I., Tetteh, P. A., Ofori, J. N. A., Tumpa, R. J., Pariafsai, F., Tenakwah, E. S., ... & Tenakwah, E. J. (2024). A bibliometric review of barriers to circular economy implementation in solid waste management. *Discover Environment, 2*(1), 20. https://doi.org/10.1007/s44274-024-00050-4.

Ali, N. E. H., Talmizi, N. M., Wahab, S. N. A., Rijal, N. S., Abd Rased, A. N. N. W., & Saleh, A. A. (2021, August). Solid waste management hierarchy: An empirical investigation. In *International, Invention, Innovative & Creative (InIIC) Conference* (p. 8). https://www.researchgate.net/profile/Mohd-Misran/publication/364194541_Unaware_Threat_of_Cabin_Vehicle_Safety_A_Review_PROCEEDINGS_InIIC_CONF_SERIES_1_2021/links/633e4c6476e39959d6a18b37/Unaware-Threat-of-Cabin-Vehicle-Safety-A-Review-PROCEEDINGS-InIIC-CONF-SERIES-1-2021.pdf#page=12.

Boloy, R. A. M., da Cunha Reis, A., Rios, E. M., de Araújo Santos Martins, J., Soares, L. O., de Sá Machado, V. A., & de Moraes, D. R. (2021). Waste-to-energy technologies towards circular economy: A systematic literature review and bibliometric analysis. *Water, Air, & Soil Pollution, 232*(7), 306. https://doi.org/10.1007/s11270-021-05224-x.

De Jesus, A., & Mendonça, S. (2018). Lost in transition? Drivers and barriers in the eco-innovation road to the circular economy. *Ecological Economics, 145*, 75–89. http://dx.doi.org/10.1016/j.ecolecon.2017.08.001.

Didenko, N. I., Klochkov, Y. S., & Skripnuk, D. F. (2018). Ecological criteria for comparing linear and circular economies. *Resources, 7*(3), 48. https://doi.org/10.3390/resources7030048.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research, 133*, 285–296.

Ellen MacArthur Foundation. (2020). The Global Commitment 2020 Progress Report. Retrieved from https://content.ellenmacarthurfoundation.org/m/64e0598fa6fb1d8b/original/The-Global-Commitment-2020-Progress-Report.pdf.

European Commission. (2015). *Closing the loop - An EU action plan for the Circular Economy* (pp. 1–21). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614.

European Commission. (2020). Circular Economy Action Plan: For a cleaner and more competitive Europe. Publications Office of the European Union. https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf

Eurostat. (2022). *Packaging Waste Statistics* (s. 24). Eurostat. https://ec.europa.eu/eurostat/statistics-explained/index.php/Packaging_waste_statistics.

Food and Agriculture Organization. (2023). *Turkey food waste report* (p. 34). FAO. https://openknowledge.fao.org/server/api/core/bitstreams/9bd8458e-08bb-47e5-b467-ecdc71189b8d/content.

Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. Science advances, 3(7), e1700782. https://doi.org/10.1126/sciadv.1700782.

Gharfalkar, M., Court, R., Campbell, C., Ali, Z., & Hillier, G. (2015). Analysis of waste hierarchy in the European waste directive 2008/98/EC. *Waste Management, 39*, 305–313. https://doi.org/10.1016/j.wasman.2015.02.007.

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production, 114*, 11–32. https://doi.org/10.1016/j.jclepro.2015.09.007.

González-Sánchez, R., Alonso-Muñoz, S., & Medina-Salgado, M. S. (2023). Circularity in waste management: A research proposal to achieve the 2030 Agenda. *Operations Management Research, 16*(3), 1520–1540. https://doi.org/10.1007/s12063-023-00373-0.

Gündüzalp, A. A., & Güven, S. (2016). Waste, types, waste management, recycling and consumer: The case of Çankaya municipality and neighbourhood consumers. *Hacettepe University Sociological Research E-Journal, 9*(1), 1–19. https://www.researchgate.net/publication/295693401_Waste_and_Waste_Types_Waste_Management_Recycling_and_Consumer_Cankaya_Municipality_and_Instance_of_Neighbourhood_Consumers/links/56cc765f08ae1106370d924b/Waste-and-Waste-Types-Waste-Management-Recycling-and-Consumer-Cankaya-Municipality-and-Instance-of-Neighbourhood-Consumers.pdf.

GWP Group. (2024). What is the packaging extended producer responsibility (EPR)?. Retrieved from https://www.gwp.co.uk/guides/packaging-extended-producer-responsibility-epr/.

Huang, B., Wang, X., Kua, H., Geng, Y., Bleischwitz, R., & Ren, J. (2018). Construction and demolition waste management in China through the 3R principle. *Resources, Conservation and Recycling, 129*, 36–44. https://doi.org/10.1016/j.resconrec.2017.09.029.

International Synergies. (n.d.). *Industrial symbiosis facilitation*. https://international-synergies.com/what-we-do/industrial-symbiosis-facilitation/.

İBB. (2023). İstanbul Büyükşehir Belediyesi Atık Yönetimi Faaliyet Raporu 2023 [Waste Management Activity Report 2023 of Istanbul Metropolitan Municipality]. İstanbul: İBB Department of Environmental Protection. https://uploads.ibb.istanbul/uploads/2023_Faaliyet_Raporu_1_fa79d76a01.pdf.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualising the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling, 127*, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005.

Leibniz Centre for Tropical Marine Research. (2024, January 13). *Raimund Bleischwitz*. https://www.leibniz-zmt.de/en/marine-tropics-research/who-we-are/raimund-bleischwitz-en.html.

Michelini, G., Moraes, R. N., Cunha, R. N., Costa, J. M., & Ometto, A. R. (2017). From linear to circular economy: PSS conducting the transition. *Procedia CIRP, 64*, 2–6. https://doi.org/10.1016/j.procir.2017.03.012.

Negrete-Cardoso, M., Rosano-Ortega, G., Álvarez-Aros, E. L., Tavera-Cortés, M. E., Vega-Lebrún, C. A., & Sánchez-Ruíz, F. J. (2022). Circular economy strategy and waste management: A bibliometric analysis in its contribution to sustainable development, towards a post-COVID-19 era. *Environmental Science and Pollution Research, 29*(41), 61729–61746. https://doi.org/10.1007/s11356-022-18703-3.

O'Leary, P. R., Tchobanoglous, G., & Kreith, F. (2002). *Handbook of solid waste management: Landfilling*.

Ranjbari, M., Saidani, M., Esfandabadi, Z. S., Peng, W., Lam, S. S., Aghbashlo, M., ... & Tabatabaei, M. (2021). Two decades of research on waste management in the circular economy: Insights from bibliometric, text mining, and content analyses. *Journal of Cleaner Production, 314*, 128009. https://doi.org/10.1016/j.jclepro.2021.128009.

Reike, D., Vermeulen, W. J., & Witjes, S. (2018). The circular economy: New or refurbished as CE 3.0? Exploring controversies in the conceptualisation of the circular economy through a focus on history and resource value retention options. *Resources, Conservation and Recycling, 135*, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027.

Reis, W. F., Barreto, C. G., & Capelari, M. G. M. (2023). Circular economy and solid waste management: Connections from a bibliometric analysis. *Sustainability, 15*(22), 15715. https://doi.org/10.3390/su152215715.

Resmî Gazete. (2018). Sıfır Atık Yönetmeliği [Zero Waste Regulation]. Official Gazette of the Republic of Turkey, No. 30413, 12 July 2018. https://www.yyu.edu.tr/images/files/Sifir_Atik_Yonetmeligi.pdf.

Singh, S., Trivedi, B., Dasgupta, M. S., & Routroy, S. (2021). A bibliometric analysis of circular economy concept in E-waste research during the period 2008–2020. *Materials Today: Proceedings, 46*, 8519–8524. https://doi.org/10.1016/j.matpr.2021.03.525.

Sohal, A., & De Vass, T. (2022). Australian SME's experience in transitioning to circular economy. *Journal of Business Research, 142*, 594–604. https://doi.org/10.1016/j.jbusres.2021.12.070.

TÇMB. (2021). Türkiye Çimento Sektöründe Atıkların Alternatif Yakıt Olarak Kullanımı Raporu [Report on the Use of Waste as Alternative Fuel in the Turkish Cement Industry]. Ankara: Turkish Cement Manufacturers' Association. https://www.turkcimento.org.tr/.

Thelwall, M., Kousha, K., Abdoli, M., Stuart, E., Makita, M., Wilson, P., & Levitt, J. (2022). Are internationally co-authored journal articles better quality?: The UK case 2014-2020. https://discovery.dundee.ac.uk/en/publications/are-internationally-co-authored-journal-articles-better-quality-t/.

Thelwall, M., Kousha, K., Abdoli, M., Stuart, E., Makita, M., Wilson, P., & Levitt, J. (2024). Which international co-authorships produce higher quality journal articles? *Journal of the Association for Information Science and Technology*. https://doi.org/10.1002/asi.24881.

Tsai, F. M., Bui, T. D., Tseng, M. L., Lim, M. K., & Hu, J. (2020). Municipal solid waste management in a circular economy: A data-driven bibliometric analysis. *Journal of Cleaner Production, 275*, 124132. https://doi.org/10.1016/j.jclepro.2020.124132.

TÜBİTAK. (2023). 2023 Yılı AR-GE Proje Destekleri Faaliyet Raporu [R&D Project Support Activity Report 2023]. Ankara: The Scientific and Technological Research Council of Turkey (TÜBİTAK). https://tubitak.gov.tr/sites/default/files/2024-04/tubitak_2023_yili_faaliyet_raporu.pdf.

United Nations Environment Programme (UNEP). (2017). *Resource efficiency: Potential and economic implications* (pp. 1–88). https://discovery.ucl.ac.uk/id/eprint/1575504/1/resource_efficiency_report_march_2017_web_res.pdf.

United Nations Environment Programme (UNEP). (2019). Waste Management during the SDGs Era: An Overview. Osaka: UNEP International Environmental Technology Centre. https://www.unep.or.jp/ietc/Publications/spc/Waste_Management_During_SDGs_Era.pdf.

Upadhayay, S., Alqassimi, O., Khashadourian, E., Sherm, A., & Prajapati, D. (2024). Development in the circular economy concept: Systematic review in context of an umbrella framework. *Sustainability, 16*(4), 1500. https://doi.org/10.3390/su16041500.

Van Eck, N., & Waltman, L. (2010). Software survey: VOSviewer, a computer programme for bibliometric mapping. *Scientometrics, 84*(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3.

Zeng, D. Z., Cheng, L., Shi, L., & Luetkenhorst, W. (2021). China's green transformation through eco-industrial parks. World Development, 140, 105249. https://doi.org/10.1016/j.worlddev.2020.105249.