



# A Bibliometric Analysis on Circular Economy of Packaging

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## Abstract

The aim of this study is to analyze the packaging in all areas by examining the studies on the subject of circular economy, which is becoming increasingly important in the field of sustainability, and to provide researchers with a perspective by mapping. The research was conducted in Scopus, between 2010 and 2022. Between these years, 761 publications by 2695 authors, 2154 keywords, 85 countries, and many criteria of these publications were analyzed. The obtained data were mapped by VOSviewer and presented with the help of diagrams and graphs. Studies in this field were examined bibliographically according to years, subject area, and country. When the number of publications between 2010 and 2022 is examined, it is seen that there is a regular increase every year. When the most cited publications were examined, it was seen that 2018 was the year with the most cited publication with 37.93%. The year 2018 is followed by 2019, 2020, and 2021, respectively. In addition, when the number of publications and citation numbers are examined, we see that the countries with the highest number of publications with 60.50% are the European Union countries. In addition to the European Union countries, the presence of Far East countries with 8.26% draws attention. As a result of the mapping, it was concluded that the European Union countries had more scientific relations with each other and the Far East countries with each other. In addition, it has been concluded that European Union countries and Far East countries are making more publications together strikingly.

**Keywords** Circular economy · Packaging · VOSviewer · Bibliometric analysis

## Highlights

- In this study, the literature on packaging in the circular economy (CE) was mapped by using VOSviewer.
- The research was conducted in Scopus, between 2010 and 2022.
- Citation numbers, authors with most publications, source titles, document numbers, subject area, keywords, publications per year, and countries were presented and analyzed. For bibliometric analysis, 5 basic analysis types such as co-authorship, co-occurrence, bibliographic coupling, co-citation, and citation were examined. In these analysis types, subheadings of documents, authors, keywords, countries, sources, and cited sources are mapped.

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## Introduction

While the emergence of the concept of packaging in today's sense dates back to the 1700s, it has been seen that a lot of development has emerged in the 1900s. Due to the increased production and consumption activities after the industrial revolution, the importance of packaging used for the protection of products has also increased [1].

Packaging industry has a huge role in today's economy. In 2015, packaging had \$839 billion value [2]. Despite its importance and large economic share, packaging wastes constitute a major problem for the environment.

Due to the fact that the widely used economic model, also known as the buy-use-consume-dispose model, could no longer be a solution to the problems such as climate change, air pollution, using nonrenewable products, etc., the concept of circular economy emerged, and in a short time it started to be implemented all over the world and became the focal point of the targets [3].

According to the definition of the European Union, the circular economy is a model that aims to use, reduce, reuse, and recycle as long as possible in order to extend the life cycle of all materials and products and minimize waste during production and consumption. In contrast to the linear economy, in the circular economy, materials are used productively in a continuous cycle, thereby becoming more valuable [4].

The circular economy, which is a solution to environmental pollution and resource depletion, which is one of the most important problems of the world, has been the subject of many studies in recent years. Many countries, especially the European Union countries, are planning to carry out to a completely circular economy in order to conserve resources and reduce pollution [3]. Every research in this subject has great importance to solve problems and adapt to "zero waste" life. Considering that packaging causes waste in the world, compilation and bibliometric analysis of circular economy studies in the field of packaging will make an important contribution to the literature.

The packaging industry is constantly developing in line with the demands and keeps up with the innovations rapidly. The circular economy, on the other hand, has become the solution method used against the problems caused by plastics, which is the most used material in packaging [5]. According to the 2050 European Union targets, every step of packaging, as indicated in Fig. 1, from production to raw materials, from process to waste, is evaluated within the framework of circular economy and is the subject of many studies. For this reason, a bibliographic review covering each step was made and presented by mapping for researchers.

Especially within the framework of circular economy, the concept of packaging has been discussed in many aspects, and in this study, circular economy studies applied at every step of packaging have been examined.

## Literature Review

Bibliometric methodology is a quantitative technique for analyzing bibliometric data such as publication and citation details. It facilitates the analysis of large-volume databases such as Scopus and web of science and facilitates the view of the big picture. Bibliometric analysis has 2 main techniques: performance analysis and science mapping. Performance analysis, which is one of the main techniques, is examined under 3 headings as publication-related metrics, citation-related metrics, and citation-and-publication-related metrics.

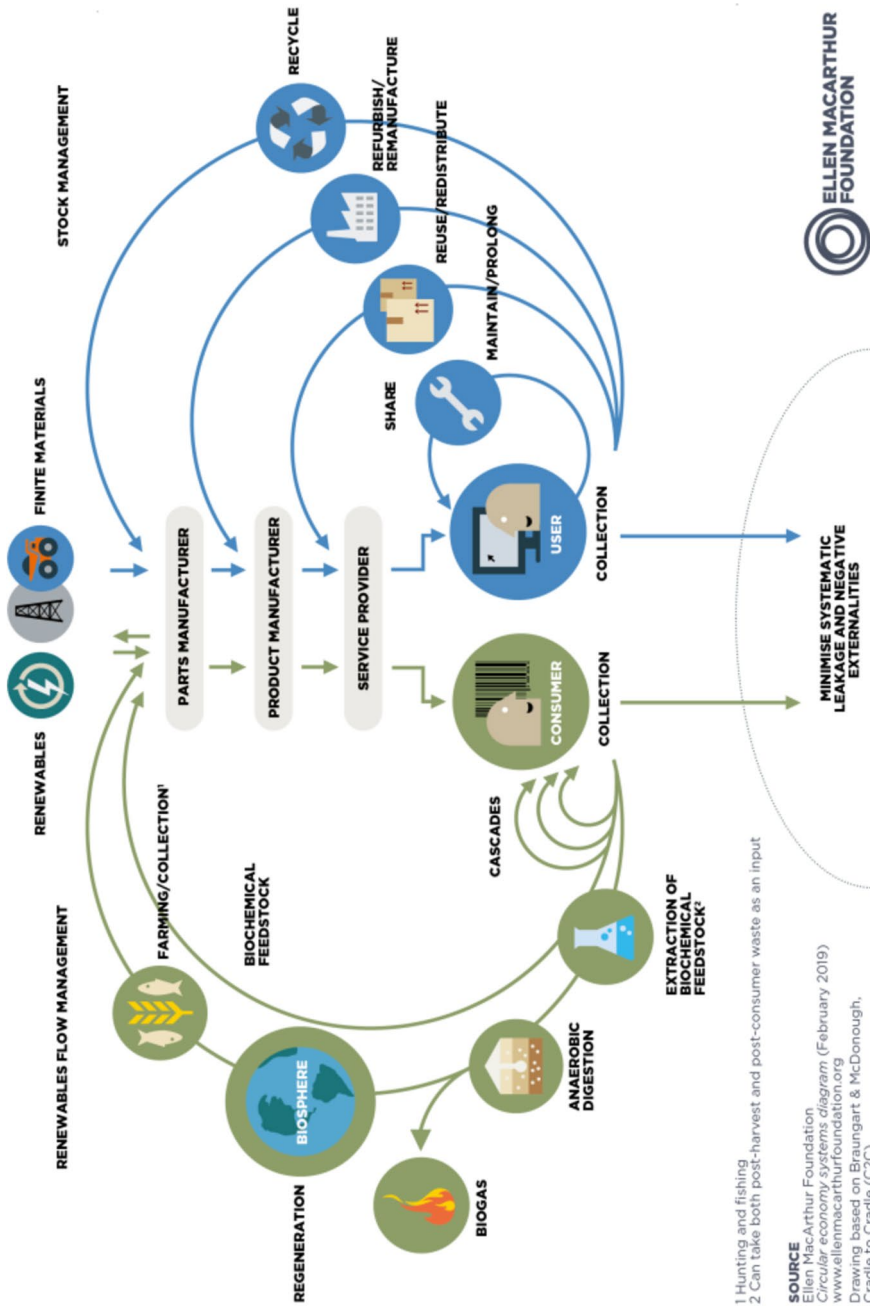


Fig. 1 Butterfly diagram of circular packaging [6]

Science mapping is examined under 5 headings as citation analysis, co-citation analysis, bibliographic coupling, co-word analysis, and co-authorship analysis [7].

Due to both the situation of the packaging in our lives and the importance of the circular economy in our present and future, a lot of research has been done on this subject and papers have been published. For example, Vila-Lopez and Küster-Boluda [8] published a bibliometric analysis on sustainable and healthy packages. They analyze the papers between 1956 and 2019 by using WOS (Web of Science) and Scopus. As a regional research, Wang et al. [9] published a bibliometric analysis of sustainability of packaging on the Greater China. Papers between 1989 and 2019 analyzed by using keyword co-occurrence for five common subjects.

Rodriguez-Rojas et al. [10] published a bibliometric analysis on packaging materials from 1996 to 2016. This paper focused especially on food packaging, but it is of great importance as it is a 20-year research, which is a long process.

Tsai et al. [11] published a bibliometric analysis about municipal solid waste management in a circular economy. This paper focused on waste management and analyzed 413 articles with 41 indicators by comparing 5 regions. Ranjbari et al. [12] analyzed the waste management in the circular economy bibliometrically for two decades. The 7 main topics were analyzed and mapped with VOSviewer.

Goyal et al. [13] also published a bibliometric analysis about circular economy between 2000 and 2019. They analyzed 2279 articles from WOS and mapped 33 top-cited articles.

Mustafa and Lengyel [14] published a bibliometric mapping about circular economy. This study had a broad perspective and analyzed 1541 publications from 1990 to 2020. Türkeli et al. [15] published a bibliometric, network, and survey analysis about circular economy between 2006 and 2016 in the EU and China. This study includes analysis with a lot of indicator and comparison the EU and China.

Alnajem et al. [16] also mapped circular economy by using bibliometric analysis. WoS is used, and papers between 2009 and 2018 are analyzed. Citations, co-citations, collaborations and keywords co-occurrence are chosen as indicators.

Luis and Celma [17] published a review and bibliometric about circular economy. Between 2016 and 2019, 3391 records from WoS, 36300 records from Google Scholar Metrics, and 1901 records from Scopus are analyzed by using VOSviewer and SciMAT.

## Methodology

In this study, publications containing the words “circular economy” and “packaging” were examined as a bibliometric analysis. Mapping was done in all 5 categories under the Science mapping title.

In the literature, for the visualization of the publication results, more sophisticated simulation programs are used such as VOSviewer, SciMAT, CiteSpace, and Bibliometrix. For this research, VOSviewer is chosen. VOSviewer is an open-source software, and it is developed for mapping. In addition to its widely use, easy to use and the outputs are clearly interpretable. It is freely available at website [18].

Literature searches were conducted in Scopus. For this research, keywords such as “circular economy” and “packaging” had been used in “title, abstract and keyword,” and results between 2010 and 2022 were listed for mapping analysis. All details of data collection is given in Table 1.

**Table 1** Steps of the data collection

Search date	27.02.2023
Search string	“Circular economy” AND “packaging”
Total number of publications	761
Total number of authors	2695
Total author keywords	2154
Countries	85
Fields mined	Article title, Abstract, Keywords
Database	Scopus

## Results and Discussion

As a result of searching Scopus with the keywords “circular economy” and “packaging,” 761 articles and publications were found between 2010 and 2022.

According to the citation numbers, the most important articles are presented in Table 2. It is seen that 11 of the 29 articles with more than 100 citations among 761 articles in Scopus were published in 2018, with a rate of 37.93% of these articles. The high percentage of 2018 is followed by 2020 with 7 articles with 24.14%. Afterwards, 2019 is followed by 5 articles with 17.24% and 2021 with 4 articles with 13.79%, respectively. Although there is 1 article from 2011 and 2016, it has a rate of 3.45% in both years. The effect of the acceleration of the works in 2018 began to be seen here.

When the documents with a minimum of 50 citations were mapped in the citation analysis, it was seen that 69 documents out of 761 documents met the criteria and 42 of them were connected. Looking at the map in Fig. 2, it is clearly seen that the publications with the most citations cite each other.

When the publications with more than 100 citations are examined in bibliographic coupling analysis, we see that 29 of 761 publications meet this criterion. Among these 29 publications, 26 appear to have common references and are mapped in Fig. 3. It is clearly seen on the map which of these publications listed in also Table 2 have common references. Here, groupings, that is, publications with common references, draw attention. These groupings show which publications have the most common reference with each other. It is seen that these publications that use a lot of common references (bibliographic coupling) with each other are also very similar with most cited documents in Table 2. In this case, we can say that articles with too much citation also have too many common publications.

The authors with the most publications on circular economy and packaging are listed with document number and citations in Table 3. At the same time, it is seen that these 12 authors with the most publications also have high citation numbers.

When the authors with a minimum of 3 publications in the co-authorship analysis type were examined, it was seen that 72 of the 2695 authors met this criterion and 17 of them were related. Here, we get that 72 authors have done at least 3 academic studies with 2 or more people. Seventeen of these 72 authors have worked in co-authorship with each other. Authors who have joint academic publications with each other appear on the map.

**Table 2** The most cited articles (citation over 100)

No	Item title	Authors	Year of publication	Citation
1	The Chinese import ban and its impact on global plastic waste trade	Brooks A.L., Wang S., Jambeck J.R	2018	400
2	Food packaging in the circular economy: overview of chemical safety aspects for commonly used materials	Geuteke, B., Groh, K., Munteke, J	2018	247
3	Circular supply chain management: a definition and structured literature review	Farooque, M., Zhang, A., Thürier, M., Qu, T., Huisingsh, D	2019	244
4	Mechanical recycling of packaging plastics: a review	Schyns, Z.O.G., Shaver, M.P	2021	241
5	Plastic pollution and potential solutions	Rhodes C.J	2018	199
6	Closing the loop on plastic packaging materials: what is quality and how does it affect their circularity?	Hahladakis, J.N., Iacovidou, E	2018	187
7	Mushroom cultivation in the circular economy	Grimm, D., Wösten, H.A.B	2018	185
8	Recycling potential of post-consumer plastic packaging waste in Finland	Dahlbo, H., Poliakov, V., Mylläri, V., Sahimaa, O., Anderson, R	2018	184
9	Recycling of polymer-based multilayer packaging: a review	Kaiser, K., Schmid, M., Schlummer, M	2018	181
10	The next generation of sustainable food packaging to preserve our environment in a circular economy context	Guillard, V., Gaucel, S., Fornaciari, C., Angelliet-Coussy H., Buche, P., Gontard, N	2018	178
11	Packaging materials with desired mechanical and barrier properties and full chemical recyclability	Sangroniz, A., Zhu, J.-B., Tang, X., Etxeberria A., Chen, E.Y.-X., Sardon, H	2019	157
12	Technologies for chemical recycling of household plastics – a technical review and TRL assessment	Solis, M., Silveira, S	2020	156
13	Closed-loop production systems-a sustainable supply chain approach	Winkler H	2011	152
14	Circular economy of plastic packaging: current practice and perspectives in Austria	Van Eygen, E., Laner, D., Fellner, J	2018	145
15	Circular economy in corporate sustainability strategies: a review of corporate sustainability reports in the fast-moving consumer goods sector	Stewart, R., Niero, M	2018	142
16	Plastics in the time of COVID-19 pandemic: protector or polluter?	Parashar, N., Hait, S	2021	137
17	Single-use plastics: production, usage, disposal, and adverse impacts	Chen, Y., Awasthi, A.K., Wei, F., Tan, Q., Li, J	2021	135
18	Towards sustainability? Forest-based circular bioeconomy business models in Finnish SMEs	D'Amato, D., Vejjonaho, S., Toppinen, A	2020	129

Table 2 (continued)

No	Item title	Authors	Year of publication	Citation
19	Closing the loop for PET, PE and PP waste from households: influence of material properties and product design for plastic recycling	Eriksen, M.K., Christiansen, J.D., Daugaard, A.E., Astrup, T.F	2019	118
20	Environmental impact of food packaging materials: a review of contemporary development from conventional plastics to polylactic acid based materials	Ncube, L.K., Ude, A.U., Ogunmuyiwa, E.N., Zulkifli, R., Beas, I.N	2020	116
21	Predictive model for the Dutch post-consumer plastic packaging recycling system and implications for the circular economy	Brouwer, M.T., Thoden van Velzen, E.U., Augustinus, A., Soethoudt H., De Meester, S., Ragaert, K	2018	111
22	Green chemistry and the plastic pollution challenge: towards a circular economy	Sheldon, R.A., Norton, M	2020	109
23	Towards a circular economy for plastic packaging wastes – the environmental potential of chemical recycling	Meys, R., Frick, F., Westhues, S., Sternberg A., Klankermayer, J., Bardow, A	2020	108
24	Poly(glycolic acid) (PGA): a versatile building block expanding high performance and sustainable bioplastic applications	Samantaray, P.K., Little, A., Haddleton, D.M., McNally T., Ji, Y., Wan, C	2020	108
25	Recent trends in the use of pectin from agro-waste residues as a natural-based biopolymer for food packaging applications	Mellinas, C., Ramos, M., Jiménez, A., Garrigós, M.C	2020	108
26	Coupling material circularity indicators and life cycle based indicators: a proposal to advance the assessment of circular economy strategies at the product level	Niero, M., Kalbar, P.P	2019	108
27	Sustainable packaging for supply chain management in the circular economy: a review	Meherishi, L., Narayana, S.A., Ranjani, K.S	2019	107
28	Life cycle environmental impacts of chemical recycling via pyrolysis of mixed plastic waste in comparison with mechanical recycling and energy recovery	Jeswani, H., Krüger, C., Russ, M., Horlacher M., Anthony F., Hann, S., Azapagic, A	2021	103
29	Circular economy: to be or not to be in a closed product loop? A Life cycle assessment of aluminium cans with inclusion of alloying elements	Niero, M., Olsen, S.I	2016	103

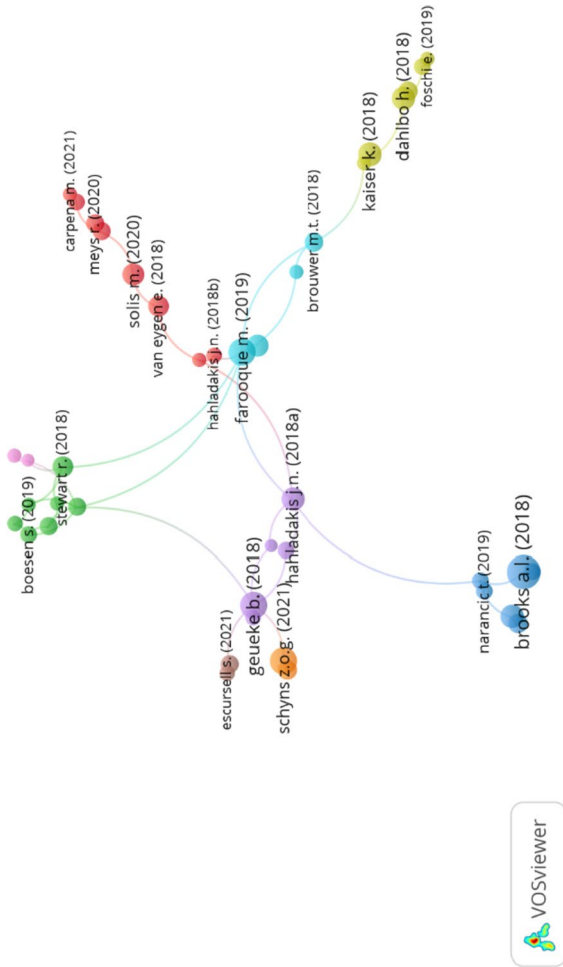


Fig. 2 Mapping of citation analysis for documents with minimum 50 citations

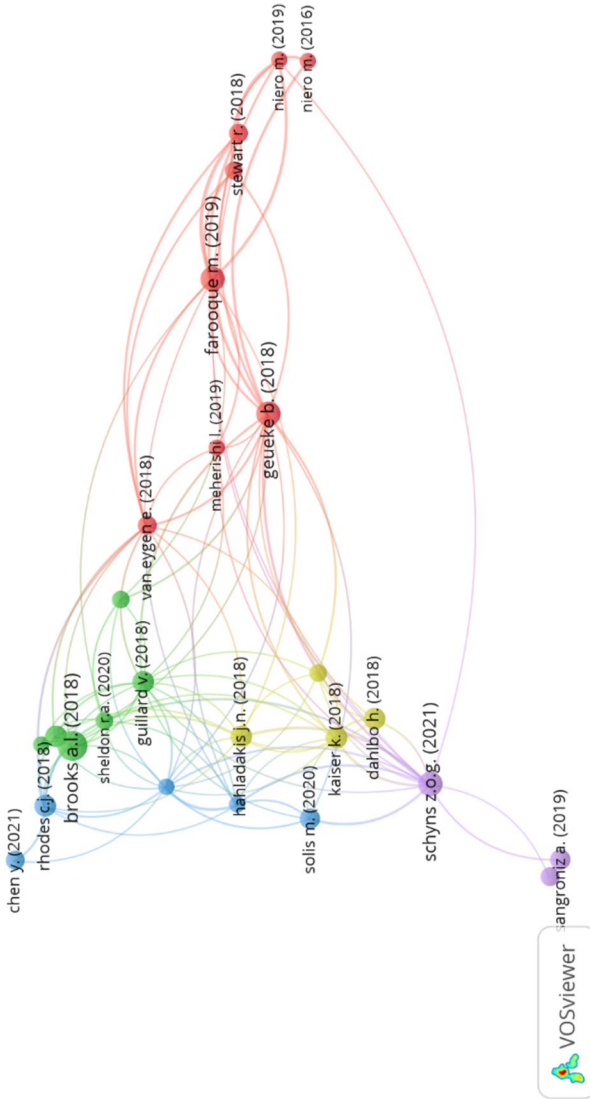


Fig. 3 Mapping of bibliographic coupling analysis for documents with minimum 100 citations

**Table 3** The authors with the most publications which have more than 5 documents

Number	Author	Documents	Citations
1	Niero M	10	635
2	Fellner J	7	246
3	Cinelli P	6	148
4	Lazzeri A	5	136
5	Grosso M	5	66
6	Olsen S.I	5	218
7	Rigamonti L	5	66
8	Laner D	5	209
9	Morganti P	5	38
10	Astrup T.F	5	233
11	De Meester S	5	195
12	Trimingham R	5	50

The mapping made via VOSviewer, where the connections are revealed, is given in Fig. 4. Many of these authors appear to be authors of publications with more than 100 citations given in Table 2. It was also revealed that these authors used common citation together in groups and that the groups used common citation with each other.

In the citation analysis, 2 criteria were used while examining the authors. The first is that the authors have a minimum of 3 publications, and the other is that these publications have a minimum of 50 citations. Among 2695 authors, 38 authors meeting these criteria were found, and 33 of them are related to each other. It is noteworthy that these authors have more connections than groups. As can be seen from this map in Fig. 5, these authors with a lot of citation also refer to each other.

For author analysis in the bibliographic coupling analysis type, 2695 authors were examined, and 72 authors with at least 3 publications were wanted to be mapped. Sixty-nine of these 72 authors were mapped as connected as in Fig. 6. The relationships of the authors who have common references to each other on the map are clearly revealed. Instead of forming groups here, a group of authors who have a lot of common publications formed a dense cluster. Except for these authors, who are in intense relationship, few authors have worked with the authors in this cluster with common references.

The data show that the first article with the keywords “circular economy” and “packaging” was written in 2010. This is also the only article on this topic published in 2010. After 2 articles written in 2011, 1 article was written again in 2012. In 2013, no articles were published on this subject. As of 2014, a significant increase has been observed. The rapidly increasing number of publications after 2014 shows us that circular economy awareness has also increased. After four articles written in 2014 and 2015, a continuous increase was observed. However, we see the highest increase after 2015, with 15 articles written in 2016 and an increase of 275%. After 20 articles published in 2017, 50 articles published on this subject in 2018 brought about a 150% increase. Although the increase continued after 2018, the rate of increase did not increase regularly. The lowest increase after 2015 was recorded with a 20% increase in 240 articles published in 2022 after 200 articles published in 2021. The results are given in Fig. 7.

When the number of publications is analyzed by years, we see that 2022 has reached the highest number of publications, but at the same time, no publication from 2022 has been observed among the most cited documents (more than 100 citation) given in Table 2.

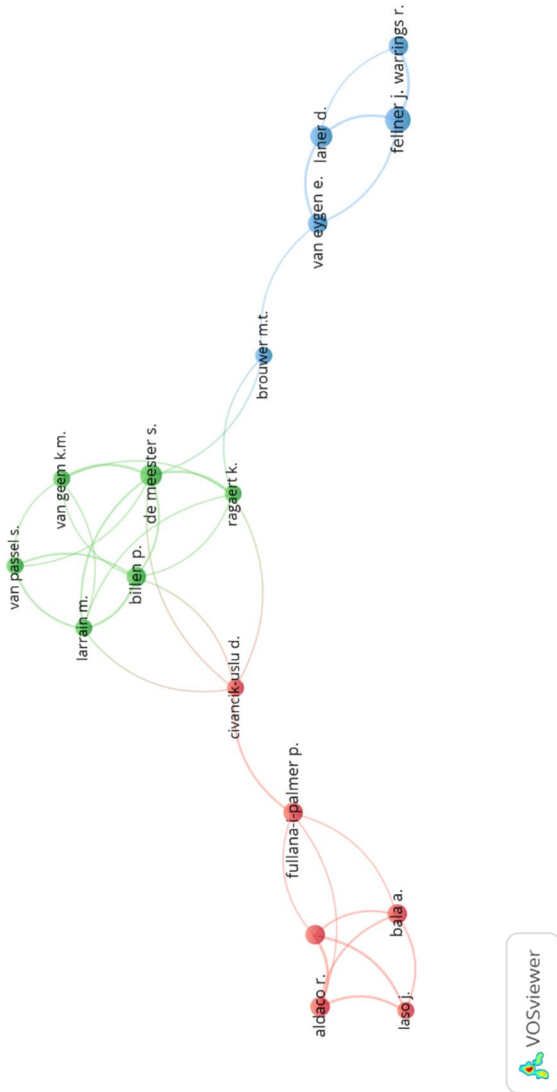


Fig. 4 Mapping of co-authorship analysis for authors with minimum 3 publications

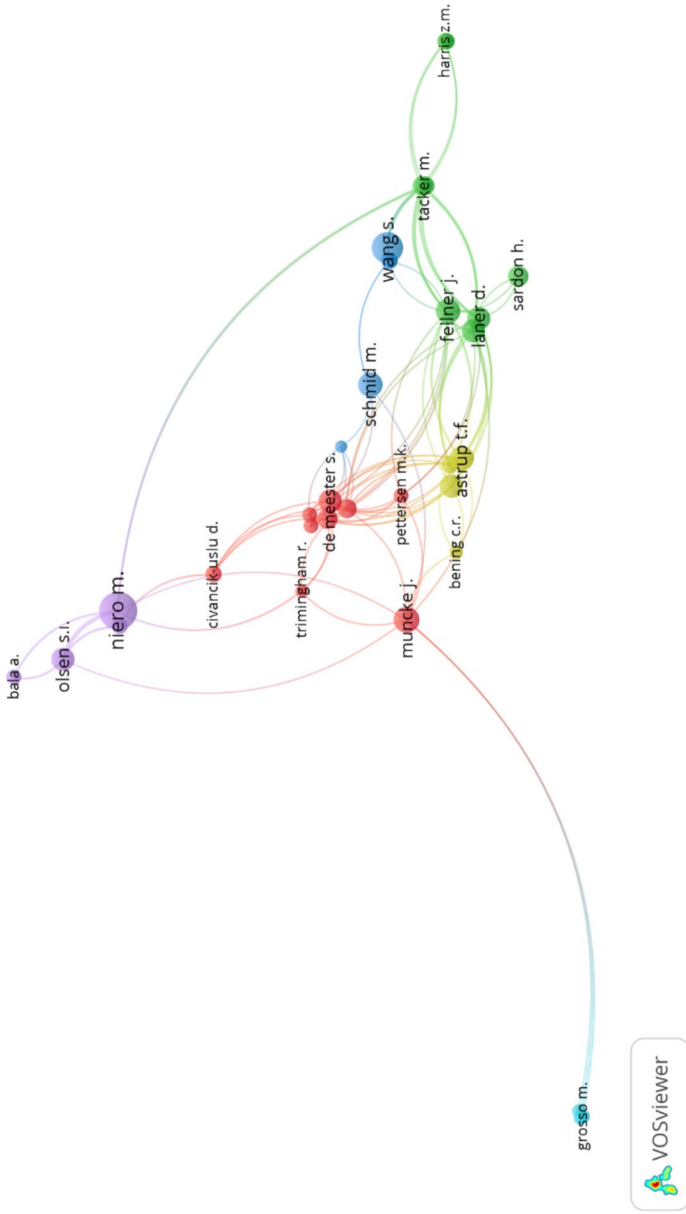


Fig. 5 Mapping of citation analysis for authors with minimum 3 publications and minimum 50 citations

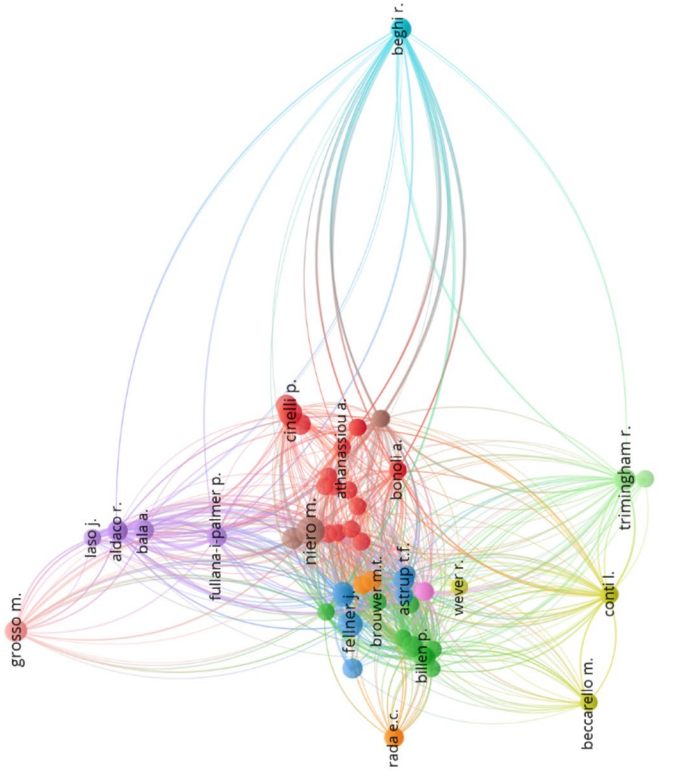


Fig. 6 Mapping of bibliographic coupling analysis for authors with minimum 3 publications



**Fig. 7** Publication numbers per years

The fact that the number of citations for 2022 is not high does not suggest that it will not last as long as 5 or 10 years. When the same study is done in later years, a different picture may emerge when most cited publications are examined between these years. This situation can be stated as a limitation of bibliometric analyses.

When the publications with the keywords “circular economy” and “packaging” are examined, as given in Table 4, it is understood that the most published language is English with 751 publications. Spanish comes second with 5 publications. The third place is German with 4 publications. Afterwards, there are two publications in Portuguese and one publication in Chinese, Russian, and Polish respectively.

As given in Table 5, when the source titles with more than five publications are examined, we see the magazine “Sustainability Switzerland” with 65 publications with the keywords “circular economy” and “packaging” in the first place. This is followed by the “Journal of Cleaner Production” with 57 publications. Although the number of publications is gradually decreasing, the “Resources, Conversation and Recycling” magazine ranks third with 31 publications. Then, we see “Waste Management” and “Polymers” magazine, which has 29 and 22 publications, respectively. It is clearly seen that the sources in the top five have more than 20 publications.

When the criterion of having a minimum of 5 publications is set for sources review in the Citation analysis type, it is seen that 24 of 313 sources meet this criterion. Twenty-two interconnected sources are mapped in Fig. 8. The similarity between the sources with

**Table 4** Number of publications by language

Languages	Number of publication
English	751
Spanish	5
German	4
Portuguese	2
Chinese	1
Russian	1
Polish	1

**Table 5** Source title with more than 5 publications

Source title	Number of publications
Sustainability Switzerland	65
Journal of Cleaner Production	57
Resources Conservation and Recycling	31
Waste Management	29
Polymers	22
Science of the Total Environment	16
Sustainable Production and Consumption	14
Waste Management and Research	13
Recycling	9
Energies	8
Environmental Science and Pollution Research	8
Foods	8
Procedia CIRP	8
ACS Sustainable Chemistry and Engineering	7
Materials	7
Packaging Technology and Science	7
Food Packaging and Shelf Life	6
International Journal of Life Cycle Assessment	6
Journal of Industrial Ecology	6
Applied Sciences Switzerland	5
Detrius	5
Glass International	5
Green Chemistry	5
Iop Conference Series Earth and Environmental Science	5

the highest number of publications given in Table 5 and the sources citing each other is also noteworthy. From this, we can conclude that sources with many publications also have many citations.

In the co-citation analysis, when examining the cited-sources, the lower limit is set to be 100 citations. Thirty-six cited sources meeting this criterion are mapped in Fig. 9. As seen on the map and expected, citation groups have been formed. Sources that mainly refer to each other manifest themselves as groups. However, it is clearly seen that these sources that refer to each other the most are also the sources that have many publications and many citations.

When the sources with a minimum of 5 publications in the bibliometric coupling analysis type were examined, it was seen that 24 of 313 sources met the criteria and 22 of these 24 sources were connected. As can be seen in the map given in Fig. 10, we see the sources with the most publications and citations as having common references. At the same time, it is clearly seen that these sources are heavily related to each other, that is, they use too many common references. Another striking point on the map is that there is no grouping on the map and almost all of the 22 sources are related to each other.

When the affiliations with more than five publications on Table 6 are examined, we see that the European Union countries' affiliations are far ahead with 38 publications.



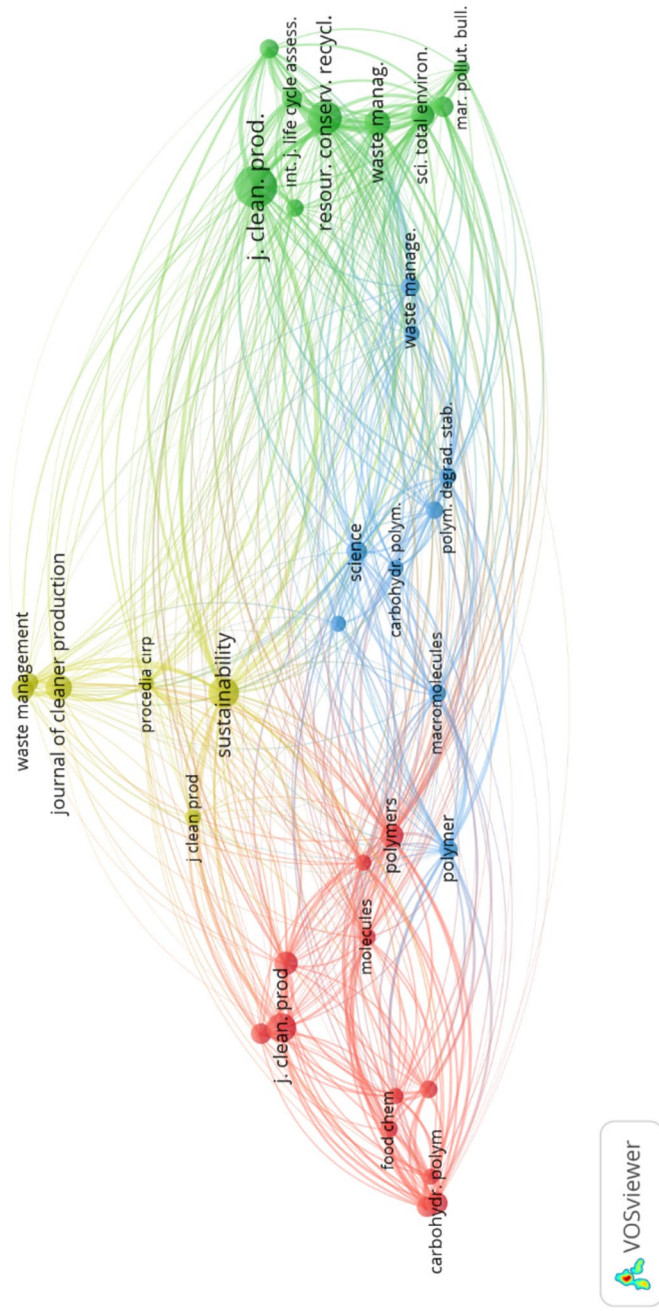


Fig. 9 Mapping of co-citation analysis for sources with minimum 100 citations



**Table 6** Affiliations with more than 5 publications and their countries

No	Affiliation	Number of publications	Country
1	Technical University of Denmark	16	Denmark
2	Technische Universität Wien	12	Austria
3	Wageningen University & Research	11	Netherlands
4	Consiglio Nazionale delle Ricerche	11	Italy
5	Universidade de Aveiro	11	Portugal
6	LAQV-REQUIMTE	10	Portugal
7	Imperial College London	9	UK
8	Politecnico di Milano	9	Italy
9	ETH Zürich	9	Switzerland
10	Kaunas University of Technology	9	Lithuania
11	Norges Teknisk-Naturvitenskapelige Universitet	8	Norway
12	Alma Mater Studiorum Università di Bologna	8	Italy
13	Università di Pisa	8	Italy
14	Christian Doppler Forschungsgesellschaft	8	Austria
15	Università degli Studi di Salerno	7	Italy
16	Universiteit Antwerpen	7	Belgium
17	Lunds Universitet	7	Sweden
18	Università degli Studi di Milano	7	Italy
19	Universiteit Gent	7	Belgium
20	Loughborough University	6	UK
21	The Royal Institute of Technology KTH	6	Switzerland
22	Iowa State University	6	USA
23	Consejo Superior de Investigaciones Científicas	6	Spain
24	Fraunhofer-Institut für Verfahrenstechnik und Verpackung	6	Germany
25	CICECO-Instituto de Materials de Aveiro	6	Portugal
26	Universidad del País Vasco	6	Spain
27	Aalto University	6	Finland
28	European Commission Joint Research Centre	6	European Union
29	The University of Manchester	5	UK
30	Universitat Politècnica de Catalunya	5	Spain
31	University of Limerick	5	Ireland
32	Universitat Politècnica de València	5	Spain
33	University of Leeds	5	UK
34	Universidad de Almería	5	Spain
35	Università degli Studi di Palermo	5	Italy
36	Geoponiko Panepistimion Athinon	5	Greece
37	Universiteit Twente	5	Netherlands
38	Aalborg University	5	Denmark
39	Università del Salento	5	Italy
40	Montanuniversität Leoben	5	Austria
41	Aarhus Universitet	5	Denmark
42	Sapienza Università di Roma	5	Italy
43	TI Food and Nutrition	5	Netherlands
44	Karlsruher Institut für Technologie	5	Germany
45	Bucharest University of Economic Studies	5	Romania
46	INRAE	5	France

In addition, there are 4 publications from UK, 2 publications from Switzerland, and one publication each from Norway and the USA. It is seen that the European Union Countries, which are the spearhead in circular economy, are also ahead in the studies.

When the publications found as a result of the search on Scopus are analyzed according to their subjects, we see that the highest number of publications is in the field of “Environmental Science” with 402 publications as seen in Fig. 11. While “Environmental Science” is followed by the field of “Engineering,” it has the highest number of publications in “Energy,” “Materials Science,” and” Social Science,” respectively. Another area with more than 100 publications is “Business, Management and Accounting.” Despite the publications in many fields, it is seen that science and engineering have more publications by far. It can be said that there are a significant number of publications in the fields of economics and social science.

It is clearly seen that circular economy is the most preferred keyword in this field. Of course, we see that the most used keyword after circular economy is “recycling” because it is the focus of environmental problems. In addition, “packaging,” which is one of the basic keywords of our research, ranks 3rd. Although it is very important that 6 of them contain the word “plastic,” among these 17 frequently used keywords examined, it clearly reveals that plastic waste is the subject of many researches because it is a big problem. Looking at

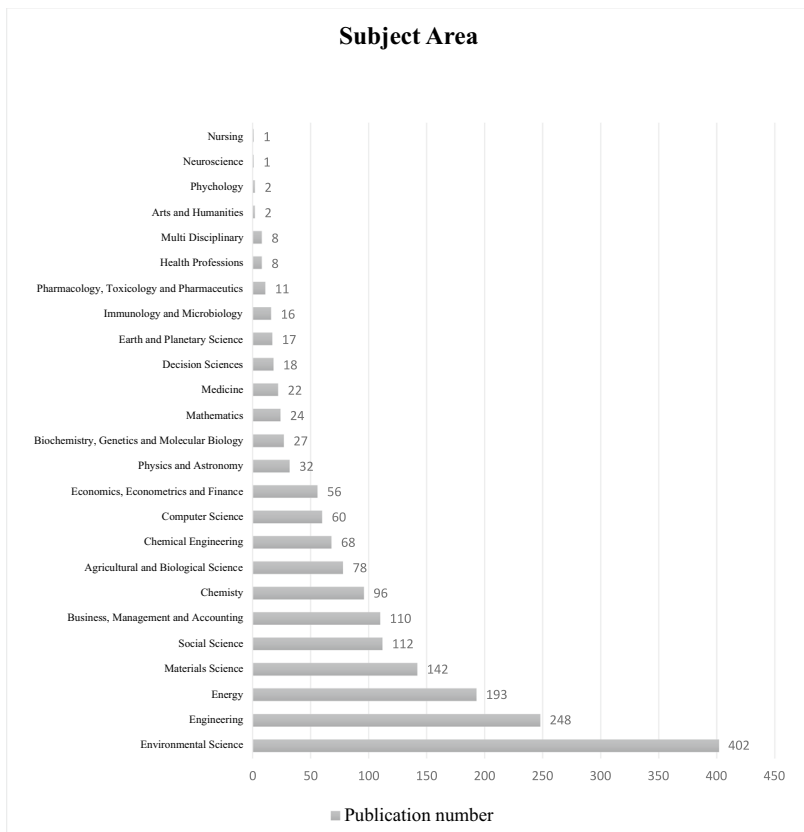


Fig. 11 Publication numbers between 2010 and 2022

the list, it is seen that the next most used keywords are mostly related to the environment. Seventeen keywords with a minimum of 15 occurrences are given in Table 7.

In the co-occurrence section, for all keywords, full counting method was chosen and was set some limitations. For this analysis, a minimum of five (5) occurrences of a keyword was set as a limiting factor of the 254 keywords, and 71 meet the threshold. So, 71 keywords were selected and analyzed. The most common keyword is “circular economy” with 392 occurrences and 355 total link strengths. These keywords also mapped in Fig. 12. It can be said that the most used keywords given in Table 7 appear dominantly in Fig. 12 when mapped. However, how often these keywords are used with each other and how much they are related are revealed when mapped.

When the 761 publications obtained in Scopus are analyzed on a country basis, Italy is the country with the most publications with 123 studies, while countries such as Spain, the UK, and Germany follow it with 82, 71, and 64 publications, respectively. The USA and China are in the 5th and 6th places with 52 and 46 publications. As can be seen in the table, when the number of publications is analyzed, 7 European Union countries are among the top 10 countries with the highest number of publications. Among all publications, European Union countries have a share of 60.50% with 579 publications. However, although the number of publications is small, there is a significant increase in Far East countries such as China, Malaysia, Taiwan, Thailand, and South Korea. They have 8.36% share with 80 publications. All details are given in Table 8.

The countries with a minimum of 5 publications, in which these studies are pioneered by the European Union countries, are mapped in Fig. 13. On Co-authorship analysis among 85 countries, there are 39 countries with a minimum of 5 publications. When mapping is done, it is seen that the European Union countries have come to the fore. However, they also seem to work together. It has been seen that other countries as well as European Union countries attach great importance to this issue and work with each other. When the studies

**Table 7** Most highly co-occurring keywords

Number	Keyword	Occurrences	Total link strength
1	Circular economy	392	355
2	Recycling	92	128
3	Packaging	78	113
4	Sustainability	68	95
5	Waste management	46	77
6	Plastic waste	25	51
7	Life cycle assessment	35	50
8	Plastic packaging	25	44
9	Food packaging	41	38
10	Food waste	16	32
11	Waste	17	30
12	Plastic	17	28
13	Plastic recycling	16	28
15	Plastics	15	27
15	Reuse	15	26
16	Bioplastics	16	25
17	Sustainable development	17	23

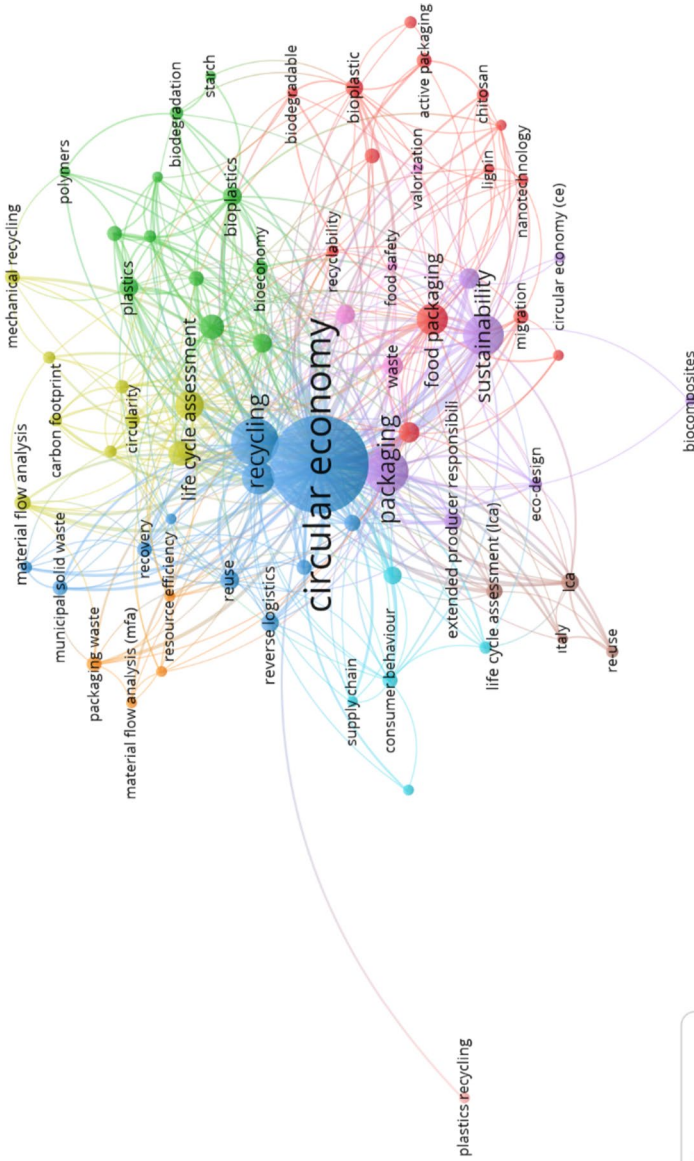


Fig. 12 Mapping of co-occurrence analysis for author's keywords with minimum 5 publications

are also examined, it can be said that countries make comparisons in studies related to packaging and look at many parts of the world from a wide window. One of the most striking issues on the map is that USA and China have worked very hard with other countries.

**Table 8** Document and citations number of countries which have at least 5 publications

Number	Country	Documents	Citations	Total link strength
1	Italy	123	1932	211
2	Spain	82	1441	141
3	UK	71	1928	207
4	Germany	64	1199	136
5	USA	52	1428	85
6	China	46	848	69
7	Portugal	36	444	32
8	Netherlands	35	1010	151
9	India	34	575	47
10	Brazil	31	377	79
11	Poland	30	163	18
12	Austria	27	683	117
13	Denmark	25	1014	157
14	Belgium	25	377	64
15	France	23	477	52
16	Sweden	22	455	69
17	Switzerland	20	648	111
18	Finland	16	443	43
19	Norway	16	205	44
20	Romania	16	113	5
21	Australia	13	365	31
22	Ireland	12	319	34
23	Canada	12	160	22
24	Columbia	11	131	7
25	Greece	11	93	8
26	Malaysia	10	253	20
27	Czechia	10	118	12
28	Lithuania	9	159	17
29	Thailand	9	92	10
30	South Korea	8	150	20
31	Slovenia	8	78	1
32	Mexico	8	13	5
33	Taiwan	7	93	7
34	Türkiye	7	47	4
35	Chile	6	80	2
36	Saudi Arabia	6	67	3
37	Serbia	6	57	5
38	New Zealand	5	246	18
39	Latvia	5	71	0

When countries are analyzed in the citation analysis type, there are 39 countries among 85 countries with a minimum of 5 publications. Thirty-eight of these 39 countries are mapped as connected in Fig. 14. As can be seen from the map, the European Union countries have a lot of publications and also have a very intense effect on citation. In addition, when we look at the citation relationship between countries, the density among the European Union countries and the density of the Far East countries among themselves draw attention. In addition, the citation relationship between the European Union and Far East countries is at a visible level.

Bibliographic coupling is an analysis method that enables connections to be revealed according to the reference numbers they share. The connection between them increases proportionally when the citation increases and provides the similarities between the documents, sources, authors, organizations, and countries between the two publications [19]. When the countries with a minimum of 5 publications in bibliographic coupling analysis are examined, we see Italy first. Spain, the UK, Germany, and the USA follow respectively. We can see that the countries in the co-authorship analysis given in Fig. 13 and the countries in the bibliographic coupling analysis given in Fig. 15 are similar and that the European Union countries are quite ahead in terms of “circular economy” and “packaging.”

On bibliographic coupling analysis, it is indicated that 39 countries with 5 documents meet the threshold and the map is given in Fig. 15.

## Conclusions

In the research conducted in Scopus, 761 articles published between 2010 and 2022 were found with the keywords “circular economy” and “packaging.” At the same time, these 761 publications and 2695 authors, 2154 keywords, and 85 countries were analyzed.

Twenty-nine of these articles have more than 100 citations. Eleven of these 29 articles were published in 2018. This was recorded as the year with the highest number of publications with 37.93%. The year 2018 is followed by the years 2019, 2020, and 2021, respectively, as a percentage. In 2011 and 2016, an article with more than 100 citations was published. These publications, which have more than 100 citations, have been mapped with citation and bibliographic coupling analysis. The citation and common reference use relationships of these publications with each other are also revealed.

The point that draws attention here is that there is no most cited article from 2022 with the highest number of articles. This is the negative aspect of bibliometric analysis. Since reliable data could not be obtained in recent years, comparisons do not provide very clear information.

In Scopus, 12 authors with more than 5 publications with the keywords “circular economy” and “packaging” between 2010 and 2022 were examined. Co-authorship analysis of these authors was also made, and their relationships were mapped. Certain clusters were observed in the bibliographic coupling analysis. This showed that some authors used more common references with each other.

When the number of publications is analyzed by years, the increase continuously draws attention by years. The highest increase was recorded from 2015 to 2016 with 275%, and then the increases continue during all these years.

It was seen that 751 of these 761 publications analyzed in Scopus were published in English. Although this high rate is expected, Spanish, German, Portuguese, Chinese, and

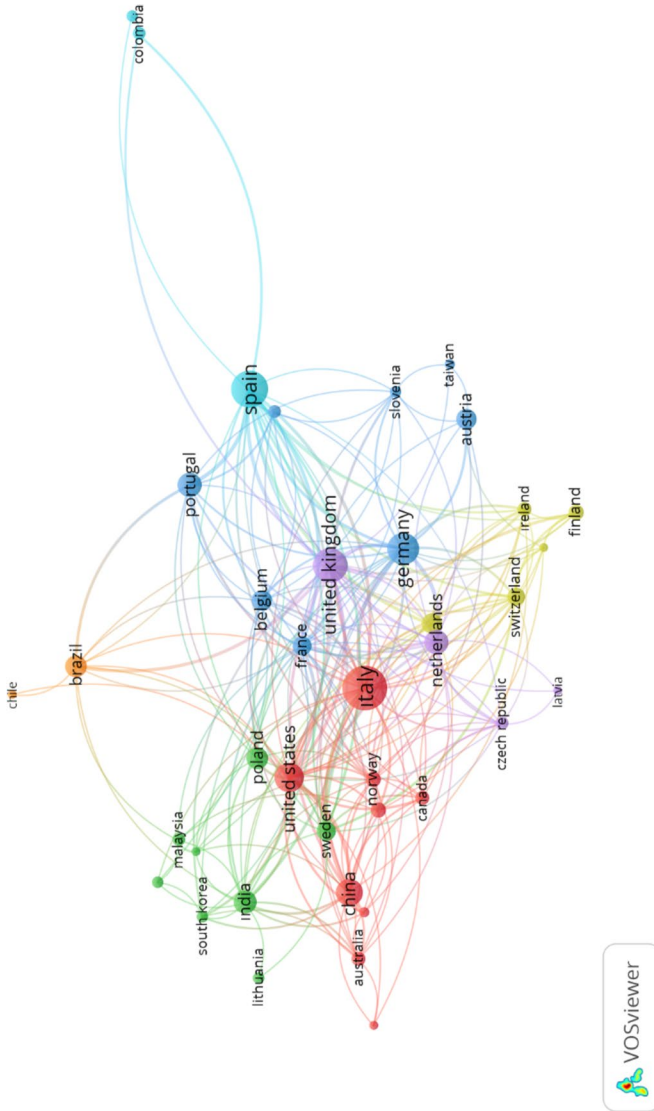


Fig. 13 Mapping of countries with minimum 5 publications on co-authorship analysis

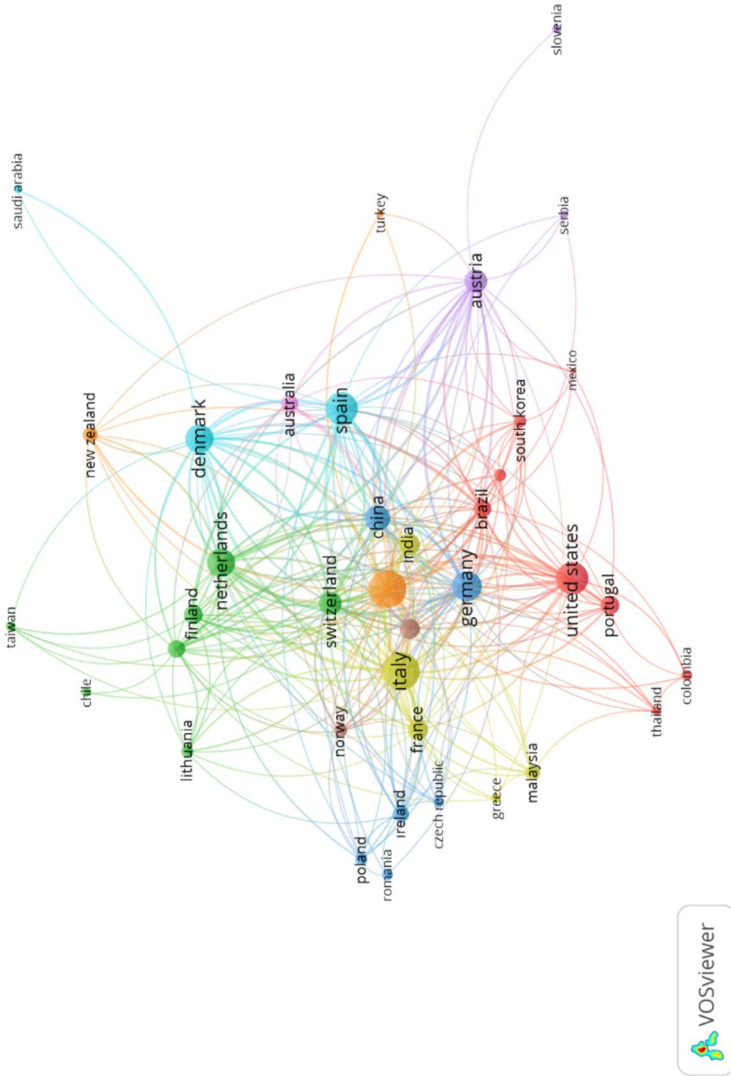


Fig. 14 Mapping of countries with minimum 5 publications on citation analysis



Russian follow respectively English. It shows the importance of the articles to be published on this subject in English.

When the publishers of publications with the keywords “circular economy” and “packaging” are examined in Scopus, “Sustainability Switzerland” takes the first place with 65 publications. The “Journal of Cleaner Production” comes with the 57 publications of the Sustainability Switzerland magazine. In the 3rd place is the magazine “Resources, Conservation and Recycling” with 31 publications. When citation analysis was made to these sources, it was seen that the exhibitions with the most publications were also heavily related to each other. When the co-citation analysis of the publishers is made and mapped, sources that refer to each other are seen as expected. It has been clearly seen that these sources are both the sources with the most publications and the sources with the most citations. In the bibliographic coupling analysis, it was seen that the sources with the most publications used more common references with each other.

When both affiliations and publication countries are examined, we can say that European Union countries are ahead in the number of publications by a large margin. Far East countries also have a significant number of publications. According to the number of publications, European Union countries have a large rate of 60.50%. Far East countries have a rate of 8.36%. It has been observed that the European Union countries are quite ahead in the number of citations. In the mappings, it was seen that the European Union countries mostly work together with the European Union countries, use common references, and refer to each other. We can talk about this situation for the Far East countries as well. In addition, the relations of European Union countries with Far East countries are at a remarkable level. As a result of the mapping, it is clearly seen that countries other than the Far East countries, especially the European Union countries, should study a lot in this field and publish scientific papers.

In this research, it was seen that the publications with the keywords “circular economy” and “packaging” were mainly in the field of sciences, especially in environmental science. In addition, it is noteworthy that the social science category is in the 5th place.

When the keywords are examined, it is an expected result that “circular economy” will be in the first place. This keyword is followed by the recycling and packaging keywords. In accordance with the subject area, it is seen that most of the most used keywords are related to the environment. In addition to this, the density and relationship of the keywords used together are also revealed. It is quite remarkable that the word plastic is mentioned in 6 of the 17 most highly co-occurrence keywords examined. Emphasizing plastic packaging in the studies planned to be done in the future may mean that it will come to the fore as it has the plastic keyword among the articles in this field.

With this bibliometric analysis, a photograph of the publications with the keywords “circular economy” and “packaging” was revealed; it is aimed to create ideas for future studies by identifying the gaps in the literature, to reveal the situation of these many articles, which have been continuously increasing over the years and published in a wide area, with all the details. All these findings we suggest and outline have various aspects on how to react to each subject. So the authors believe that the project makes the majority of the way toward selecting how to proceed for a better future.

**Author Contribution** All authors have contributed substantially to the conception, design, and elaboration of the manuscript.

**Data Availability** All data generated or analyzed during this study are included in this published article (and its supplementary information files).

## Declarations

**Ethics Approval and Consent to Participate** This is a literature review and no ethical approval is required.

**Consent for Publication** Not applicable.

**Competing Interests** The authors declare no competing interests.

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