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The 100 most cited articles in microplastics: A bibliometric perspective

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Abstract

This study focused on the 100 most cited articles in microplastic research that were published between 2008 and 2022, with 68% being original research articles and the remainder comprising reviews, short surveys, and other formats. These articles received a total of 113,160 citations, with an average citation density indicating sustained impact. The most cited article received 3,847 citations, while the least cited among the top 100 received 717. These articles appeared in 27 different journals, with Environmental Science and Technology contributing the highest number of publications (n=25) and total citations (n=29,965). The United Kingdom was the most prolific country, producing 25 articles, followed by the United States (n=17) and Germany (n=16). Richard Thompson emerged as the most prominent author, contributing 11 articles with 16,592 citations, while Tamara Galloway demonstrated the highest level of collaboration based on total link strength. Keyword analysis revealed that “microplastics” was the dominant theme, with emerging interests in human health implications, as evidenced by citation density trends. This bibliometric study provides a comprehensive overview of microplastic research, highlighting key journals, authors, institutions, and thematic shifts, thereby facilitating future research directions and collaborations.

Keywords: Microplastics pollution, bibliometric study, journal article, article citation, microplastics future research direction

Introduction

Microplastics are defined as small plastic particles less than 5mm in size (Yap, 2023). They originate from various sources, such as cosmetic products, industrial processes, and the degradation of larger plastic debris (Chen et al., 2023). The distribution of microplastics in marine ecosystems is widespread, including surface waters, deep-sea environments, and sediments (Amelia et al., 2021). They are pervasive in marine environments, freshwater systems, soils, and even atmospheric deposits. Studies have reported that their presence across diverse ecological compartments, including surface waters, sediments, and marine organisms, raises concerns about their potential ecological and health impacts (Li et al., 2023; Ziani et al., 2023). Because of their persistence, mobility, and capacity to adsorb harmful chemicals, microplastics represent one of the most pressing global environmental threats.

The impact of microplastics on marine ecosystems is a growing concern. Studies have shown that microplastics can act as vectors for transporting major ocean

pollutants, posing hazards to marine ecosystems and potentially impacting human health (Amelia et al., 2021). The accumulation of microplastics in marine sediments has been linked to various factors, such as seasonal variations and the composition of the microplastics, with polypropylene, polyethylene terephthalate, and polyethylene being the most frequently detected compositions (Chen et al., 2023). Additionally, the fate of microplastics in the environment is crucial, as they may be transferred or accumulated in the biological chain, potentially affecting marine organisms and human health (Liu et al., 2021).

While extensive research has been conducted on microplastic pollution, there has been no consolidated analysis summarizing the most influential studies in this field. Identifying the 100 most cited articles provides valuable insights into the progress, trends, and seminal works shaping microplastic research globally. Such analysis helps scholars and policymakers recognize the key contributions, influential authors, and main research themes that have driven understanding and innovation in this domain. Bibliometric and citation analyses are widely used to evaluate the impact and dissemination of research within a field, helping to identify influential studies, collaboration networks, and emerging trends. Therefore, a bibliometric overview of the most cited literature on microplastics can provide important insights into the evolution and direction of this research area. Given the rapid expansion of microplastic research and the need to understand its intellectual structure, this study aims to identify and analyze the 100 most cited articles on microplastics using a bibliometric approach. By doing so, it connects environmental concerns with scientific contribution patterns, thereby highlighting research dynamics, influential authors, and emerging topics within this field.

Methods

Data search strategy

In the present study, a literature search was conducted in the Scopus database as of January 2024. The terms “microplastic” in the article title were used to search for relevant articles related to microplastic research. The retrieved documents were structured in decreasing order of the number of citations counts and the 100 most cited articles were recorded. There were no restrictions in terms of document type, source type, language, publication date, or status.

Data analysis

Bibliomagika (Aidi, 2024) was used to calculate the citation metric and evaluate the characteristics of the citation (authors, title, year of publication, journal), and the VOSviewer software version was utilized to create and visualize the bibliometric network.

Results

Research trends, types of documents, number of citations, and citation density

The publication number of journal articles in the Scopus database shows that microplastic research has been drastically increasing since 2008. The publications started with 2 digits between 2008-2014 and started increasing to several hundred publications per year in 2015 until 2019. Year 2020 onwards, thousands of publications appeared every year, indicating keen interest in this research topic (Figure 1).

Out of the 100 most cited articles, 68 were Research Articles, 26 were Reviews, 3 were Short Surveys, 2 were Notes, and 1 was a Letter, with all articles written in English. The citation metric of the 100 most cited articles is shown in

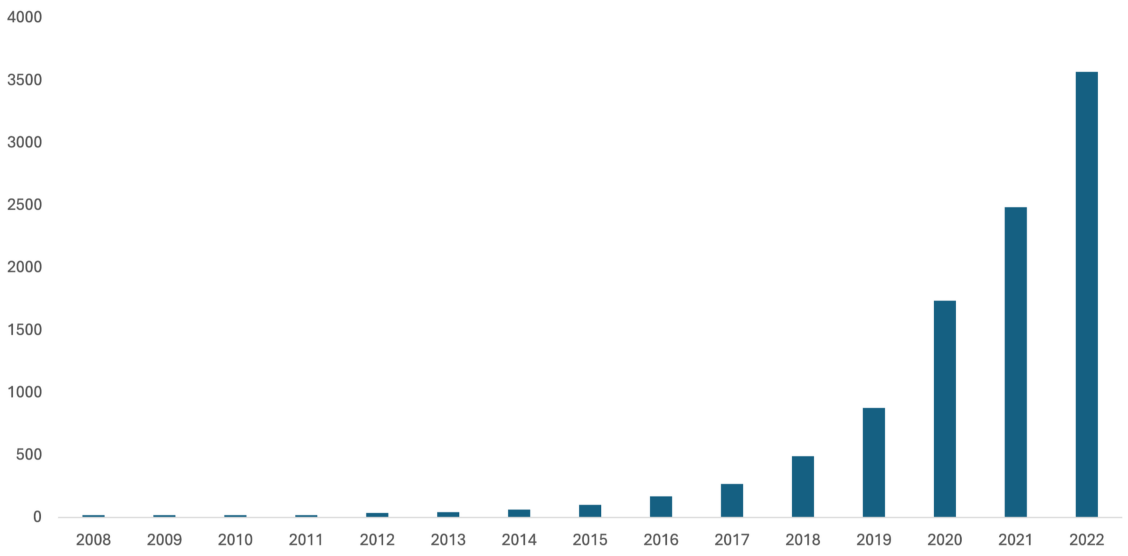


Figure 1. Total articles about microplastics per year.

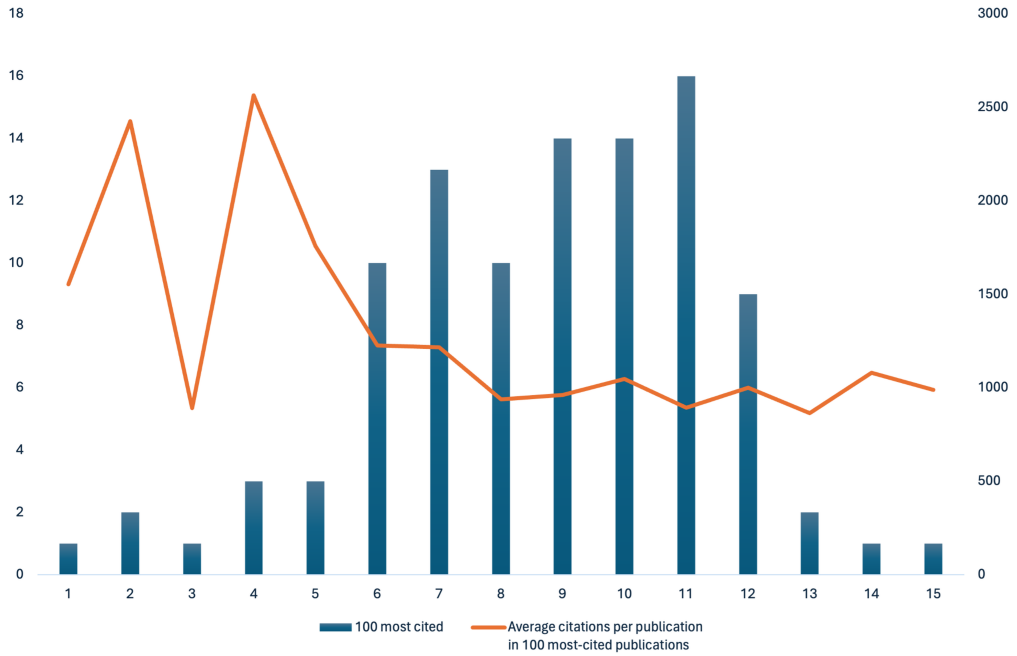


Figure 2. Distribution of the 100 most cited articles and average citations per publication.

Table 1. Citation metric.

Publication years	2008-2022
Citations	113160
Cites/Year	7072.5
Cites/Paper	1131.6
Authors/Paper	4.96
H- index	100
g-index	100

Table 1. The articles were published between 2008 and 2022 (Figure 2), with a total citation of 113160, with an H-index and g -index each of 100. The year 2018 recorded the highest number of publications out of the 100 most cited articles (n=16).

Each of the top 40 articles received over 1000 citations. The article by Barnes et al. (2009) entitled "Accumulation and fragmentation of plastic debris in global environments "is the first top 100 with 3847 citations. The article by Cole et al. (2011) entitled "Microplastics as contaminants in the marine environment: A review" was ranked second with 3614 citations. The last 100 top-cited articles are "Current research trends on plastic pollution and ecological impacts on the soil ecosystem: A review" by Chae & An (2018) with 717 citations.

The articles were then ranked in order of their citation density (the total number of citations divided by the number of years the article was published) (Jones et al., 2017). The article with the highest citation density is (Leslie et al., 2022) entitled "Discovery and quantification of plastic particle pollution in human blood" with 329 citations. 33 citation density, while the lowest is the article by Browne et al. (2010) entitled "Spatial patterns of plastic debris along estuarine shorelines" with 59.4 citation density.

Journal characteristics

The total of 16063 documents related to microplastics research in 156 journals. Journals of the 100 most cited articles are listed in Table 2 in descending order based on the total number of publications. The articles appeared in 27 separate journals. Journal of "Environmental Science and Technology" published the most articles (n=25), followed by "Environmental Pollution" (n=16), and Marine Pollution Bulletin (n=12). These three journals contributed 53% of the most cited articles in microplastic research. Sixteen out of 27 journals (59.2%) published only one article each in the 100 most cited articles list. SCImago Journal Rank (SJR) of the journals ranged between 0.774-13.328. The journal with the highest SJR was Science (13.328), which contributed two articles, and the lowest SJR was Estuarine, Coastal and Shelf Science (0.774).

Productive authors and co-authorship

A total of 429 researchers contributed to the 100 most cited articles in microplastic research. Thompson Richard authored 11 articles with a total citation of 16592, followed by Galloway Tamara (n=8) with 11403 citations. However, Galloway has the highest total link strength (TLS), indicating more collaboration with other authors. This is also observed in Cole`s work, which

Table 2. Descriptions of journals in which the 100 most cited articles were published.

Journal title	TP	TC	Publisher	Cite Score	SNIP (2022)	SJR (2022)
Environmental Science and Technology	25	29965	American Chemical Society	16.7	2.052	3.123
Environmental Pollution	16	16531	Elsevier	14.9	1.704	2.11
Marine Pollution Bulletin	12	15099	Elsevier	10.1	1.305	1.49
Science of the Total Environment	8	7923	Elsevier	16.8	2.026	1.946
Water Research	8	8471	Elsevier	19.8	2.421	3.338
Environment International	5	5164	Elsevier	22	2.594	3.075
Current Biology	2	1560	Elsevier	12.1	1.81	2.806
Estuarine, Coastal and Shelf Science	2	1736	Elsevier	5.5	0.966	0.774
Marine Environmental Research	2	1575	Elsevier	6	0.946	0.865
Proceedings of the National Academy of Sciences of the United States of America	2	3158	National Academy of Sciences	19.2	2.765	4.026
Science	2	1686	American Association for the Advancement of Science	59	7.729	13.328
Annals of Internal Medicine	1	857	American College of Physicians	21.1	5.157	3.845
Biological Reviews	1	1545	Wiley-Blackwell	23.5	4.195	4.388
Current Environmental Health Reports	1	895	Springer Nature	10.4	2.094	1.791
Environmental Chemistry	1	997	Springer Nature	23.9	2.738	2.295
Environmental Research Letters	1	1067	Institute of Physics Publishing	10.1	1.656	2.119
Environmental Science and Technology Letters	1	824	American Chemical Society	16.2	1.888	2.909
Environmental Sciences Europe	1	1012	Springer Nature	9.2	1.574	1.227
Global Change Biology	1	1225	Wiley-Blackwell	19.5	3.007	4.069
International Journal of Environmental Research and Public Health	1	745	Frontiers Media S.A.	5.4	1.28	0.828
Nature Ecology and Evolution	1	1097	Springer Nature	24.9	3.989	5.374
Nature Geoscience	1	1098	Springer Nature	32.5	4.78	6.11
Philosophical Transactions of the Royal Society B: Biological Sciences	1	3864	The Royal Society	12	1.629	2.084
PLoS ONE	1	2963	Public Library of Science	6	1.253	0.885
Royal Society Open Science	1	1263	The Royal Society	6	1.173	0.841
Science Advances	1	741	American Association for the Advancement of Science	20.4	2.861	4.598
Scientific Reports	1	752	Springer Nature	7.5	1.312	0.973

has 10 TLS, albeit a low number of articles (Table 3). Figure 3 shows a collaboration network that was created for authors for authors who contributed at least 2 or more articles in the 100 most cited articles. In the collaborative network, only 24 of 46 authors who produce at least 2 articles were linked together. The remaining 22 authors were not connected to each other.

Table 3. The top five productive authors. : TC= total citations, TLS= total link strength.

Rank	Author`s name	Articles	TC	TLS
1	Thompson, Richard	11	16592	5
2	Galloway, Tamara	8	11403	14
3	Janssen, Colin	6	5941	5
4	Koelmans, Albert	5	4517	5
5	Cole, Matthew	4	7391	10

Countries of origin, institutions, and funding bodies

The 100 most cited articles on microplastics originated from 32 different countries. The most prolific country was the United Kingdom with 25 documents, followed by the United States (n=17), Germany (n=16), the Netherlands (n=14), France (n=11), Australia (n=10), Canada, Belgium, and China each with 7 documents, Italy (n=6), and other countries. Figure 4 shows a collaboration network of the countries that was created with a threshold of 2 or more documents per country. The number of international collaborations was the largest in the United Kingdom and the United States (Figure 5).

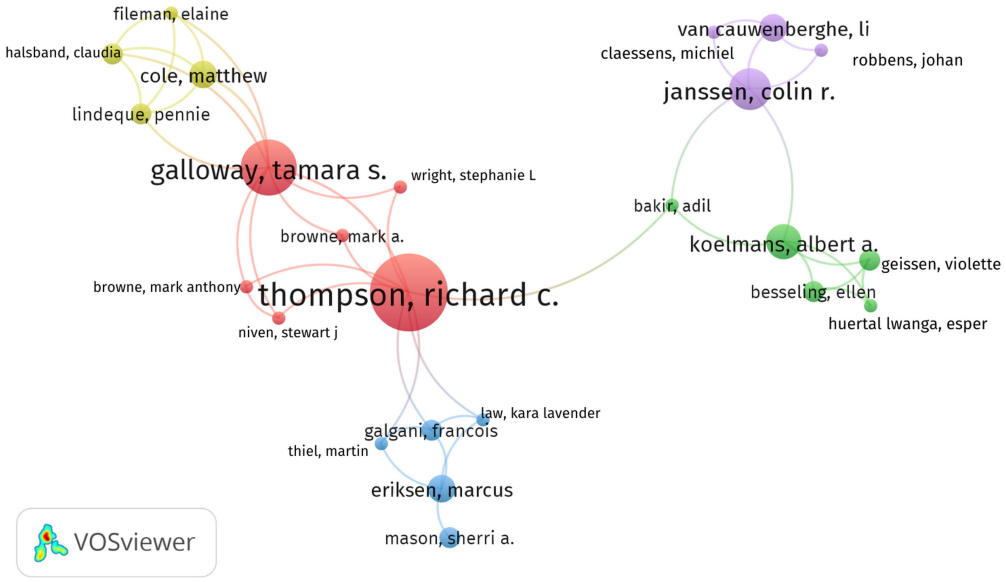
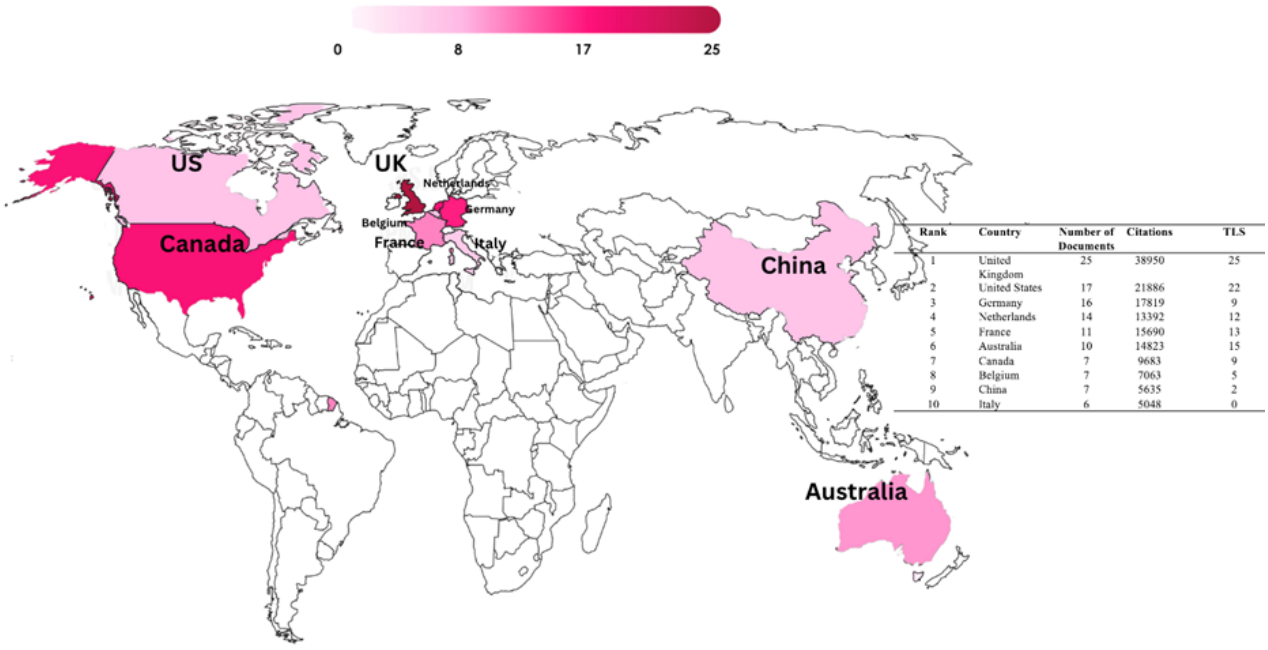


Figure 3. Co-author contribution with 2 or more articles with their network in the top 100 most cited articles.



Rank	Country	Number of Documents	Citations	TLS
1	United Kingdom	25	38950	25
2	United States	17	21886	22
3	Germany	16	17819	9
4	Netherlands	14	13392	12
5	France	11	15690	13
6	Australia	10	14823	15
7	Canada	7	9683	9
8	Belgium	7	7063	5
9	China	7	5635	2
10	Italy	6	5048	0

Figure 4. Top 10 contributing countries. TLS = Total link strength.

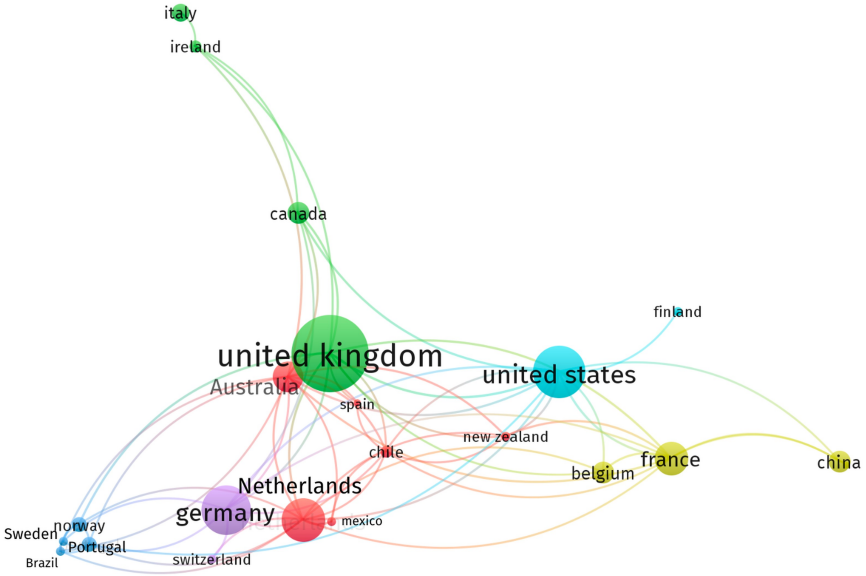


Figure 5. Visualization map of country co-authorship (international collaboration) for publications related to microplastics.

A total of 300 organisations contributed to the top 100 articles on microplastics. Two institutions with the highest number of articles were the Institute for Marine Resources and Ecosystem Studies, Wageningen University, and State Key Laboratory of Estuarine and Coastal Research, East China Normal University (n=3, each).

Keywords of the top cited studies

A total of 217 author keywords were identified, with 179 of them appearing only once. Figure 6 shows the network analysis of keyword co-occurrence. “Microlastics” is the largest node, with 29 occurrences, followed by “microplastic” (n=17), “marine debris” (n=8), “pollution” and “nanoplastics” (n=5, each), “plastic pollution”, “plastic” and “human health” (n=4).

Discussion

Citation analysis is a widely used method to estimate impact and trace the dissemination of knowledge in a particular research niche (Bradley et al., 2020; Sharma & Lawrence, 2022). It is an active area of research used to assess the impact of individual works, researchers, institutions, and entire

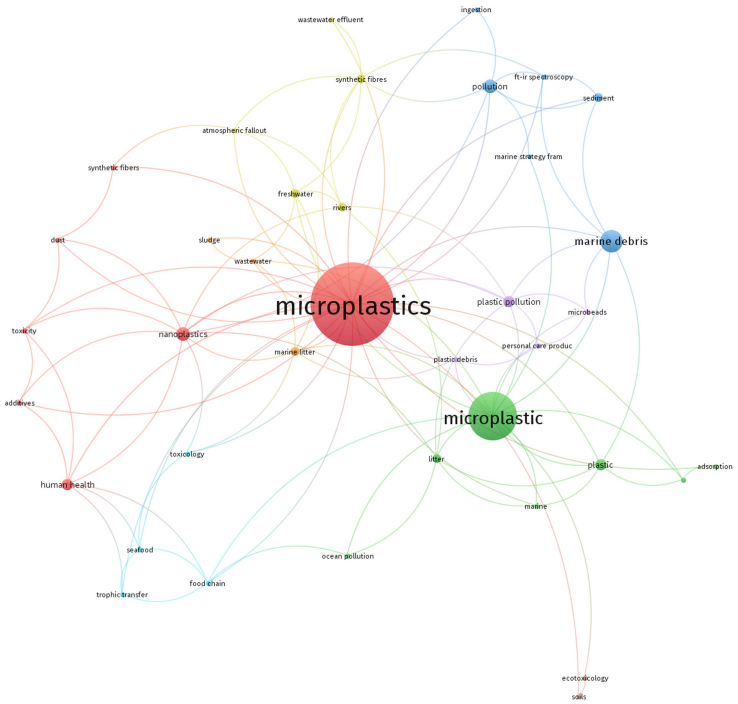


Figure 6. Keyword co-occurrence network of the top 100 most cited articles.

fields of study (Frachtenberg, 2023; Roman et al., 2021). It also provides insights about relationships between different publications and authors, identifies different areas of research, and determines the most cited publications (Nascimento et al., 2020). Furthermore, citation analysis is employed to identify the most influential publications, authors, and institutions, and to allocate research funds (Jiang & Liu, 2023; Nazir et al., 2022).

In this study, we focus on the top 100 most cited articles in microplastics research. All the articles have more than 700 citations, showing their high contribution to microplastic research. The average citation per publication is high in early years (2008-2012), with a sharp decline in 2010, due to the limitation of highly cited documents during those years. Older articles typically had plenty of time to reach a global audience and were therefore more likely to be cited than those that were recently published, irrespective of their scientific merit. Consequently, although highly significant, the recent publications would not be reflected in citation analysis (Aziz et al., 2021). The average citation started to fall in 2013 onwards due to a sharp increase number of highly cited publications starting in 2013 until 2019. The average citation remains stagnant from 2020-2022, although a very small number of highly cited documents were published in those years. The possible reason for the small number of documents in 2020-2022 is due to the time required to accumulate citations of these published articles.

Citation density, defined as the number of citations a document receives per year, allows for the assessment of the frequency of citations over time, providing insights into the sustained impact of a publication within the scholarly community (Mattos et al., 2020; Memon et al., 2021). The highest cited article by Barnes et al. (2009), entitled "Accumulation and fragmentation of plastic debris in global environments," ranked number eight in citation density. The second-highest cited article by Cole et al. (2011), entitled "Microplastics as contaminants in the marine environment: A review," ranked fourth in citation density. Although it has been a decade, these two articles are still referred to in microplastic studies, showing that the effect of microplastics on the marine environment is an evergreen research interest. The article by Leslie et al. (2022) entitled "Discovery and quantification of plastic particle pollution in human blood" has the highest citation density, although ranked number 44 in citations. Second-highest citation density is the article by Ragusa et al. (2021) entitled "Plasticenta: First evidence of microplastics in human placenta". This shows the new interest emerging in microplastic studies is its existence in humans.

Country contribution of the top 100 most cited publications shows that top five countries ranked based on highest contribution are United Kingdom (25%), United States (17%), Germany (16%), Netherlands (14%) and France (11%) are the top five countries ranked based on highest contribution. It is clear that research on microplastics is contributed mainly by European and Western countries.

The top 100 most cited articles in microplastic appeared in 27 separate journals, with the Journal of "Environmental Science and Technology" published the most articles (n=25), "Environmental Pollution" (n=16), and Marine Pollution Bulletin (n=12) contributing 53% of the most cited articles in microplastic research. This indicated that the 100 most cited publications in microplastics are largely in Q1 or higher-ranked journals, with all three journals focusing on environmental science with specific emphasis on the marine environment.

The origin of the 100 most cited articles on microplastics from 32 different countries is similar to the findings of Qin et al. (2020). The United Kingdom is the most prolific country in microplastics research in terms of the number of documents, total citations, and total link strength (TLS) consistent with the study of microplastics in soil (Yang et al., 2023). This also emphasizes the influence of the UK in terms of collaboration between countries. Richard Thompson is the most prominent author in microplastic research, having authored 11 articles with a total citation of 16592, followed by Galloway Tamara (n=8) with 11403 citations. Collaboration among authors can be observed in Total Link Strength, such as Galloway Tamara (n=15) and Cole (n=10), indicating more collaboration with other authors.

Co-occurrence network analysis is a method used in bibliometric research to identify and visualize the relationships between keywords. This analysis provides insights into the patterns of keyword co-occurrence, highlighting the interconnectedness of concepts and the prevalence of specific themes within the literature. By examining the co-occurrence of keywords, researchers can gain a deeper understanding of the knowledge structure, emerging trends, and research hotspots within a particular field (Du et al., 2021; Yao et al., 2020). In this study, "Microplastics" still remains the major theme in the study with a focus on marine debris and pollution as the basis of research. Keyword co-occurrence analysis reveals that 'human health' has emerged as a high-impact node, reflecting a bibliometric transition in microplastic research from oceanic contamination to human toxicology. This thematic shift mirrors scientific and political recognition under UNEA's plastic governance initiatives, emphasizing the urgent need for harmonized monitoring frameworks linking marine and human exposure pathways (Mary Ellen & Jeffrey, 2023; Wiesinger et al., 2021).

Conclusions

In this study, we focus on the top 100 most cited articles in microplastics research. All of the articles have more than 700 citations, showing their high contribution to microplastic research. The analysis reveals that microplastics have moved beyond being characterized as a marine pollutant to becoming a major interdisciplinary topic bridging marine science, environmental toxicology, and public health.

Citation density and keyword co-occurrence analyses reveal a notable shift in research focus from ecological and physical characterization toward "human microplastic exposure," marking the emergence of microplastics as a human health concern. The findings of this study underscore microplastic pollution as a persistent and multifaceted environmental challenge with global implications. The bibliometric perspective not only maps past and current research strengths but also highlights potential future directions in nanoparticle behavior, trophic transfer mechanisms, biodegradation solutions, and policy-oriented risk assessments. Furthermore, this study provides a valuable reference point for early-career researchers, policymakers, and funding agencies seeking to align research agendas with the emerging interdisciplinary approaches required to address microplastic impacts from oceans to organisms.

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Authorship contributions

Muhammad Fitri Yusof: Conceptualization, methodology, investigation, formal analysis, data curation, software, resources, writing - original draft, riting - review and editing. **Mohd Fuad Miskon:** Writing - review and editing. Authors reviewed and approved the final manuscript and are responsible for the integrity and accuracy of the work.

Data availability

The data supporting the findings of this study are available upon reasonable request from the corresponding author.

Conflict of interest

The authors declare that they have no conflicts of interest regarding the publication of this article.

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