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Mapping the Plastic Waste Research Landscape: A bibliometric analysis of the interdisciplinary nature of plastic waste research

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Abstract
The purpose of this study was to explore a comprehensive bibliometric analysis of research on plastic waste. A systematic literature search was conducted using the Scopus database to retrieve articles published between 2011 to 2022. The bibliometric indicators used such as the number of publications, citations, and collaboration networks. The study revealed 2735 articles on plastic waste were published. India and China were the most productive countries in terms of publication output. The analysis identified a strong network of collaborations among researchers. Several limitations were also identified. This study provides insights for future research and recommendations for policymakers.

Keywords: plastic waste; sustainability; bibliometric

1.0 Introduction

Recent bibliometric studies have highlighted the increasing volume of research on plastic waste and the growing recognition of plastic waste as a significant environmental issue (Zhang et al., 2023; de Sousa, 2021). Some of the key areas of focus in recent research on plastic waste include the impact of plastic on marine ecosystems (Kasavan et al., 2021), the role of microplastics in the environment (Zhang et al., 2020), and the effectiveness of policy interventions aimed at reducing plastic waste (Wang et al., 2022). In addition, recent studies have also highlighted the need for interdisciplinary collaboration and innovation to address the complex and multifaceted issue of plastic waste (Getor et al., 2020; William et al., 2022). The motivation for conducting bibliometric studies on plastic waste is driven by the urgent need to address the global environmental and social challenges associated with plastic waste.

Bibliometric studies on plastic waste aim to identify the trends and patterns of research on plastic waste. This information can help guide future research and support the development of evidence-based policies and practices that can mitigate the negative impacts of plastic waste. However, many bibliometric studies on plastic waste tend to focus on plastic waste in general, without differentiating between different types of plastic waste, such as microplastics, macroplastics, or single-use plastics (Wang et al., 2022). Most studies tend to focus on research from developed countries, such as the United States and European countries, and there is a lack of research that examines the trends and patterns of research on plastic waste from developing countries (Kibria et al., 2023). Therefore, bibliometric studies that examine the research trends and impact of plastic waste on a diverse scale are needed to inform policies and practices that can mitigate these impacts.

2.0 Literature Review

2.1 Plastic Waste

Plastic waste has become a global environmental concern due to its significant impact on ecosystems and wildlife (Jambeck et al., 2015). Mastellone et al. (2019) explored various recycling technologies to improve plastic waste management practices. Additionally, Coelho et al. (2020) evaluated the effectiveness of plastic waste reduction policies, highlighting the importance of policy interventions for sustainable plastic waste management. Also, Koelmans et al. (2019) conducted extensive research on the sources, distribution, and potential ecological impacts of microplastics. Plastic waste has socio-economic implications that extend beyond environmental concerns. Huang et al. (2019) assessed the economic costs associated with plastic pollution while Borrelle et al. (2020) examined policy interventions and regulations targeting plastic waste, underscoring the importance of multi-faceted approaches involving stakeholders at various levels.

2.2 Plastic Waste and Sustainability

Studies have highlighted the need to reduce plastic waste generation and mitigate its impact on ecosystems. Geyer et al. (2017) conducted a comprehensive assessment of global plastic production, use, and disposal, emphasizing the urgency of transitioning towards a circular economy to enhance environmental sustainability. Andrady (2022) discussed the persistence and long-term effects of plastic debris on land and marine environments. In addition, Santos et al. (2021) investigated the social perception and behavior toward plastic waste management, providing insights into public attitudes, awareness, and engagement. Torkashvand et al. (2021) conducted a comprehensive economic analysis of plastic waste management options, assessing the costs and benefits associated with recycling, landfilling, and incineration. Jambeck et al. (2018) discussed the potential of waste management strategies while Liao et al. (2021) focused on the development of sustainable materials and bio-based alternatives to conventional plastics

3.0 Methodology

The present study employs bibliometric analysis as a method to evaluate contemporary developments in academic discourse concerning the plastic waste research landscape. Through the utilization of network visualization and bibliometric indicators, this paper endeavors to demonstrate the outcomes of the analysis.

3.1 Bibliometric Analysis

Bibliometric analysis is a research method used to quantitatively analyze the characteristics of scientific publications (Zyoud et al. 2017). It involves examining patterns and relationships among various bibliographic elements, such as authors, journals, citations, and keywords, to provide insights into the structure, impact, and development of a particular research field or topic (Dabirian et al. 2016).

To conduct the bibliometric analysis for this study, the researchers utilized VOSviewer, a freely accessible tool that enables the construction and visualization of network relationships (vosviewer.com). It provides researchers with a means to construct and visualize networks based on citation data extracted from well-established databases such as PubMed, Scopus, Dimensions, and Web of Science (Donthu et al., 2021) which enables researchers to understand the significance and strength of the connections between publications.

Harzing's Publish or Perish has been another tool performed in this analysis. It provides researchers with a comprehensive set of tools to assess the impact and visibility of scholarly publications. It facilitates the analysis of citation patterns across different disciplines, journals, and publication years (Harzing.com). By employing VOSviewer and Publish or Perish, this study could gain valuable insights into the citation landscape and make informed decisions regarding their publishing strategies.

3.2 Sources and Data Collection

In this study, the Scopus database is used as the primary source of data because it is known to be one of the most renowned and prominent academic databases. According to Sweileh (2018), the elements contained in the Scopus database help to suit the bibliometric indicators precisely and concisely. The scope of the topic was focused on 'plastic waste and sustainability'. The authors further followed the guidelines contained in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) for document search purposes which can be seen in Figure 1. Furthermore, a combination of the search strings was conducted in searching the data from the database such as TITLE-ABS-KEY ("plastic waste" AND "sustainability").

Based on the search conducted in the Scopus database, a total of 2735 documents were generated (refer to Figure 1). This search was performed on 15 March 2023. Subsequently, a series of filtrations were applied to this initial set of documents. It involved excluding publications from 2023, as the year had not yet concluded, papers that did not align with the concept of plastic waste and sustainability, duplications among conference papers, articles, and books, and unqualified document types such as notes, editorials, letters, retracted papers, and short surveys. Consequently, a total of 649 documents remained after removing 2087 documents. These 649 documents were then subjected to comprehensive analysis using tools such as Harzing Publish or Perish, Microsoft Excel, and VOSviewer for further examination and exploration.
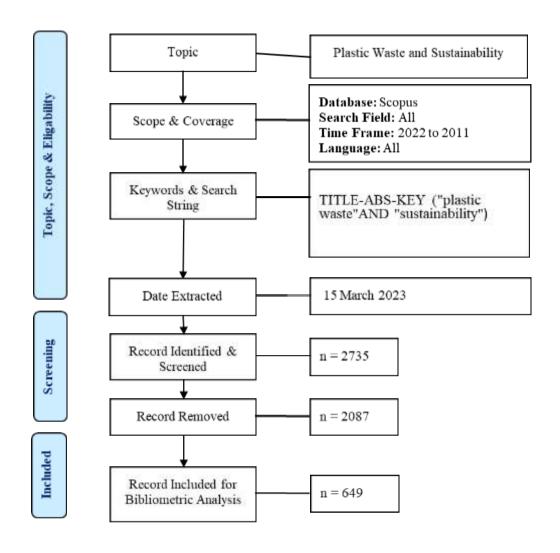
Fig. 1: PRISMA Flow Diagram
(Source: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097)

4.0 Findings

4.1. Document and Source Types

Table 1 provides an overview of the publication types within a certain dataset. The data shows that the majority of the publications are articles, accounting for 63.02% of the total publications. Reviews and conference papers represent 19.11% and 13.10% of the publications respectively, while book chapters and books make up only 4.47% and 0.31% of the total publications respectively. The predominance of articles in the dataset is in line with the trend observed in scholarly publishing, where articles are the most commonly published document type across various fields and are considered the primary means of disseminating research findings.

Table 1. Document Type

Document Type	Total Publications (TP)	Percentage (%)
Article	409	63.02%
Review	124	19.11%
Conference Paper	85	13.10%
Book Chapter	29	4.47%
Book	2	0.31%
Total	649	**100.00**

The distribution of source types in the field of study being analyzed presents in Table 2. The data shows that the majority of publications come from journals, accounting for 82.59% of the total publications. Conference proceedings are the second most common source type,

comprising 11.09% of the total publications. Books and book series make up a smaller portion of the publications, with 3.39% and 2.77%, respectively. Finally, trade journals account for only 0.15% of the publications.

Table 2. Source Type

Source Type	Total Publications (TP)	Percentage (%)
Journal	536	82.59%
Conference Proceeding	72	11.09%
Book	22	3.39%
Book Series	18	2.77%
Trade Journal	1	0.15%
Total	**649**	**100.00**

4.2. Year of Publications/Evolution of Published Studies
Table 3 provides detailed information on the publication statistics covering the period from 2006 to 2018. In 2006, a total of 65 publications were recorded, accounting for 5.89% of the overall publications analyzed. As we move to the subsequent years, the number of publications shows an increasing trend. In 2007, the total number of publications rose to 95, representing 8.61% of the cumulative count. By 2008, there were 69 publications, comprising 6.26% of the total. The year 2009 witnessed a further increase, with 88 publications, making up 7.98% of the cumulative count. The following year, 2010, saw 80 publications, contributing to 7.25% of the total publications analyzed. The trend continued in 2011, with 74 publications (6.71% of the cumulative count), and again in 2012, with 74 publications (6.71%).

Table 3. Year of Publications

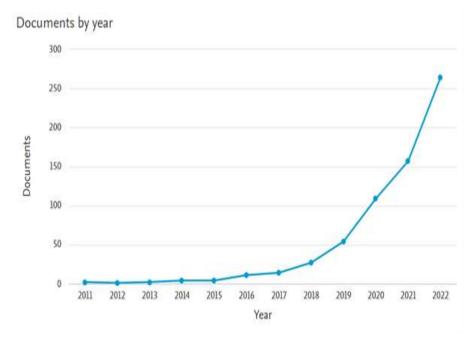| Year	Total Publications	Percentage (%)	Cumulative Percent
2011	74	6.71	58.48
2012	74	6.71	65.19
2013	76	6.89	72.08
2014	76	6.89	78.97
2015	60	5.44	84.41
2016	72	6.53	90.93
2017	80	7.25	98.19
2018	20	1.81	100.00
Total	**1103**	**100.00**	

Fig. 2: Document by Year

4.3. Subject Area
Table 5 provides the total number of publications for each subject area and its percentage. The subject area with the highest number of publications is Environmental Science, with a total of 329 publications, representing 50.69% of the overall count. Engineering is the second most prevalent subject area, with 206 publications, accounting for 31.74% of the total. Energy is the third most represented subject area, with 156 publications, constituting 24.04% of the total. Materials Science follows with 117 publications, representing 18.03% of the total, followed by Chemical Engineering represented by 100 publications, accounting for 15.41% of the overall count. Other subject areas witnessed less than 100 publications.

234

Table 5. Subject Area

Subject Area	Total Publications	Percentage (%)
Environmental Science	329	50.69%
Engineering	206	31.74%
Energy	156	24.04%
Materials Science	117	18.03%
Chemical Engineering	100	15.41%
Social Sciences	83	12.79%
Chemistry	69	10.63%
Computer Science	55	8.47%
Earth and Planetary Sciences	45	6.93%
Physics and Astronomy	44	6.78%
Business, Management, and Accounting	40	6.16%
Agricultural and Biological Sciences	33	5.08%
Economics, Econometrics, and Finance	25	3.85%
Medicine	20	3.08%
Mathematics	16	2.47%
Biochemistry, Genetics, and Molecular Biology	15	2.31%

4.5 Most Active Source Titles

The most active source titles in the analyzed publications are stated in Table 6. The table includes the total number of publications for each source title, as well as the percentage of publications represented by each source title. The most active source title in terms of the number of publications is "Sustainability Switzerland," with a total of 35 publications, representing 5.39% of the overall count. The high number of publications from this source indicates its prominence as a platform for disseminating research on sustainability-related topics. The second most active source title is the "Journal of Cleaner Production," with 20 publications, accounting for 3.08% of the total.

The "Science of the Total Environment" follows closely with 19 publications, constituting 2.93% of the overall count. The "IOP Conference Series Earth and Environmental Science" and "Waste Management" both have 17 publications, representing 2.62% each of the total. Other active source titles show less than 17 total publications.

Table 6. Most Active Source Title

Source Title	Total Publications	Percentage (%)
Sustainability Switzerland	35	5.39%
Journal Of Cleaner Production	20	3.08%
Science Of The Total Environment	19	2.93%
IOP Conference Series Earth And Environmental Science	17	2.62%
Waste Management	17	2.62%
Resources Conservation And Recycling	15	2.31%
Environmental Science And Pollution Research	11	1.69%
Construction And Building Materials	9	1.39%
Journal Of Hazardous Materials	9	1.39%

4.6 Keywords Analysis

The top keywords in the analyzed publications are listed in Table 7. The table includes the keywords, the total number of publications in which each keyword appears, and the percentage of publications represented by each keyword. The most frequently occurring keyword is "Plastic Waste," which appears in 293 publications, accounting for 45.15% of the total. The keyword "Plastics Waste" follows closely with 182 publications, representing 28.04% of the total. "Recycling" is another prominent keyword, appearing in 175 publications (26.96% of the total). Moreover, "Waste Management" appears in 162 publications, accounting for 24.96% of the total whereas "Plastic Recycling" is mentioned in 156 publications (24.04%), highlighting the specific focus on the recycling of plastic materials.

Other notable keywords include "Plastics" with 135 publications (20.80%), "Plastic" with 132 publications (20.34%), "Sustainable Development" with 106 publications (16.33%), "Plastic Wastes" with 92 publications (14.18%), and "Pyrolysis" with 90 publications (13.87%).

Table 7. Top Keywords

Author Keywords	Total Publications	Percentage (%)
Plastic Waste	293	45.15%
Plastics Waste	182	28.04%
Recycling	175	26.96%
Waste Management	162	24.96%
Plastic Recycling	156	24.04%
Plastics	135	20.80%
Plastic	132	20.34%
Sustainable Development	106	16.33%
Plastic Wastes	92	14.18%
Pyrolysis	90	13.87%

4.7 Geographical Distribution of Publications - Most Influential Countries

Table 8 provides information on the top 10 countries that have contributed to the analyzed publications. India ranks first in terms of the number of publications, with 87 publications, accounting for 13.41% of the total. China follows closely with 76 publications, representing 11.71% of the total. The United States ranks third, with 63 publications, accounting for 9.71% of the total. Other countries that have made substantial contributions to the analyzed publications include Malaysia with 49 publications (7.55%), Indonesia with 46 publications (7.09%), the United Kingdom with 39 publications (6.01%), and Australia with 36 publications (5.55%). Italy, Spain, and Canada are also among the top contributors, although with slightly fewer publications compared to the leading countries.

Table 8. Top 10 Countries contributed to the publications

Country	Total Publications	Percentage (%)
India	87	13.41%
China	76	11.71%
United States	63	9.71%
Malaysia	49	7.55%
Indonesia	46	7.09%
United Kingdom	39	6.01%
Australia	36	5.55%
Italy	35	5.39%
Spain	25	3.85%
Canada	22	3.39%

4.10 Citation Analysis

Table 11 provides information on the citation metrics for the analyzed publications. The publication years covered in this analysis are from 2011 to 2012. The citation years span a longer period, from 2011 to 2022, indicating the timeframe during which citations have been accumulated for the analyzed papers. In total, there are 649 papers included in this analysis, which have received a total of 14,412 citations.

The "Citations/year" metric measures the average number of citations received per year. In this case, there is an average of 1,201 citations per year for the analyzed papers, indicating a sustained and ongoing interest in the research. The "Citations/paper" metric calculates the average number of citations received per paper. For the analyzed papers, the average is 22.21 citations per paper, indicating the level of impact and attention received by individual papers. The "Papers/author" metric calculates the average number of papers authored by each author. The average in this analysis is 202.94 papers per author, indicating the level of research productivity and contribution by individual authors.

The "h-index" and "g-index" are bibliometric indices that provide measures of the productivity and impact of the publications and authors. In this analysis, the h-index is 56, indicating the presence of 56 papers with at least 56 citations. The g-index is 103, suggesting that the 103 most highly cited papers collectively account for a significant portion of the total citations.

The top 10 most cited articles on plastic waste and sustainability were presented in Table 12 below. S.B. Borrelli et al. was the most cited article recently with 687 citations in total. It is followed by J.J. KlemeÅ¡, et al. It is followed by Jiang which 487 citations with the title "Minimising the present and future plastic waste, energy and environmental footprints related to COVID-19". The majority of these top ten papers deal with plastic waste pollution and recycling. This reflects that the concern of authors was mainly on the adverse impact of plastic waste and the importance of recycling plastic waste in its pathway to achieve sustainability.

Table 11. Citations Metrics

Metrics	Data
Publication years	2011-2012
Citation years	12 (2011-2022)
Papers	649
Citations	14412
Citations/year	1201
Citations/paper	22.21
Citations/author	3759.85
Papers/author	202.94
h-index	56
g-index	103

Table 12. Highly cited articles

No.	Authors	Title	Year	Cites	Cites per Year
1	S.B. Borrelli, J. Ringma, K. Lavender Law, C.C. Monnahan, L. Lebreton, A. McGivern, E. Murphy, J. Jambeck, G.H. Leonard, M.A. Hilleary, M. Eriksen, H.P. Possingham, H. De Frond, L.R. Gerber, B. Polidoro, A. Tahir, M. Bernard, N. Mallos, M. Barnes, C.M. Rochman	Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution	2020	687	229
2	J.J. KlemeÃ¡, Y.V. Fan, R.R. Tan, P. Jiang	Minimizing the present and future plastic waste, energy, and environmental footprints related to COVID-19	2020	487	162.33
3	K.R. Vanapalli, H.B. Sharma, V.P. Ranjan, B. Samal, J. Bhattacharya, B.K. Dubey, S. Goel	Challenges and strategies for effective plastic waste management during and post-COVID-19 pandemic	2021	285	142.5
4	S.D. Anuar Sharuddin, F. Abnisa, W.M.A. Wan Daud, M.K. Aroua	A review on pyrolysis of plastic wastes	2016	951	135.86
5	I. Vollmer, M.J.F. Jenks, M.C.P. Roelands, R.J. White, T. van Harmelen, P. de Wild, G.P. van der Laan, F. Meirer, J.T.F. Keurentjes, B.M. Weckhuysen	Beyond Mechanical Recycling: Giving New Life to Plastic Waste	2020	402	134
6	A.L. PatrÃ-cio Silva, J.C. Prata, T.R. Walker, D. Campos, A.C. Duarte, A.M.V.M. Soares, D. BarcelÃ², T. Rocha-Santos	Rethinking and optimizing plastic waste management under COVID-19 pandemic: Policy solutions based on redesign and reduction of single-use plastics and personal protective equipment	2020	256	85.33
7	T. Thiounn, R.C. Smith	Advances and approaches for chemical recycling of plastic waste	2020	218	72.67
8	R. Miandad, M.A. Barakat, A.S. Aburiazaiza, M. Rehan, A.S. Nizami	Catalytic pyrolysis of plastic waste: A review	2016	463	66.14
9	O. Dogu, M. Pelucchi, R. Van de Vijver, P.H.M. Van Steenberge, D.R. D'hooge, A. Cuoci, M. Mehl, A. Frassoldati, T. Faravelli, K.M. Van Geem	The chemistry of chemical recycling of solid plastic waste via pyrolysis and gasification: State-of-the-art, challenges, and future directions	2021	132	66
10	M.S. Qureshi, A. Oasmaa, H. Pihkola, I. Deviatkin, A. Tenhunen, J. Mannila, H. Minkkinen, M. Pohjakallio, J. Laine-Ylijoki	Pyrolysis of plastic waste: Opportunities and challenges	2020	194	64.67

5.0 Conclusion & Recommendations

This bibliometric analysis provides an overview of the research conducted on the plastic waste within the context of sustainability. The analysis reveals a growing body of literature addressing various dimensions of plastic waste, including its environmental, social, and economic implications. However, plastic waste studies often overlook its specific types and lack of research in developing countries. Therefore, the findings highlight the urgency of addressing plastic waste as a significant sustainability challenge and offer insights into potential strategies and innovations for a more sustainable future.

The bibliometric analysis of plastic waste shed light on several recommendations for future research. Researchers could analyze different types of plastic found in waste streams and identify the most prevalent sources of plastic pollution and explore innovative and sustainable approaches to plastic waste management. Also, researchers can analyze the existing policies related to plastic waste management and evaluate their impact. Potential job creation in recycling industries and cross-sector collaboration and partnership opportunities among stakeholders to tackle plastic pollution collectively need to be explored further.

Paper Contribution to Related Field of Study
This study makes a valuable contribution to the field of environmental science and sustainability by providing insights into the state of research, assessing the impact of research, informing policy and practice, and supporting interdisciplinary research. Information from this study helps stakeholders identify pathways to achieve sustainable development goals and promote the transition toward a circular economy.

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