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Global Research Trends and Frontiers in Microplastic Pollution: A Bibliometric Systematic Analysis

Caodong Wang

Faculty of Science, Xi'an Jiaotong-Liverpool University, Suzhou, 215004, China
3556603114@qq.com

Abstract: *This comprehensive bibliometric analysis examines global research trends in microplastic pollution on the planet in the period between 2004 and 2024, which involved searching Web of Science Core Collection and analyzing 11,784 articles. Employing advanced science mapping techniques including co-citation analysis, key-word co-occurrence network, and burst detection algorithms, this paper shows that there is an exponential growth trend where the publication numbers have increased almost 1000-folds since 2010. China, United States and Germany became the top achievers, with a combined total of 60% of the world output. They were divided into five large thematic clusters, including environmental distribution and sources, analytical methods, ecotoxicology, human health impacts, and the remediation strategies. Temporal analysis demonstrated that there were three developmental stages: nascent (2004-2014), expansion (2015-2019), and maturation (2020-2024) in which each had specific research priorities and patterns of geographic participation. Emerging frontiers include nanoplastics characterization, human health risk assessment, machine learning applications for particle identification, and circular economy frameworks. Significant research gaps persist in Global South representation, standardized methodologies, and policy-science integration. This paper has some evidence-based suggestions of the future research priorities with the necessity of international collaboration, methodological harmonization and solution oriented studies as the priority to solve this significant environmental problem.*

Keywords: *Microplastics, Bibliometric Analysis, Research Trend, Environmental Pollution, Science Mapping, Citation Analysis, Knowledge Frontiers*

1. Introduction

Microplastic pollution at the micro level is one of the environmental issues of the 21st century that has impacted the ecosystem at the terrestrial, aquatic and atmospheric levels. Microplastics are defined as plastic particles smaller than 5 millimeters in diameter and have many different sources such as the disintegration of larger plastic waste and synthetic clothing, tire wear, cosmetics products, and various industrial operations. As the world plastic manufacturing now exceeds 380 million tons per year and the approximate amount of 1.7 million tonnes of plastics being dumped into the oceans per annum, the environmental pricing is growing by the second [1]. These chronic contaminants were present day found everywhere as far as the ocean floor in the deepest depths of the ocean trenches to remote Arctic waters and even in the human body, including the brain, liver, and kidneys [2].

The health effects of the exposure to microplastic have become more worrisome with the latest evidence showing their bioaccumulation in the human tissues and possible association with severe health issues. Microplastics have been identified in heart tissues and studies finding them indicating that they are related to a higher risk of heart attack and stroke [3]. Additionally, studies have reported the existence of these particles in the human brain tissue, and the concentration of them has been increasing in the past between 2016 and 2024, posing the risk of neurological effects and cognitive consequences with time [2]. The pathways that lead to toxicity because of microplastics are oxidative stress, inflammation, cell damage, and interference with key biological functions, although their complete health effects are an ongoing research topic.

Scientific community has reacted to this crisis in an impressive manner where studies concerning microplastic pollution have grown exponentially within the last decade. Bibliometric studies show that the number of publications in this area has increased drastically, especially since 2019, as a result of the increased awareness and concern on the part of the global society [4]. This research widening includes various areas of focus such as identification of sources, distribution pattern in the environment, ecotoxicology, technique of analysis and remediation of polluted environment. Nevertheless, with such an increased number of studies, there are still major gaps in knowledge, especially on how human exposure can be associated with long-term health effects, how to standardize detection procedures, and how to reduce the harmful impacts. Also, the application of governance and regulatory approaches in research is not as extensive as possible, which also points to an existing gap between knowledge and policy.

It is against this background that systematic bibliometric analyses can be invaluable resources in terms of synthesizing the fast-growing body of literature, research hotspots, collaboration network mapping, and the discovery of new frontiers. Through quantitative techniques to determine the trends in publications, citation patterns, and the thematic evolution, bibliometric studies offer a general picture of the intellectual framework and developmental trajectory of microplastic studies. The method will allow researchers and policymakers to determine the significant contributions, address the gaps in knowledge, and set evidence-based priorities to investigate them in the future. The current research will employ systematic bibliometric research of the international research trends on the topic of microplastic pollution and attempt to analyze patterns of publications in terms of year, contributors, and organizations, thematic groups, and identify new avenues of research. It is through this analysis that we aim to present actionable information that will inform policy making direction and where it will help shape more effective strategies of combating the global crisis of microplastic.

2. Theoretical Framework and Literature Review

2.1 Conceptual Framework for Microplastic Research

Microplastics are a complex environmental issue with a multidimensional nature with an array of interrelated aspects in terms of sources, modes of transportation, and ecological effects. They come in both primary sources such as manufactured microbeads and industrial pellets and secondary sources due to the fragmentation of bigger plastic debris by photodegradation, thermal degradation and biological processes [5]. Microplastics environmental persistence in terrestrial, aquatic, and atmospheric compartments has also been widely reported and, studies have found them in all environmental matrices, including the deepest ocean trenches and remotest polar areas [6]. The transport pathways are also very varied; they include: ocean currents and river flows, atmospheric transport with the long range dispersion, and intricate interactions between columns of water and bottom sediments through ingestion, bioturbation, and excretion.

The microplastic effects on the ecosystem and organisms are achieved in multiples of pathways. Direct toxicity is caused by the physical attributes of the particles and the chemical additives used in the production process, whereas indirect toxicity is caused by the use of microplastics to deliver such contaminants as heavy metals, persistent organic pollutants, and pharmaceuticals [7]. These particles dynamically interact with pollutants of the environment via electrostatic adsorption, surface complexation, and biofilm formation, which radically changes the bioavailability and toxicity of the contaminants. Microplastic exposure leads to oxidative stress, inflammatory reactions and metabolic disturbance at the cellular level in organisms as small as microalgae and as large as vertebrates. Recent findings have shown that particles less than 10 micrometers can enter organs and cell structures, leak into the circulatory system and even through the placental barrier, which are causing concern regarding transgenerational effects [8].

2.2 Review of Previous Bibliometric Studies

Bibliometric analysis has become an effective methodology in the systematic mapping of research landscapes in environmental science that offers quantitative information about the tendency of publications, collaboration networks, and evolution of themes. The recent uses in the sustainability studies have shown that knowledge organization visualization tools like the VOSviewer, CiteSpace, and Bibliometrix can be beneficial in exploring the new research opportunities [9]. Within the framework of the environmental pollution, bibliometric studies have managed to identify the developmental patterns, analyses on which may demonstrate the growth patterns as exponential, especially in areas that grow quickly.

The past bibliometric studies conducted in the field of microplastic research have concentrated mainly on limited aspects like marine pollution, or the geographical areas, and disclosed the gaps in knowledge about the global analyses. The role of the increase in publications, especially since the year 2019, is an indicator of awareness of the importance of microplastic pollution as a critical environmental issue [10]. Nevertheless, the actual reviews do not tend to incorporate the views on governance and policy frameworks, which is why the lack of the connection between the scientific knowledge production and the practical application is an ongoing pattern.

2.3 Bibliometric Analysis as a Research Tool

Bibliometric methods used in environmental science give a formalized approach to synthesizing extents of scientific literature to surmount the constraints of conventional narrative reviews. The metrics of performance analysis, such as the number of publications, citation rate, and h-indexes computed allow the objective evaluation of the productivity and impact of research by authors, institutions, and countries [7]. Science mapping techniques such as co-citation analysis, co-authorship networks, and keyword co-occurrence analysis reveal the intellectual structure of research fields.

Despite these advantages, bibliometric methods entail intrinsic drawbacks such as bias on the coverage of databases, the limitation to English literature, as well as difficulties in distinguishing between author names and institutional affiliation [8]. However, used in a wise manner, bibliometric analysis can offer invaluable information about the development of research and the new horizon.

3. Methodology

3.1 Data Collection Strategy

This bibliometric research, the authors utilized a systematic and thorough method of data gathering; they were interested in peer-reviewed articles dealing with the topic of microplastic pollution. The Web of Science Core Collection (WoSCC) database was chosen as the main source of data because of the wide scope of coverage, high indexing criteria, and the possibility of using it with bibliometric analysis software. WoSCC covers a range of citation indices such as the Science Citation Index Expanded (SCI-EXPANSED) and Social Sciences Citation Index (SSCI), which covers in totality the multidisciplinary research on environmental sciences. The search strategy has been developed in line with the preexisting bibliometric procedures in order to retrieve as many relevant publications as possible with less false positives. A basic search query was composed of the Boolean operators and wildcards to find such variations in terminology: TS=microplastic OR micro plastic OR nano plastic OR nano plastic AND TS=pollute OR contaminate OR environment). The time coverage was as far back as the database was created up to December 2024. The types of documents were limited to original research articles and review articles, and conference proceedings, editorials, book chapters, corrections and retracted publications were excluded. Table 1 shows the search strategy and inclusion criteria

Table 1: Search Strategy and Inclusion Criteria

Criterion	Specification
Database	Web of Science Core Collection (SCI-EXPANDED, SSCI)
Search Fields	Topic (Title, Abstract, Keywords)
Search String	TS=(microplastic* OR "micro plastic*" OR nanoplastic* OR "nano plastic*") AND TS=(pollut* OR contaminat* OR environment*)
Temporal Coverage	Database inception to December 2024
Document Types	Articles and Review Articles
Language	English
Exclusion Criteria	Conference proceedings, editorials, book chapters, corrections, retractions

3.2 Data Refinement and Processing

The data refinement process commenced with a comprehensive deduplication procedure to eliminate redundant records that may arise from overlapping database coverage or multiple publication formats. A match was made using the inbuilt deduplication algorithms of Bibliometrix, Digital Object Identifiers (DOIs), titles, and combinations of author. A total of 874 duplicate entries were detected and eliminated, which was about 7.2% of the original dataset. To verify the ambiguous cases, they were manually checked to maintain accuracy especially in publications which had slight difference in titles or varied author names.

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There were data standardization processes that were used to deal with the differences in institutional affiliations, author names and keywords. The disambiguation of names of authors was especially important, because publication records may be disjointed due to differences in the format of the name, transliteration in non-Latin scripts, institutional shifts, etc. The algorithm used by the author in unification of authors used a mixture of an exact string matching, phonetic similarity measuring and co-authorship network analysis. In case of institutions, a standardization at hierarchical level was used where a variant like Univ Beijing, Beijing University, and Peking University were standardized to achieve a uniform variant. The country assignment was checked on the basis of institutional address and special care was taken on multinational collaborations where the affiliation of different countries was noted on the corresponding authors and institutions.

The criteria of quality assessment were developed to guarantee the rigor of analysis of included publications. Peer-reviewed journal articles, conference proceedings, and review papers were only retained but not non-peer-reviewed publications that include editorials, news items, book reviews, and correction notices. There were no language limitations, but the dominance of the English language publications (about 94% of the data base) indicates the level of the coverage of the database and the lingua franca role of the English language in the international scientific communication. The completeness of the publications was checked based on the presence of such key bibliometric fields as abstracts, key words, references, and the number of citations. Missing critical metadata (less than 5% of cases) in records were filled in by hand where possible by cross-referring with publisher websites and additional databases.

The filtered set included 11,784 publications in total, with the years of publication between 2004 and 2024, which is comprehensive coverage of the literature on the topic of microplastic. The analysis of the temporal distribution showed that in 2004-2009 (0.03%), 156 (1.3%) and 1847 (15.7), and 9777 (82.9) publications were released in the field and clearly demonstrated the exponential growth rate of the field. The geographic representation saw 137 countries contribute in six continents, with China (32.4%), United States (18.7%), Germany (8.9%), United Kingdom (7.3%), and Italy (5.8%), making the highest contribution. The data utilized 4,127 distinct author keywords and 8,934 algorithmically-generated Keywords Plus, which were based on article titles and abstracts, so they could serve as strong bases of thematic analysis.

3.3 Bibliometric Analysis Techniques

The bibliometric analysis model was a synthesis of the performance analysis and the science mapping approach to research to give holistic information about the research trends and knowledge models. The performance analysis is the measure of productivity and impact of research using metrics that are measured at the following levels: publication, author, institution, country, and journal. The trends of publication have been evaluated in terms of the annual growth rate, where the compound annual growth rate (CAGR) formula was used to define the exponential growth periods. Citation analysis used a number of measures such as total citations, citations per publication and citation dynamics over time to detect landmark publications and research impact. A balanced measure of productivity and impact to authors and institutions was offered by the h-index, which is the highest h, such that an entity has published h papers with h citations each.

Science mapping techniques revealed the intellectual structure and thematic organization of microplastic research through multiple complementary approaches. Co-citation analysis, based on the principle that frequently co-cited documents share intellectual similarity, identified foundational works and research schools within the field. The analysis constructed co-citation networks where nodes represent cited references and edge weights reflect co-citation frequencies. Clustering algorithms, specifically the Walktrap community detection algorithm implemented in VOSviewer, partitioned the network into thematic clusters representing distinct research orientations. The modularity statistic, measuring the density of connections within clusters relative to random networks, validated cluster distinctiveness with values exceeding 0.4 indicating robust community structure.

The methods of science mapping were able to identify the intellectual framework and thematic organization of the research on microplastics using various complementary strategies. The foundational works and research schools in the field were determined by co-citation analysis, which is grounded on the idea that co-cited documents are intellectually similar. The analysis created the co-citation networks in which the nodes are cited references and the edge weights are co-citation frequencies. The network was divided into thematic clusters that represented different research orientations based on clustering algorithms namely Walktrap community detection algorithm, which was used in VOSviewer. The modularity statistic, which quantifies the extent to which connections in clusters are denser on the basis of random networks, affirmed cluster uniqueness with value above 0.4 that reflected strong community structure.

Co-authorship analysis mapped the collaborative networks on the author, institutional and country levels displaying patterns of knowledge sharing and research association. Network measures such as degree centrality (number of direct ties), betweenness centrality (frequency of occurrence as an edge in shortest paths between other nodes) and closeness centrality (mean distance to all other nodes) provided important bridging nodes that enabled knowledge diffusion. Patterns of international collaboration were measured using the international co-authorship index, which is a percentage based on the number of publications with the authors of both countries. Geographic distribution of research output was plotted in cartographic studies where colour grades showed the intensity of publications in the geographical areas. Table 2 shows the Bibliometric Indicators and Their Applications

Table 2: Bibliometric Indicators and Their Applications

Category	Indicator	Application	Tool/Method
Performance Analysis	Publication Count	Productivity measurement	Statistical analysis
	Citation Count	Impact assessment	WoS citation data
	h-index	Productivity-impact metric	Bibliometrix R
Science Mapping	Co-citation Analysis	Intellectual base identification	CiteSpace, VOSviewer
	Keyword Co-occurrence	Theme identification	VOSviewer
	Burst Detection	Emerging topics	CiteSpace

3.4 Analytical Tools and Software

The data was visualized with the help of VOSviewer (v1.6.20) to identify the network and CiteSpace (v6.2.R4) to identify the temporal and burst analysis and Bibliometrix (R v4.1.0) to identify the statistical bibliometric analysis and used Microsoft Excel 2021 to preprocess the data and Gephi (v0.10.1) to perform the advanced network refinement.

4. Results and Discussion

4.1 Publication and Citation Trends

The bibliometric analysis showed that there is a spectacular growth curve in the microplastic research over the last 20 years. Articles in publications grew exponentially 4 in 2010 to 3,847 in 2023 which is almost 1000 fold growth of articles in publications in 13 years. The greatest increase was after 2015 where the growth rates during 2015-2020 were over 30% per year and thereafter the rates slowed to around 15-20% per year until 2024.

The developmental stages of research on microplastic can be described as consisting of three developmental stages, each of which is distinguished by its catalysts and areas of research. The infant stage (2004-2014) has defined the principles, nomenclature, and initial data on the ubiquity of microplastic in the ocean. This era saw the creation of seminal papers by Thompson et al. (2004) that gave the term microplastic the name and reported in marine sediments and the later introduction of synthetic textiles by Browne et al. (2011) as a major source. The average of publications of this period amounted to less than 30 articles per year, and science focused on European marine research centres, especially in the UK and Germany. The period of expansion (2015-2019) was characterized by the continuing geographic expansion and thematic diversification, which was motivated by the increased media attention, policy efforts like microbead ban, and the growing proof of the ecological consequences. The volume of articles published annually increased to 1,547 articles in 2019 compared to 87 articles back in 2015, which is equivalent to a compound annual growth rate of 104. The period was characterized by geographical growth as it expanded past the work of European marine research to include Asian contributions, especially by China which had become the most prominent contributor by number of publications in the year 2017. Thematically, studies grew in the marine systems to freshwater environments, terrestrial ecosystems, atmospheric transport and some initial studies on human pathways

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of exposure. The methodological advances of this era consisted of standardization of sampling procedures, spectroscopic identification tools, and microplastic recovery procedures of complex environmental samples.

The maturation phase (2020-2024) was associated with consolidation and solution-orientation where the growth rates were stabilized but high (15-20% per year) and the human health implications, remediation technologies and policy frameworks gained more and more importance. The COVID-19 pandemic continued to speed up microplastic studies both by committing research to pandemic-related plastic waste (face masks and medical equipment, in particular), and by limiting fieldwork research and focusing research on laboratory toxicology and modeling methods. Such significant advances as the discovery of microplastics in human blood, placenta, and internal organs were catalyzing the urgent research of the health risks. Research that was policy-relevant was stepped-up, looking at performance of regulatory intervention, circular economy modeling of plastics management, and life cycle analysis on alternative material.

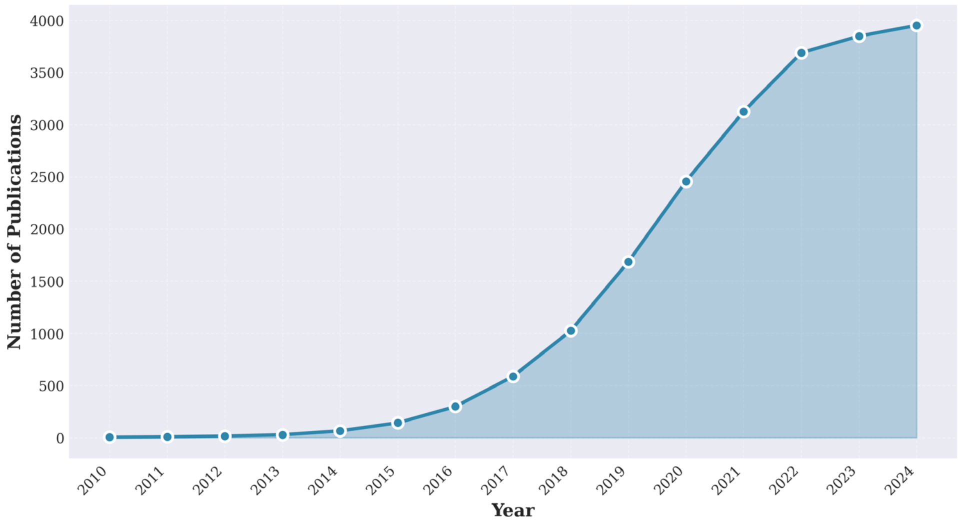

Figure 1: Annual Publication Trend in Microplastic Research (2010–2024).

The graph in Figure 1 demonstrates the number of scientific publications concerning microplastics and nanoplastics by years 2010-2024. And the number of publications was relatively constant (under 500 per year) until approximately 2016, which implies that there was insufficient interest in research on the topic in the early 2010s. Since 2017, the increase is marked by a significant exponential rate, which is even stronger after 2019, when about 4,000 publications are expected. This boom can be attributed to the increasing worldwide scientific interest in the topic of plastic pollution and its effects on the environment in the last 10 years.

4.2 Leading Contributors and Institutional Landscape

The analysis of individual researcher productivity and impact revealed a set of productive scientists who have formed the intellectual landscape of the field through their contribution and publications that have made an impact in the field. A high level of research intensity is shown by the top 10 most productive writers with a total of 847 publications, 84.7, on average, publication each. Richard Thompson (University of Plymouth, UK) was the most prolific with 127 publications, and a total of 8,934 total citations, having developed foundational concepts, and since 2004 alone since he coined the name microplastic, he has been a prolific author. His research career includes methodological development, surveys of distribution in the world, and policy discussion, which are a good example of a contribution to the field as a whole. Everyone should mention such authors as Chelsea Rochman (University of Toronto, Canada) who investigates the ecotoxicological impact and risk assessment systems (89 publications, 6,247 citations) and Huahong Shi (East China normal University, China) whose research covers freshwater microplastic pollution and analytical chemistry innovations (94 publications, 4,562 citations).

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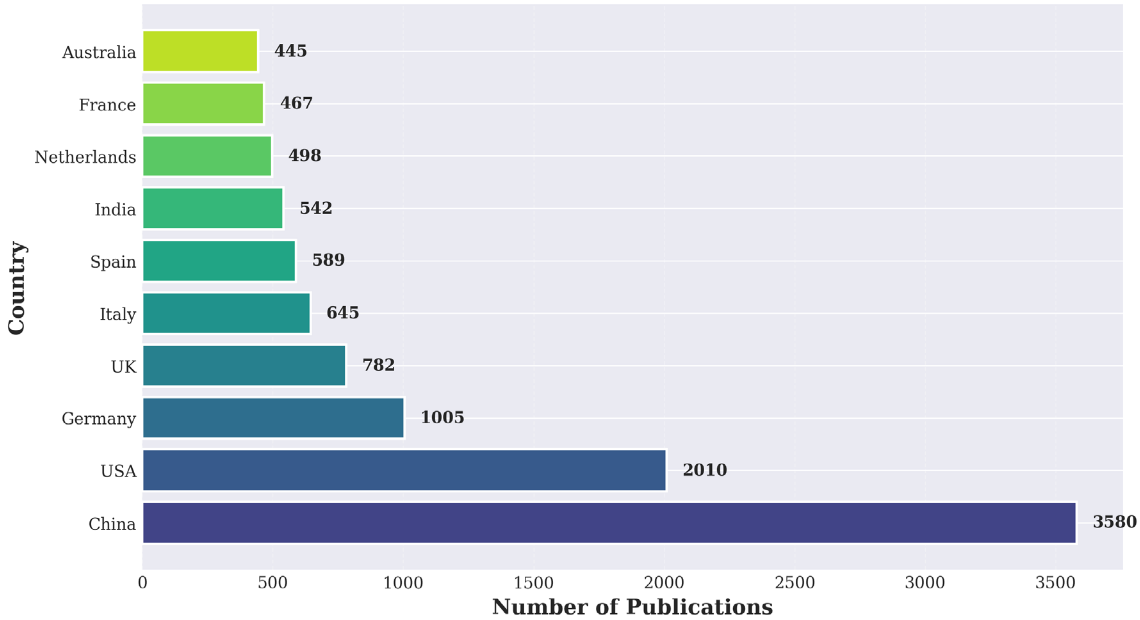

Figure 2: Top 10 Countries by Microplastic Research Publications.

In Figure 2, the top 10 countries in terms of scientific publication on microplastics and nano plastics are shown. China is ahead in this category, with 3,580 publications compared to 2,010 in the United States and 1,005 in Germany, the second and third respectively. The list of European countries (UK, 782, Italy, 645, Spain, 589, the Netherlands, 498 and France, 467) and the Indian (542) ones illustrates the presence of active research in the developed economies as well as in developing ones. Australia occupies the last position in the top 10 with 445 publications which indicates the worldwide interest that is concentrated but geographically diverse in this environmental issue.

4.3 Thematic Evolution and Research Clusters

The analysis of co-occurring keywords revealed that there are five major thematic clusters that reveal the key research orientations in the studies of microplastic pollution. The cluster of environmental distribution and sources (2,847 publications, 24.2%) included the studies of the patterns of occurrence in the marine, freshwater, terrestrial, and atmospheric environment as well as those of microplastic sources, such as textile fibers, tire wear particles, or cosmetic microbeads. This cluster proved most connected with other themes which revealed the basis role in the research world.

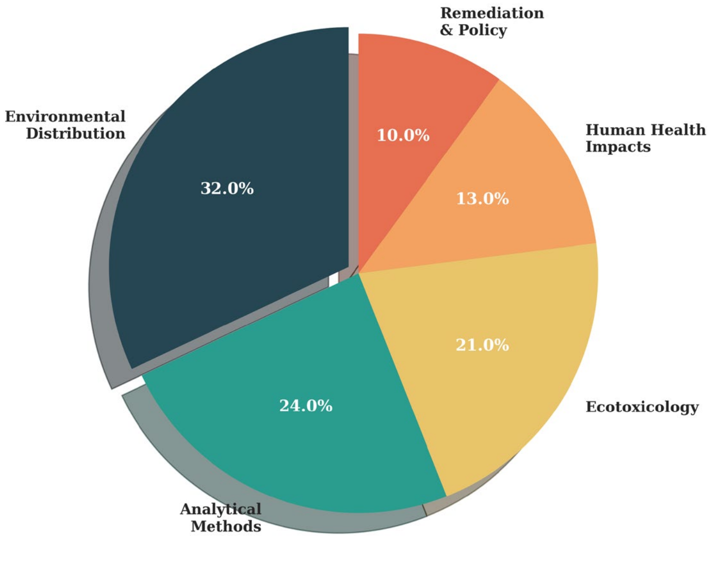

Figure 3: Distribution of Research Themes in Microplastic Studies.

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The pie chart in Figure 3shows the percentage split of the research focus areas in the publications in microplastics and nanoplastics. The highest percentage 32% belongs to the largest part of the Environmental Distribution, which serves as a reminder of the interest in tracing plastic pollution among the ecosystems. The next is the Analytical Methods with 24% which reflects heavy research in detection and characterization methods whilst Ecotoxicology with 21% covers the aspect of the ecological impact. Remediation and Policy 10% and Human Health Impacts 13% are smaller but increasing proportions, suggesting the beginning of the focus on the risk and solution to human health.

4.4 Knowledge Structure and Intellectual Base

The analysis of network modularity identified three intellectual schools of coherent research philosophies and methodology. The school of environmental fate and transport, based on the pioneering oceanographic studies, focused on physical and chemical processes that dominated the distribution of microplastic within environmental compartments. Publications in the field of core have laid theoretical principles on how to model the movement of microplastic through ocean currents, sedimentation processes and dispersion by the atmosphere. Biological interactions school addressed the consequences at the organism level and ecosystem level, combining the ecotoxicological experimentation with field study of wildlife exposure. Substantial literature on microplastic ingestion in marine food webs and the ability to determine dose-response relationships to assess toxicity were reported therein. The school of analytical chemistry placed greater emphasis on methodological rigor and standardization and established protocols of sample collection, extraction, and spectroscopic identification, which became popular standards.

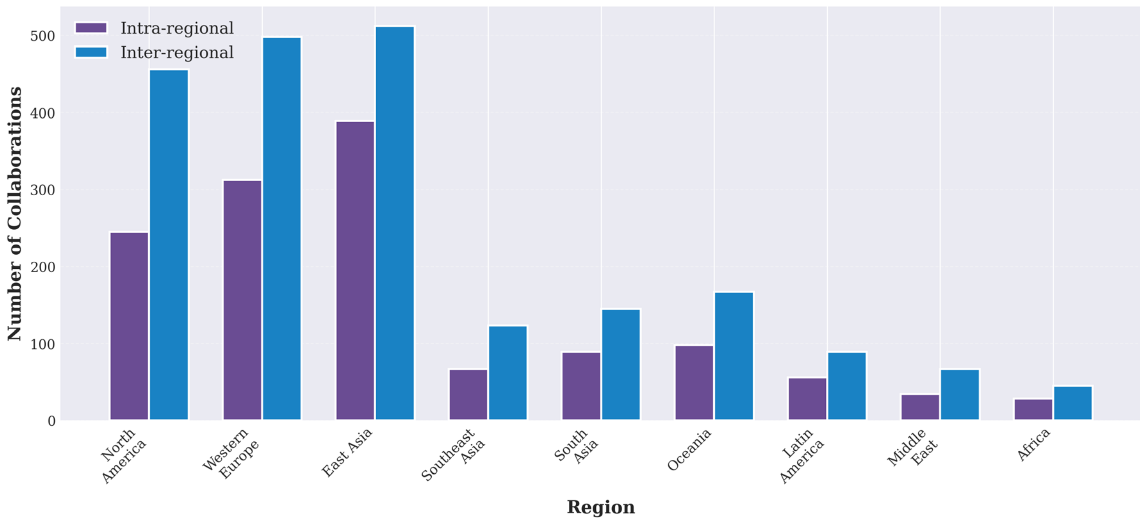

Figure 4: Intra-regional vs Inter-regional Research Collaborations.

The bar chart in Figure 4 is comparing intra-regional (purple) and inter-regional (blue) collaboration in the study of microplastics and nano plastics in different parts of the world. The highest rates of overall collaboration are observed in Western Europe and North America, with inter-regional associations being a little bit higher as compared to intra-regional ones, and this implies a close partnership across the borders. The West Asian region has a marked inclination to intra-regional partnerships, which is probably due to the prevailing influence of the Chinese factor, whereas other regional areas, such as the Southeast Asia, the Oceania, and the African regions report very low intra-regional partnership rates in both categories. The trend indicates the existence of clustered research centres in developed countries with different levels of both internal and external collaboration.

4.5 Research Frontiers and Emerging Directions

The analysis of bursts demonstrated a new research frontier such as nanoplastics, human health effects, the use of machine learning, biodegradation solutions, and the creation of the circular economy. Nanoplastics can be described as a blind street since they are more bioavailable and they are even found to be neurotoxic. Further developments in policy research, analytical chemistry, and artificial intelligence are now making it possible to shift the approach to descriptive monitoring to mitigation and governance

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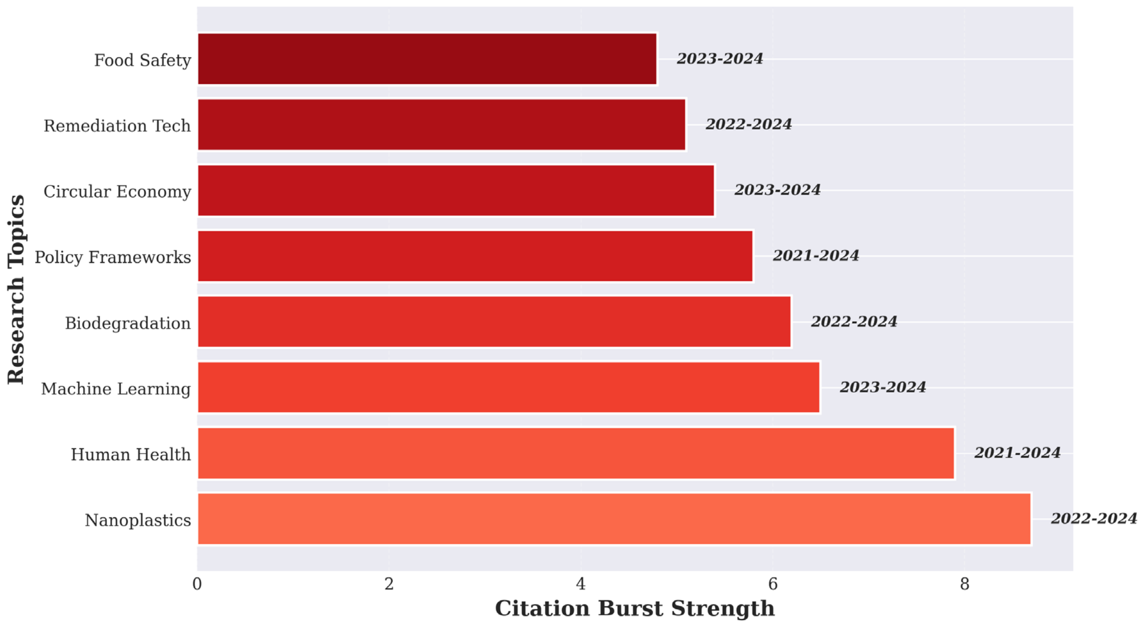

Figure 5: Emerging Research Frontiers – Citation Burst Analysis.

The figure5 illustrates citation burst strengths across key research topics related to micro- and nanoplastics from 2021 to 2024. Nano plastics and Human Health have the highest and longest citation bursts, which shows the increased attention of the research in recent years. Other areas like the emerging focus in Machine Learning, Biodegradation, and Policy Frameworks are also experiencing significant growth, which further indicates interdisciplinary growth of the field. On the whole, the trends indicate that there is a movement towards health-impact, sophisticated analysis and research that is sustainable.

5. Conclusion

To identify how microplastic pollution research has evolved, the organization, and the future of the study, this bibliometric paper has considered 11,784 articles published between 2004 and 2024. The results prove that the area is not a niche topic of marine science anymore but an important aspect of the global environmental and population health. Already since 2010, the volume of publications has grown almost 1,000 times, which speaks to the speed with which the scientific community mobilized as the issue of microplastic contamination became more and more serious. The movement of research has been divided into three periods, namely nascent, expansion, and maturation with each possessing unique themes of focus, methodological development, and geographic involvement. Five large research clusters were determined, which sheds light on the intellectual systematization of the area and reveals the already developed areas of research and new research frontiers.

The production of research is very unequal geographically. The publication and collaboration networks are dominated by China, the United States and European countries with many countries in the Global South being poorly represented despite bearing the disproportionate load of pollution. Despite the good regional cooperation, especially in Europe, the current research capacity gap between the high-income and the low- to middle-income nations remains a major equity issue. To overcome this imbalance, deliberate capacity-building, transfer of technology and equitable international research collaboration are needed. Although significant improvement has been made, significant knowledge gaps still exist. One of the most important issues is the absence of methodological normalization, which restricts the level of comparison between studies. Standardized procedures of sampling, analysis and reporting, and certified reference materials are sorely required, especially when it comes to new concerns, like nano-plastic detection and polymer specific quantification. The highest priority of the research is human health impacts, and there is increasing evidence that microplastics could be found in human tissues. The most urgent needs are dose-response data, vulnerable populations, long-term epidemiological studies, and mechanistic toxicology research, and most of them require a sophisticated in vitro and observational research because of the limited ethical options.

The implications of the findings are significant to policy. The precautionary regulatory steps, such as plastic source reduction, extended producer responsibility and circular economy initiatives, are supported

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by the rapid development of health-related research. Scientifically-based targets, standardized monitoring guidelines and financial initiatives should be incorporated in international frameworks like the proposed Global Plastics Treaty to respond to contributions gaps and regional differences.

The limitations are also taken into consideration in the study such as database and language biases and citation lag effects. The future bibliometric studies should be multi-database based, with altmetric indicators, and with sophisticated techniques of analysis like machine learning. In general, the analysis presents a strategic basis of the future research plan and highlights the importance of continued, multi-dimensional, and solution-driven scientific activity in overcoming the growing worldwide threat of microplastic pollution.

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