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Mapping Global Microplastics Pollution Research (2014–2024): A Bibliometric Analysis of Trends, Collaboration Networks, and Policy Gaps

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Abstract:
This study presents a bibliometric analysis of global research on microplastics pollution from 2014 to 2024 using Scopus data and VOSviewer, examining publication growth, key contributors, thematic developments, and international collaboration networks. Results show a sharp increase in output after 2019, reflecting heightened concern, with China leading in publications, authorship, and institutional contributions due to strong national agendas and research investment. Core research areas include marine and freshwater pollution, toxicity, and polymer analysis, while recent studies have expanded toward nanoplastics, soil contamination, wastewater treatment, and biodegradation, indicating a shift to more interdisciplinary inquiry. Despite this progress, research integrating governance and regulatory perspectives remains limited, highlighting a persistent knowledge–action divide. Co-authorship networks show strong national clustering but weaker global collaboration, with Southeast Asia and the Philippines notably underrepresented despite being major sources of marine plastic leakage. These gaps underscore the urgency of fostering broader international cooperation and collaboration among developing countries, strengthening ASEAN participation, and linking science with policy reforms, public health monitoring, economic assessments, and sustainability education. This study provides evidence across a decade of research, contributing to bridging the science–policy divide and supporting evidence-based decision-making in line with the Sustainable Development Goals and the forthcoming Global Plastics Treaty
Keywords: Microplastics, Bibliometric Analysis, Global Collaboration, Scopus Database, ASEAN Research

1. INTRODUCTION

Microplastic pollution has emerged as one of the most pressing environmental challenges of the past decade, drawing increasing concern from the global scientific community. Defined as plastic particles smaller than 5 millimeters, microplastics originate from diverse sources such as industrial activities, synthetic textiles, packaging waste, and the breakdown of larger plastic items (Uddin et al., 2025). These particles are now recognized as widespread contaminants across marine, freshwater, terrestrial, and even atmospheric systems, where they persist, accumulate in organisms, and act as carriers for toxic substances (Mishra et al., 2024; Wang et al., 2022).

The rapid growth of publications on microplastics reflects the expanding scope and complexity of this field. Research has advanced from describing pollution sources to examining transport, fate, biological impacts, and remediation strategies. To make sense of this expanding body of knowledge, systematic approaches are needed. Bibliometric techniques, particularly citation and co-word analysis, have proven valuable for identifying influential contributions, mapping thematic clusters, and tracking research developments over time (Ahmad et al., 2024; Donthu et al., 2021). Citation analysis highlights the most impactful studies, authors, and institutions shaping the field, while co-word analysis reveals conceptual linkages by examining keyword co-occurrence (Zhang et al., 2022). Combined, these approaches provide a macroscopic perspective on collaborative networks, research gaps, and emerging trends in microplastics scholarship (Kum et al., 2025).

Recent bibliometric reviews have underscored the interdisciplinary nature of microplastics research, spanning ecotoxicology, public health, wastewater treatment, food safety, and environmental policy (Uddin et al., 2025; Kum et al., 2025). Emerging frontiers include nanoplastics, food chain bioaccumulation, risk assessment frameworks, and bioremediation strategies (Ahmad et al., 2024; Mishra et al., 2024). However, significant regional disparities remain, with only about 5% of global microplastics publications originating from ASEAN countries (Gabisa & Gheewala, 2022). The Philippines, despite

being ranked as the third largest global contributor to marine plastic leakage, accounts for only a small fraction of published output (Jambeck et al., 2015; Lebreton et al., 2017). This imbalance highlights the need for greater representation of Southeast Asian research, particularly given the region's dependence on coastal ecosystems for food security, trade, and livelihoods.

Unlike earlier bibliometric studies that focused narrowly on ecological or toxicological dimensions, this work integrates thematic evolution, collaboration networks, and policy-relevant gaps across a full decade of research (2014–2024). By situating microplastics research within a wider interdisciplinary context—including public health risks (Barboza et al., 2018; Wright & Kelly, 2017), economic costs of pollution (Beaumont et al., 2019), and sustainability education linked to the UN Sustainable Development Goals (SDGs) (Rifa & Hossain, 2022)—this study underscores its importance not only for advancing ecological science but also for informing governance, community engagement, and curriculum development.

Against this backdrop, the present study provides a comprehensive bibliometric analysis of microplastics research published from 2014 to 2024 using Scopus-indexed data. Employing VOSviewer software, it maps citation networks, co-authorship structures, and keyword clusters to reveal the intellectual landscape and developmental trajectory of this vital field. By identifying global and regional trends, collaboration imbalances, and underexplored policy linkages, the study contributes to bridging the persistent divide between scientific evidence and policy action.

The general aim of this study is to analyze the scientific landscape of global microplastics pollution research between 2014 and 2024 using bibliometric techniques. Specifically, it seeks to:

1. Examine temporal growth and publication trends, highlighting key turning points in research output.
2. Identify the most influential countries, journals, institutions, and authors through citation analysis.
3. Explore thematic trends and conceptual linkages using keyword co-occurrence analysis.
4. Visualize the evolution of research themes, including emerging subfields such as nanoplastics and policy responses.
5. Map international collaboration networks to understand co-authorship patterns and geographic distributions.

2. Research Design

2.1 Data Source

Scopus is one of the world's largest and most comprehensive abstract and citation databases, widely recognized for its extensive coverage of peer-reviewed scientific literature across diverse academic disciplines, including environmental sciences, health sciences, life sciences, and social sciences (Elsevier, 2021). Its robust indexing protocols and high-quality bibliographic content—comprising journal articles, review papers, book chapters, and conference proceedings—make it a reliable platform for scientific research evaluation and bibliometric analysis. Given its breadth, consistency, and relevance to the research topic, Scopus was selected as the primary data source for this study.

To ensure a thorough and representative assessment of global research on microplastics, a systematic search strategy was employed within the Scopus database. The primary keyword "microplastics pollution" was applied to the Title, Abstract, and Keyword fields, retrieving documents directly relevant to environmental, toxicological, and ecological concerns. While this precise term ensured topical relevance, it may have excluded studies using alternative descriptors such as microplastic contamination or plastic debris. The decision to prioritize precision over breadth was made to ensure that the dataset remained highly focused on the core theme of microplastics pollution. The timeframe was set from 2014 to 2024, a decade during which global attention and scholarly output on microplastics surged. A total of 4,585 initial documents were retrieved, encompassing peer-reviewed journal articles, review papers, and conference proceedings.

To refine the dataset for accuracy and consistency, exclusion criteria were applied: duplicate entries, non-English publications, and records lacking essential bibliographic metadata (e.g., keywords, publication year, or author details) were removed. Restricting the dataset to English-language publications, while a common approach in bibliometric studies to ensure consistency in metadata and keyword analysis, may have led to some underrepresentation of valuable regional or non-English contributions. After applying these criteria, the dataset was reduced to 4,189 records. The final dataset was exported in .CSV format with full records and cited references, making it suitable for bibliometric analysis using VOSviewer.

This curated dataset provided the foundation for mapping the scientific landscape of microplastics research, enabling citation, co-authorship, and co-word analysis across a broad spectrum of environmental, interdisciplinary, and policy-relevant studies.

2.2. METHODS

Bibliometric analysis is a quantitative method for evaluating scientific literature and mapping research trends (Achuthan et al., 2023). By analyzing citation data and keyword patterns, it uncovers influential publications, thematic structures, and knowledge evolution (Glänzel, 2003; Wang et al., 2023). Unlike traditional peer review, bibliometric methods offer objective, replicable insights into scholarly activity (Hammarfelt & Rushforth, 2017).

This study employed citation analysis to identify key authors, institutions, and journals, and co-word analysis to reveal thematic clusters based on keyword co-occurrence (Chen & Guan, 2011; Yu et al., 2016). The analysis focused on microplastics pollution research indexed in the Scopus database from 2014 to 2024, using the keyword "Microplastics Pollution" applied to titles, abstracts, and author keywords.

Non-English documents, duplicates, and entries lacking metadata were excluded. The final dataset was exported in .CSV format and analyzed using VOSviewer (v1.6.19), which supports mapping of co-occurrence, citation, and co-authorship networks (van Eck & Waltman, 2010). This enabled the visualization of intellectual structures and emerging themes in microplastic pollution research. Figure 1 shows the framework of the study.

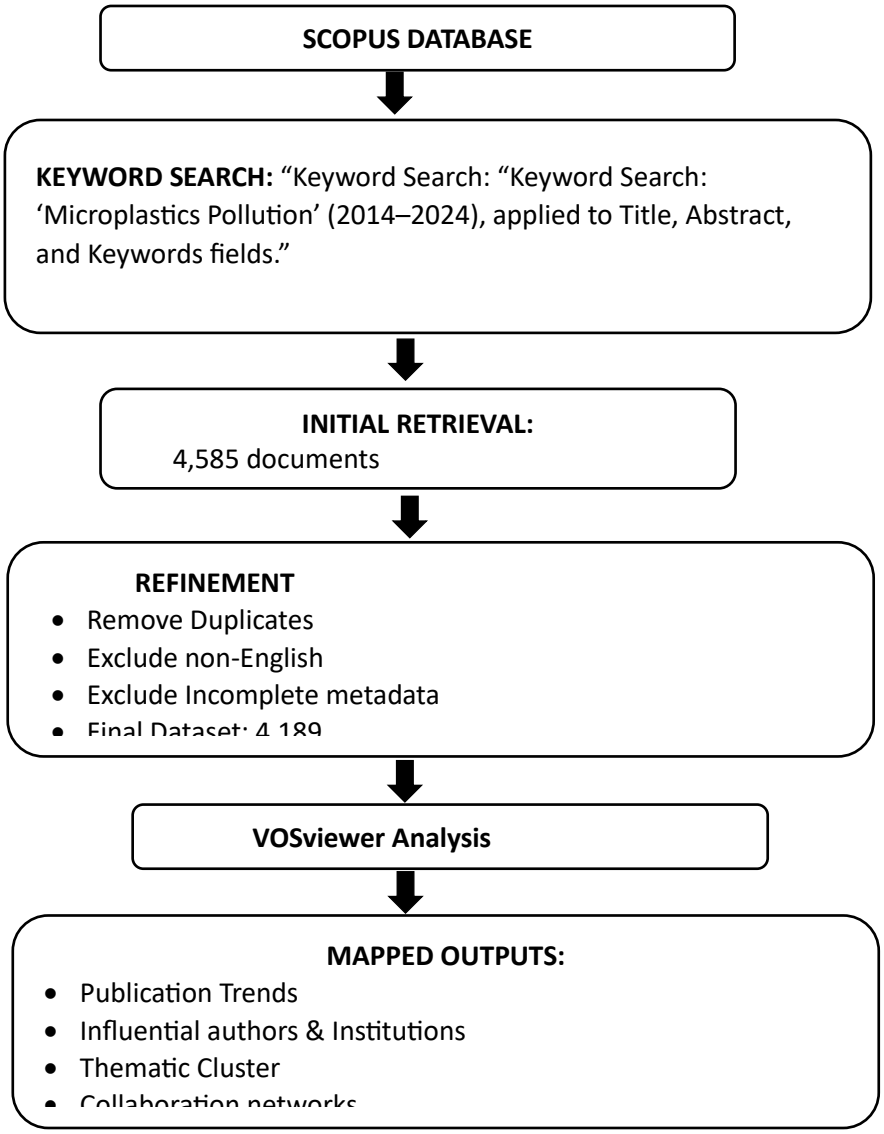

Figure 1: Framework of the Study

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3. BIBLIOMETRIC RESULT AND ANALYSIS

3.1. Trends in Microplastics Research Output (2014–2024)

The number of research publications on microplastics pollution between 2014 and 2024 as seen in figure 2 shows a clear and steady rise, highlighting growing global awareness about its environmental and health impacts. In 2014, only two papers were published on the topic. By 2024, that number had jumped to 1,210, forming a steep upward curve. A major turning point occurred in 2019, after which the number of studies began to grow rapidly year after year. This growth reflects not only increasing public concern but also a stronger focus from the scientific community and global policymakers, as microplastics became a pressing issue across many fields of research.

Several factors help explain this sharp rise. The COVID-19 pandemic played a role, largely due to the surge in single-use plastic waste, especially from personal protective equipment (PPE) like masks and gloves. This raised urgent questions about how such waste was affecting ecosystems and public health (Wang et al., 2022). At the same time, international policy efforts—such as the European Union's plastics directive and early steps toward a global plastics treaty—likely encouraged more academic research and funding in this area. Additionally, the wider use of open-access journals and research mapping tools made it easier for scientists to publish and share their work on microplastics.

Another reason for the expansion in this field is the progress made in scientific techniques. New and more sensitive tools—like Raman spectroscopy, FTIR, pyrolysis-GC/MS, and others—have helped researchers detect even smaller plastic particles (including nanoplastics) in air, water, food, and even human tissues (Uddin et al., 2025). These advancements have opened up new areas of study, including how microplastics move through the atmosphere, enter the food chain, and accumulate in the body.

However, this rapid growth also comes with challenges. Some topics, like marine microplastics and general environmental risk assessments, have been studied extensively and may now be nearing a point of saturation. While still important, continuing to focus solely on these areas may limit innovation. There's a growing need to explore less-studied areas, such as the economic impacts of microplastic pollution, the effectiveness of policies, and how microplastics behave in land-based environments (Ahmad et al., 2024).

This expansion has important consequences. For researchers, the field is full of opportunity—but it also demands more interdisciplinary collaboration and a deeper understanding of complex systems. For policymakers, the increasing body of research provides strong evidence to design better laws, monitoring systems, and cleanup strategies. Looking ahead, this upward trend is expected not just to continue, but to accelerate, especially as microplastics research becomes more integrated into broader issues like climate change, public health, and sustainability goals.

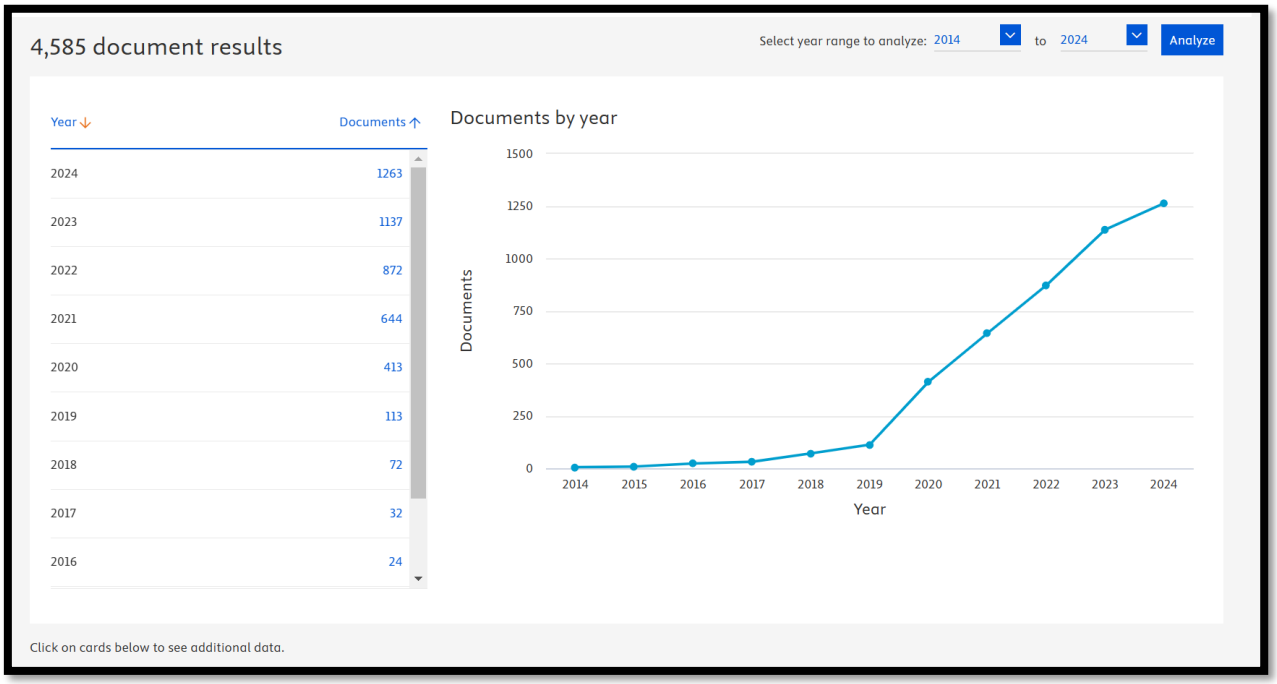


Figure 2. Annual Scientific Publications on Microplastics Pollution (2014–2024)

3.2. Global Research Distribution on Microplastics Pollution (2014–2024)

Figure 3 presents the distribution of Scopus-indexed publications on microplastics pollution by country between 2014 and 2024. The data reveals a pronounced global disparity, with China emerging as the most prolific contributor, accounting for 1,709 documents—a figure that far surpasses that of any other country. In comparison, the United States follows with 404 publications, closely trailed by India (396), while the United Kingdom (289) and Italy (236) complete the top five. Other countries such as Germany, Spain, Australia, Brazil, and Canada contribute between 150 and 220 documents, indicating steady but comparatively smaller research output.

China's remarkable lead can be attributed to several structural and environmental factors. As the world's largest producer and consumer of plastic, and home to some of the most polluted river systems (e.g., the Yangtze and Yellow Rivers), the country faces severe plastic leakage into aquatic environments (Chen et al., 2021). In response, the Chinese government has prioritized microplastics in its environmental agenda, introducing the Plastic Pollution Control Action Plan and funding large-scale marine pollution studies. This policy-backed investment in environmental research infrastructure has propelled China to the forefront of microplastics scholarship.

The United States, while contributing far fewer publications than China, maintains a significant role due to its well-established research institutions and global leadership in fields such as environmental toxicology, public health, and marine sciences. Similarly, India's increasing output reflects both its expanding academic ecosystem and the country's urgent challenges around plastic waste management in urban and coastal settings (Ahmad et al., 2024).

In Europe, countries such as the UK, Italy, and Germany remain consistent contributors. This is strongly supported by the European Union's regulatory framework, particularly the Single-Use Plastics Directive (2019/904), which has driven both policy-driven research and cross-border funding under programs like Horizon 2020 and the European Green Deal (European Commission, 2019; D'Amato et al., 2022). These initiatives promote interdisciplinary collaboration and have made Europe a leader in microplastics research and innovation.

Meanwhile, Australia and Canada show strong engagement, likely due to their geographical exposure to marine ecosystems and the associated research emphasis on marine debris, coastal contamination, and biodiversity protection (Kroon et al., 2018; Anderson et al., 2022). In the Global South, Brazil's growing involvement illustrates the increasing relevance of microplastics research in emerging economies, particularly in biodiversity-rich regions like the Amazon and coastal estuaries, where plastic pollution intersects with food security and human health risks (Silva-Cavalcanti et al., 2017; Santos et al., 2021).

Overall, this geographic distribution reflects a strong concentration of research activity in Asia, North America, and Europe, with China firmly in the lead. However, the global footprint of microplastics research is steadily expanding. The increasing contributions from developing countries signal that the issue is no longer confined to high-income nations. As the environmental and health consequences of microplastics become more visible across diverse ecosystems and populations, a more globally inclusive research effort is emerging—one that recognizes microplastics as a shared challenge requiring collaborative, interdisciplinary solutions.

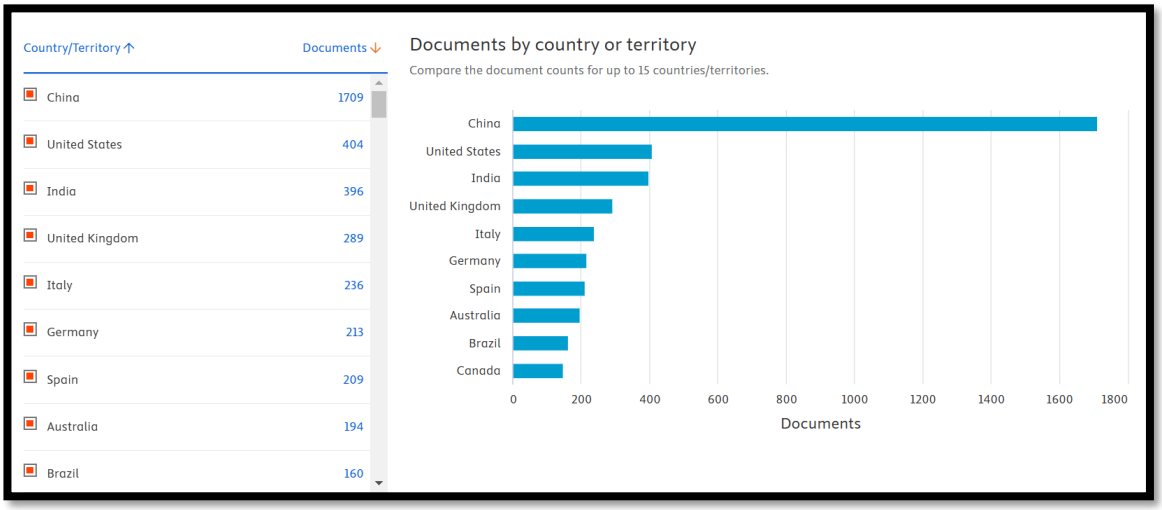


Figure 3: Global Research Distribution on Microplastics Pollution (2014–2024)

3.4. Analysis of Research Contributions by Influential Journals

Figure 4 and Table 1 reveals the leading journals publishing research on microplastics pollution from 2014 to 2024, based on Scopus-indexed literature. The most prolific journal is Science of The Total Environment, with 1,040 publications. Its interdisciplinary focus on soil, air, water, and public health makes it a central platform for comprehensive studies on microplastics and their interactions across environmental systems (Liu et al., 2023). Marine Pollution Bulletin ranks second with 596 publications, reflecting the field's early and sustained emphasis on marine ecosystems, particularly oceanic plastic debris, sediment contamination, and coastal management (Kane et al., 2020). Environmental Pollution, with 519 documents, plays a vital role in toxicological and ecological assessments of microplastics exposure—especially in aquatic organisms and food webs (Besseling et al., 2019).

The Journal of Hazardous Materials (404 publications) has become a key outlet for studies on microplastics as carriers of harmful contaminants, such as heavy metals and persistent organic pollutants (Zhou et al., 2021). It also hosts work on particle toxicity and environmental transformation mechanisms. Water Research, though contributing a smaller volume (120 papers), reflects a growing focus on microplastics in wastewater, drinking water systems, and stormwater runoff. Research here often addresses the effectiveness of filtration and treatment technologies in removing microplastics from urban water systems (Carr et al., 2016).

Other notable journals include the Journal of Environmental Management, Water Air and Soil Pollution, and Environmental Science and Pollution Research, each contributing between 80 and 100 publications. These journals cover a broad spectrum—from environmental governance and waste lifecycle analysis to studies on contamination across multiple media. The diversity of publication venues illustrates the expanding interdisciplinary interest in microplastics research, moving beyond marine-focused studies into public health, water engineering, and policy-oriented work. This shift underscores the recognition of microplastics as a complex, global pollutant requiring cross-sectoral approaches for effective monitoring and mitigation.

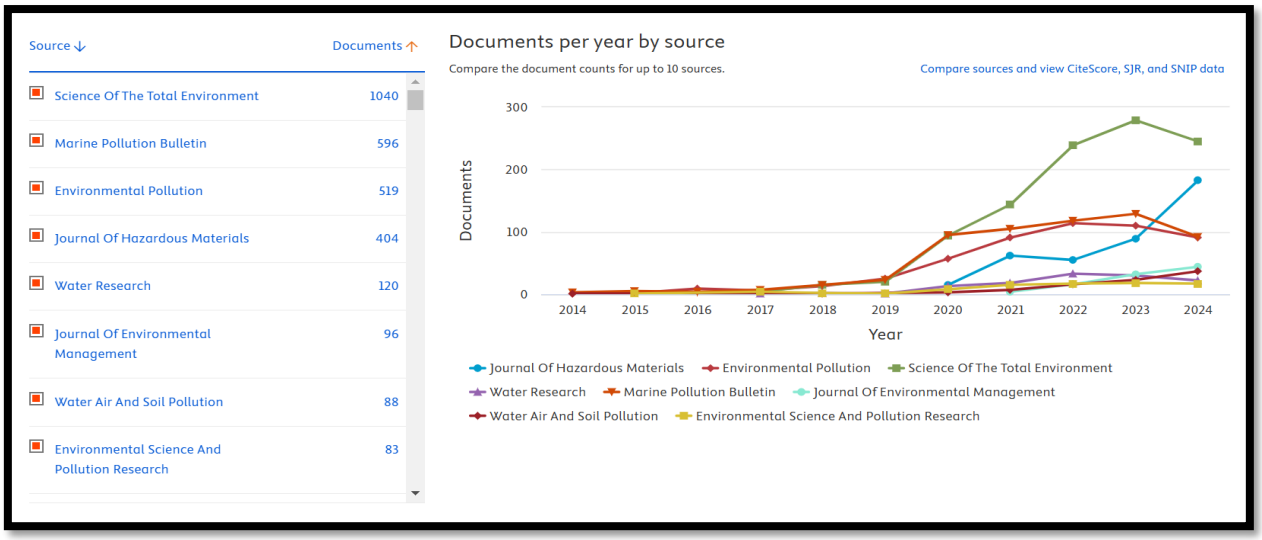


Table 1: Top Journals Publishing Microplastics Pollution Research (2014–2024)

Journal	Documents (2014–2024)
Science of The Total Environment	1040
Marine Pollution Bulletin	596
Environmental Pollution	519
Journal of Hazardous Materials	404
Water Research	120
Journal of Environmental Management	96
Water Air and Soil Pollution	88
Environmental Science and Pollution Research	83

3.4. Institutional Contributions to Microplastics Research (2014–2024)

Figure 5 presents the most active institutional affiliations contributing to microplastics pollution research between 2014 and 2024. The data strongly reflects China's institutional dominance in the field, with

seven out of the top ten affiliations based in the country. Leading contributors include the Ministry of Education of the People's Republic of China (298 publications), the Chinese Academy of Sciences (280), and the University of Chinese Academy of Sciences (145). These institutions represent key nodes in China's centralized science system, which has expanded significantly in recent decades due to state-led strategic investment in research and innovation (Zhou & Leydesdorff, 2006).

The strong presence of Chinese institutions aligns with the country's broader ambitions to become a global science and technology leader. As shown in multiple studies, China has achieved rapid growth in scientific output by promoting large-scale institutional coordination, emphasizing high-impact fields, and investing in targeted environmental challenges such as plastic pollution (Sun & Cao, 2020). This is particularly evident in areas like marine pollution, where national action plans—backed by ministries and major research universities—have driven microplastics research across aquatic and agricultural systems.

Institutions like the Ministry of Natural Resources (110) and the Ministry of Agriculture (98) support research intersecting environmental and food system domains, such as microplastic contamination in oceans, estuaries, and soils. Universities like East China Normal University (89 publications) and Nanjing University are actively contributing to research on microplastic detection, modeling, and risk assessment, especially in relation to sediment transport and water systems. These trends reflect China's broader science policy environment, which encourages inter-ministerial and university-government collaborations to accelerate environmental research impact (Fang & Zhu, 2020).

The high concentration of research within centralized institutions reflects China's model of coordinated national innovation. This model, as discussed by Persoon et al. (2020), builds a strong domestic science base through institutional clustering and the alignment of policy goals with academic output—especially in fields of environmental sustainability and emerging technologies. Moreover, China's expanding role in international scientific collaboration, as documented by Wagner et al. (2015), suggests that many of these institutions are not only leading in terms of volume but are increasingly engaged in co-authored research with global partners. Outside of China, CNRS (Centre National de la Recherche Scientifique) in France stands out with 87 publications. Its presence highlights the important role of European research networks and EU funding in addressing transboundary pollution challenges, such as marine microplastic dispersal. CNRS's participation also signals the internationalization of microplastics research and the relevance of cross-national collaboration in tackling global environmental problems.

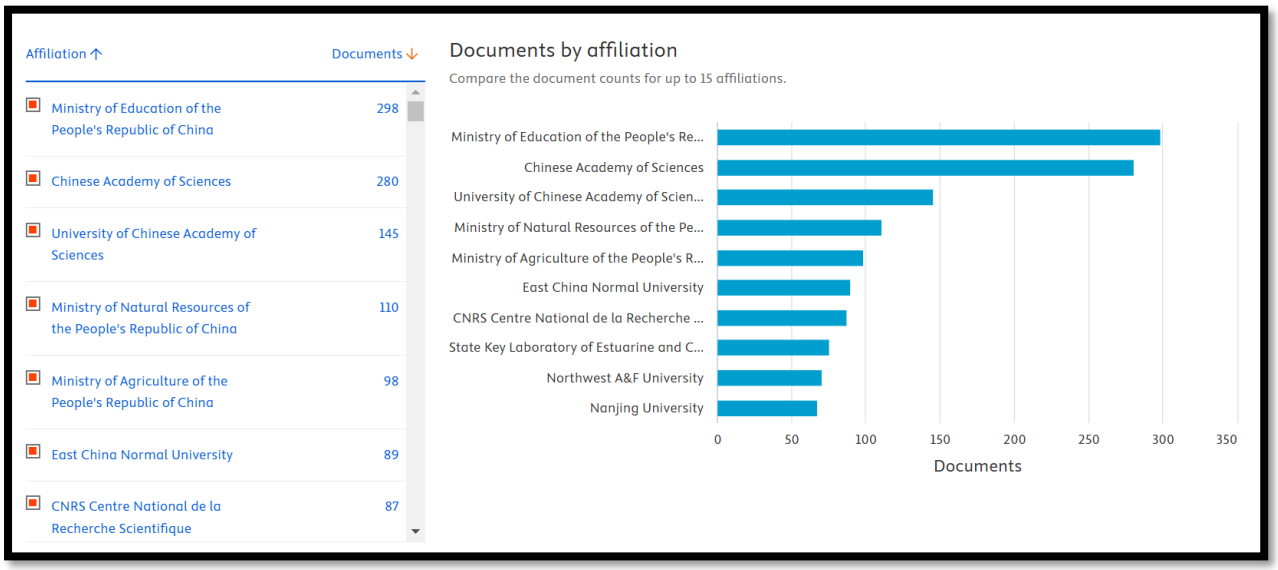


Figure 5: Discussion and Analysis: Institutional Contributions to Microplastics Research (2014–2024)

3.5. Leading Authors in Microplastics Pollution Research (2014–2024)

Figure 6 presents a closer look at the most prolific authors contributing to microplastics research over the last decade. At the forefront is Shi, H. from China, who leads with 39 publications. Shi has been deeply involved in field-based studies assessing the presence and distribution of microplastics in major Chinese rivers, including the Yangtze. His work, often carried out with collaborators, has provided critical insights into regional pollution hotspots and the environmental dynamics of microplastics in large aquatic systems (He et al., 2021).

Close behind is Huang, W., also from China, with 29 publications. Huang's research combines simulation modeling with real-world data to predict how microplastics behave in estuarine environments—specifically, how these particles move, settle, or accumulate based on water flow, sediment characteristics, and human impact (Shen et al., 2022). These models are important tools for designing prevention and cleanup strategies in river-mouth and coastal zones.

Another prominent name is Guilherme Malafaia from Brazil, with 26 publications. His work is central to understanding how microplastics affect terrestrial and aquatic wildlife. One of his recent studies explores how birds that ingest naturally aged polystyrene microplastics show signs of toxicity—and, alarmingly, may spread these particles further through digestion and movement (de Souza et al., 2022). His contributions highlight that microplastic pollution is not just an aquatic issue but one that spans ecosystems and trophic levels.

Other frequently publishing authors include Wang, J., Wu, C., Guo, X., and Li, D., all based in China. Their collective work has helped build a strong foundation in areas such as marine plastic behavior, pollutant co-occurrence, and microplastic detection methodologies. For instance, Wang, J.'s work provides an overview of how microplastics interact with the marine environment—from their entry points and transformation to their interactions with other pollutants like heavy metals and organic compounds (Wang et al., 2016).

De-la-Torre, G. E., based in Peru, adds a crucial perspective from Latin America. His research has significantly advanced our understanding of microplastic and mesoplastic contamination in Peruvian coastal zones, including sediment and beach systems impacted by both urbanization and fishing activities. His work brings visibility to coastal regions often underrepresented in global datasets (De-la-Torre et al., 2023).

Together, these authors reflect the evolving geography and scope of microplastics research. While Chinese scholars dominate in terms of volume, reflecting the country's strategic investment in environmental science, emerging voices from Brazil and Peru are expanding the field's ecological and geographic diversity. This combination of global leadership and regional specialization is essential to tackling what is clearly a planetary-scale pollution problem.

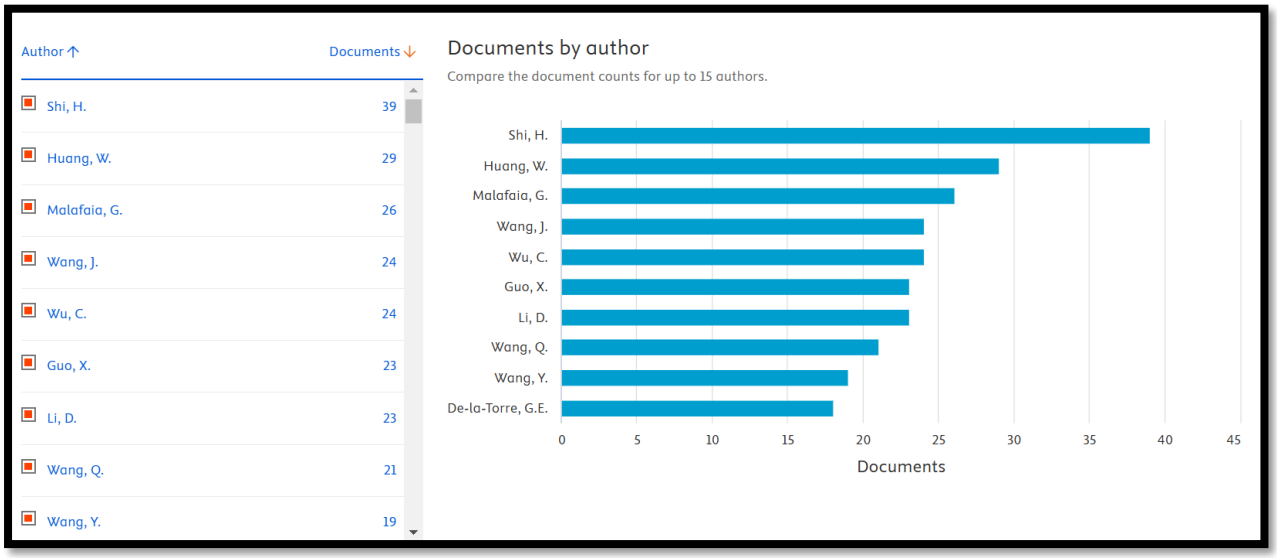


Figure 6: Most Prolific Authors in Microplastics Research (2014–2024)

3.6. Thematic Trends and Conceptual Linkages in Microplastics Research

The co-word analysis of microplastics research from 2014 to 2024 reveals a multidimensional and evolving thematic structure. Table 2 highlights the most frequently occurring keywords, with "microplastics," "plastic," and "plastic waste" showing both high frequency and total link strength, indicating their central role in shaping the field's discourse. This trend aligns with the visual representation in Figure 6 and the VOSviewer map, where "microplastics" sits at the conceptual core, strongly linked with themes of marine pollution, water quality, sediment contamination, and chemical pollutants (Wang et al., 2016; He et al., 2021).

Over time, as shown in Figure 6, the research focus has expanded from marine environments to encompass toxicological impacts, nanoplastics, soil contamination, and wastewater treatment. The red

cluster in the co-word map reinforces this foundational emphasis on aquatic systems and pollution transport, while the blue cluster signifies increasing interest in toxicology, bioaccumulation, and physiological effects on animals (de Souza et al., 2022; De-la-Torre et al., 2023). Notably, the green and yellow clusters point to emerging themes such as microbial degradation, soil and wastewater pathways, and biochemical processes (Shen et al., 2022).

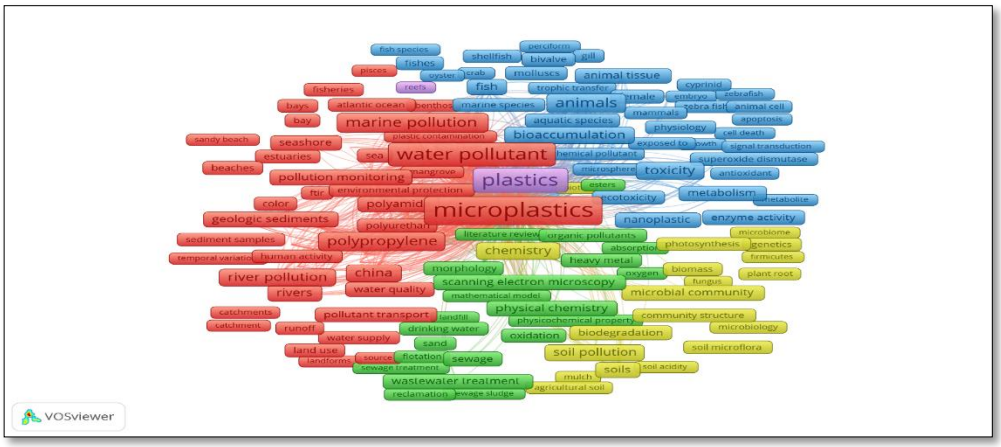
Despite the thematic expansion, policy and regulatory-oriented keywords remain underrepresented across all data layers. As reflected in the relatively low volume of publications under "policy and monitoring" in Figure 6, regulatory studies lag behind ecological and toxicological investigations. This gap is attributed to the absence of standardized risk thresholds, insufficient interdisciplinary collaboration, and delayed policy responsiveness to scientific findings (Haward, 2018; Van Sebille et al., 2020). This imbalance highlights the need for more integrative research efforts that bridge science and governance to enable actionable regulations.

Collectively, the data in Table 2, Figure 7, and the co-occurrence map suggest a maturing research domain—progressing from descriptive studies on marine litter to more impact-oriented and systems-based investigations. The transition reflects growing ecological urgency, technological capability, and interdisciplinary convergence, yet also points to a crucial opportunity to strengthen science-policy integration for real-world impact.

Table 2: Top 20 Co-occurring Keywords in Microplastics Research (2014–2024)

Keyword	Occurrences	Total Link Strength
1. microplastics	3691	111020
2. microplastic	3559	113188
3. microplastic pollution	3143	103552
4. plastic	2859	95198
5. article	2806	96213
6. plastics	2392	82879
7. plastic waste	2136	72335
8. water pollutant	2051	74225
9. water pollutants, chemical	2034	73746
10.nonhuman	1784	65731
11.environmental monitoring	1741	61613
12.controlled study	1603	56053
13.polymer	1401	48832
14.particle size	1182	41357
15.polyethylene	1162	43397
16.marine pollution	1052	34935
17.animals	993	36682
18.animal	976	36238
19.human	943	33064
20.polypropylene	889	34213

Figure 7: Thematic Trends and Conceptual Linkages in Microplastics Research



3.7

Evolution of Research Themes and Emerging Subfields (2014–2024)

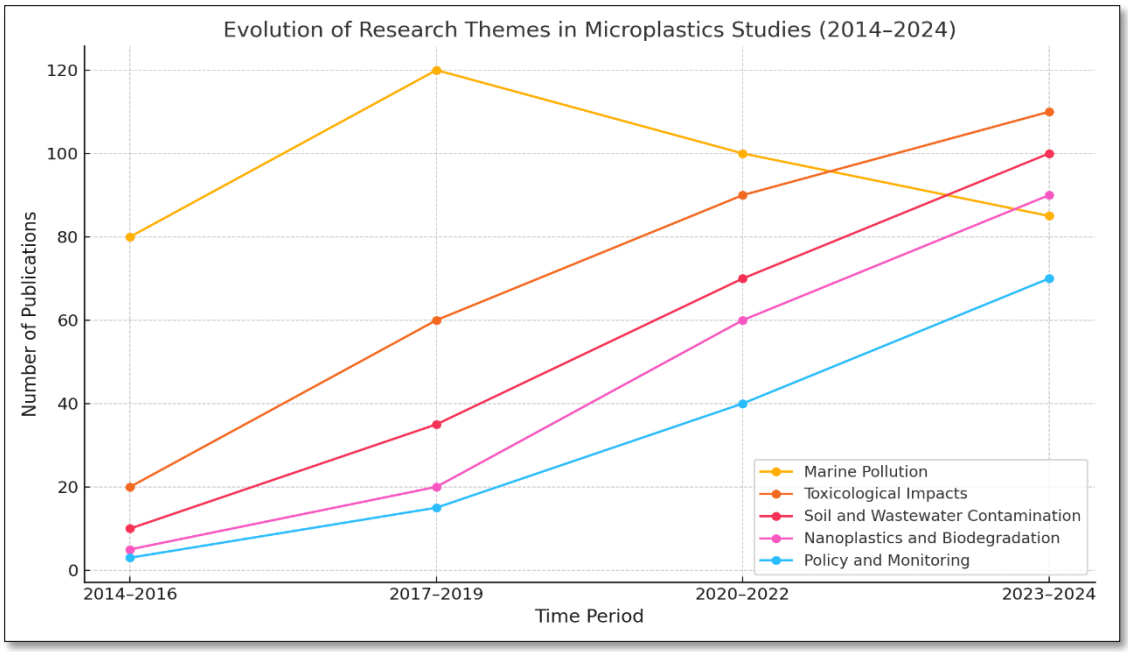
The figure 8 depicts the shifting landscape of thematic priorities within the field over the past decade. Early research was heavily focused on marine pollution, reaching a peak around 2019, a period that aligned with heightened global awareness of plastic waste in oceans and coastal systems (Wang et al., 2016; He et al., 2021). However, recent years have marked a transition toward research on toxicological impacts, which now surpass marine-focused studies. This trend reflects escalating concern over the biological consequences of microplastics, including ingestion, bioaccumulation, and physiological disruption in both aquatic and terrestrial organisms (de Souza et al., 2022; De-la-Torre et al., 2023).

Concurrently, emerging themes such as nanoplastics and biodegradation, as well as soil and wastewater contamination, have gained momentum. These developments are driven by technological advances in detection and an expanding recognition of microplastics' presence beyond marine environments, particularly in agricultural systems, freshwater ecosystems, and urban runoff (Shen et al., 2022). Notably, the rise of policy and monitoring as a research category—albeit limited in volume—suggests growing interest in applying scientific evidence to inform environmental governance and risk assessment frameworks.

Despite the upward trend in microplastics research, the figure also underscores a significant gap: regulatory-focused studies remain relatively underrepresented compared to ecological and toxicological investigations. This underrepresentation is largely attributed to historical delays in legislative responses, the absence of standardized regulatory thresholds, and limited interdisciplinary collaboration between environmental scientists, policymakers, and legal scholars. As highlighted by Horton et al. (2017), the lack of harmonized methodologies has impeded the development of regulatory frameworks, while Barboza and Gimenez (2015) emphasized that policy actions have not kept pace with the rapid expansion of scientific knowledge in this field. Furthermore, the dominance of impact-oriented studies often sidelines governance-oriented research, despite growing awareness of the need to align science with policy agendas (Gallo et al., 2018; da Costa et al., 2017).

This imbalance hinders the translation of empirical findings into enforceable standards and delays the implementation of risk-based decision-making processes. Bergmann et al. (2019) also argue that surprising discoveries—such as the presence of microplastics in remote regions—have often outstripped the readiness of regulatory bodies to respond. Overall, the limited integration of governance and scientific discourse signals the urgent need for more holistic and interdisciplinary research that bridges environmental science and policy development.

Figure 8: Evolution of Research Themes and Emerging Subfields



3.8 International research collaboration networks, showcasing key contributors, co-authorship patterns, and geographic distributions in microplastics-related studies

The figure 9 below illustrates a co-authorship network map of prominent researchers in microplastics studies from 2014 to 2024, created using VOSviewer. Each node represents an author, with node size

indicating publication output and lines representing co-authorship ties. Distinct clusters are color-coded to reveal thematic or institutional collaborations across global regions.

A prominent observation is the dominance of a central cluster composed of Chinese scholars such as Shi Huahong, Wang Jun, Wu Chenxi, Li Daoji, and Huang Wei, highlighting China's leadership in microplastics research. This tight-knit collaborative network reflects the strong institutional connectivity among Chinese research institutions like the Chinese Academy of Sciences and leading universities. These collaborations are supported by China's national environmental strategies and state-sponsored research programs focused on marine pollution and ecological monitoring (Sun & Cao, 2020; Zhou & Leydesdorff, 2006).

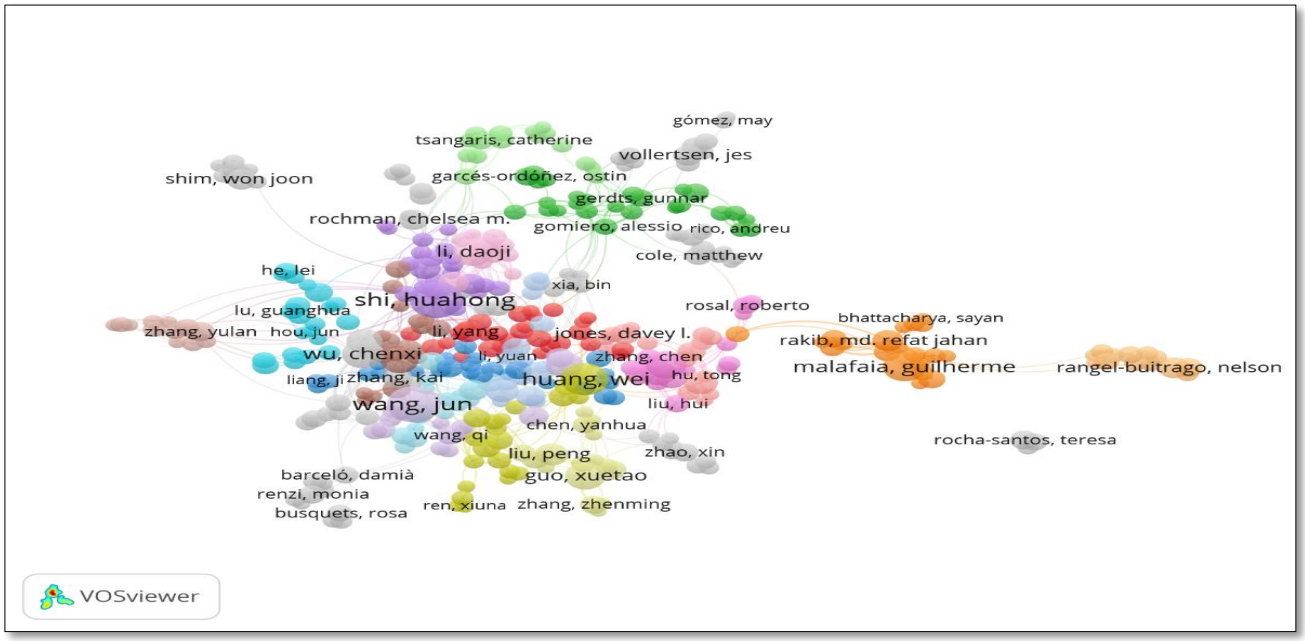
Another major group includes Latin American and Global South researchers, particularly Guilherme Malafaia (Brazil), Rakib Md. Refat Jahan, and Rangel-Buitrago Nelson. Their work often emphasizes toxicological impacts and localized environmental threats (de Souza et al., 2022), suggesting a growing regional prioritization of microplastic-related health and ecological concerns. This group, while productive, is relatively less integrated with other global networks, pointing to a fragmented global research landscape.

Smaller but strategically important clusters include Western researchers such as Chelsea Rochman (Canada/USA), Gunnar Gerdts (Germany), and Ostin Garcés-Ordoñez (Colombia). These scholars are involved in studies on risk assessment, marine plastic governance, and science-policy integration (D'Amato et al., 2022; Wagner et al., 2015), suggesting a thematic shift toward multidisciplinary approaches. However, these clusters tend to form smaller subnetworks, indicating weaker global integration compared to the Chinese nexus.

Despite increasing global awareness of microplastic threats, the map highlights a critical gap in policy- and regulation-focused research. Clusters dedicated to governance, monitoring frameworks, or legislative responses remain sparse. Scholars such as Malafaia and collaborators, though not centrally embedded, demonstrate emerging interest in science-to-policy transitions. This lack of regulatory emphasis aligns with broader observations in the literature, which note the absence of standardized international policies, underdeveloped legal frameworks, and minimal engagement between scientists and policymakers (Singh et al., 2025; Bakare-Abidola & Olaoye, 2025).

Only a handful of countries, including select EU members and Southeast Asian nations, have developed structured policies aimed at microplastic mitigation, such as circular plastic economies and microbead bans (Wu, 2025). The limited integration of regulatory themes into mainstream scientific collaborations poses challenges for translating empirical insights into actionable standards and policy interventions.

Figure 9: Co-authorship network map of prominent researchers in microplastics studies from 2014 to 2024



4.2. Theoretical and practical implications

The evolving landscape of microplastics research from 2014 to 2024 offers critical theoretical and practical insights into the structure, focus, and global dynamics of this interdisciplinary field. Thematically, the

dominance of ecological, toxicological, and marine pollution studies confirms the maturity of environmental science as a core domain. However, the conspicuous underrepresentation of regulatory and policy-oriented research highlights a persistent gap between scientific knowledge production and actionable governance. This gap supports theoretical perspectives on the "knowledge–action divide," where the integration of empirical science into policymaking remains limited (Wagner et al., 2015; Singh et al., 2025). The concentration of co-authorship networks, particularly in China, further validates social network theories suggesting that national science agendas significantly influence scholarly collaboration and research centrality (Zhou & Leydesdorff, 2006; Sun & Cao, 2020).

These theoretical insights carry direct implications for practice, particularly in addressing collaboration imbalances and strengthening science–policy linkages. On a practical level, the findings underscore the need for more inclusive and balanced research efforts. While China's dominance has advanced the technical and ecological frontiers of microplastics studies, global collaboration remains uneven, with limited connectivity between the Global North and South. To bridge these disparities, there is a pressing need to foster international partnerships, encourage South–South research exchanges, particularly within ASEAN and other developing regions heavily affected by marine plastic leakage, and invest in capacity building across underrepresented regions. Moreover, the absence of strong regulatory-focused clusters suggests that environmental science has not yet been fully leveraged to influence legislation or international agreements. Strengthening the science–policy interface through interdisciplinary research, stakeholder engagement, and targeted funding mechanisms will be essential for transforming research outcomes into enforceable standards and sustainable practices. As the field shifts toward emerging subtopics such as nanoplastics, soil contamination, and biodegradation, aligning scientific inquiry with global policy frameworks such as the Sustainable Development Goals, the Paris Agreement, and the upcoming UN Plastics Treaty becomes increasingly urgent.

4.2. Limitations and future research

This study has several limitations. First, the analysis relied solely on the Scopus database, which, although comprehensive, may exclude non-indexed publications, policy briefs, and grey literature, potentially underrepresenting region-specific studies from developing countries. Second, bibliometric tools such as VOSviewer highlight quantitative patterns of collaboration and keyword trends but do not capture the qualitative depth, contextual impact, or regulatory effectiveness of the research. In addition, reliance on author-assigned keywords may introduce inconsistencies due to variations in terminology.

Moving forward, expanding data sources to Web of Science, PubMed, and regional databases would provide a more complete view of the global landscape. Incorporating text mining, systematic reviews, and policy analysis could enrich insights into the social, economic, and health dimensions of microplastics. Comparative bibliometric studies across ASEAN countries and longitudinal mapping of policy-related keywords would clarify regional collaboration dynamics and the evolution of science–policy linkages. This study also directs Philippine and global research by emphasizing underexplored areas such as nanoplastics, wastewater, soil exposure, and health impacts, alongside the need to integrate cost–benefit assessments into governance. Strengthening interdisciplinary collaboration and embedding research into community-based monitoring and sustainability education are urgent steps toward bridging the science–policy divide in microplastics management.

5. CONCLUSION

This paper, through a bibliometric and co-word analysis, provides a comprehensive review of global research on microplastics pollution from 2014 to 2024. It systematically organizes the literature to identify major research trends, influential contributors, collaborative networks, and emerging subfields. By mapping citation patterns, keyword co-occurrence, and thematic evolution, the study highlights research hotspots and offers insight into the intellectual structure of the field.

The results reveal significant growth in microplastics research over the past decade, with increasing attention to environmental impacts, toxicological risks, and emerging topics such as nanoplastics, biodegradation, and terrestrial pollution. Chinese institutions dominate both publication volume and co-authorship networks, while policy- and regulatory-focused research remains limited.

Gabisa and Gheewala (2022) estimate that only about 5% of global microplastics research originates from ASEAN countries, underscoring the region's underrepresentation. The Philippines contributes only a small portion of this output, despite being the third largest global source of marine plastic leakage (Jambeck et al., 2015; Lebreton et al., 2017). Regional studies remain fragmented, often focused on

marine ecology or localized cases (Abreo et al., 2019), while recent assessments also highlight persistent deficits in standardized methodologies and long-term monitoring capacity (GIZ, 2024). These limitations underscore the urgent need to expand Southeast Asia's research footprint and to align scientific production with pressing governance challenges.

National policy instruments in the Philippines provide an entry point for stronger integration of research and governance. The Ecological Solid Waste Management Act (RA 9003) requires waste segregation but suffers from weak enforcement and uneven compliance (Government of the Philippines, 2000). The Extended Producer Responsibility Act of 2022 (RA 11898) introduces accountability for plastic packaging but requires more robust compliance monitoring (Government of the Philippines, 2022). Embedding microplastics studies—such as polymer fingerprinting and waste stream analysis—into these laws could strengthen implementation and accountability. At the regional level, the ASEAN Regional Action Plan for Combating Marine Debris (2021–2025) offers a coordinated strategy for harmonized monitoring, knowledge sharing, and EPR expansion (ASEAN, 2021; World Bank, 2021).

Building on these findings, several practical steps can be considered. LGUs can establish river-to-coast monitoring programs integrated into RA 9003 plans. National agencies should link EPR reports to independent leakage and recovery data. Researchers can develop standardized, low-cost protocols to improve comparability. Educators may embed citizen science initiatives into DepEd's K–12 curriculum and CHED programs, promoting both learning and community-level data generation. ASEAN networks can foster cross-country partnerships and a shared data hub to operationalize the regional action plan.

Beyond governance and education, microplastics research also intersects with public health, economics, and sustainability education. Barboza et al. (2018) and Wright and Kelly (2017) have documented microplastics in seafood, potable water, and even table salt, raising concerns over long-term health impacts. Economically, plastic leakage imposes significant costs on fisheries, aquaculture, tourism, and waste management systems, reinforcing the value of integrating cost–benefit analysis into decision-making (Beaumont et al., 2019). From an educational perspective, linking microplastics research with the Sustainable Development Goals (SDGs 3, 4, 6, 12, and 14) strengthens sustainability curricula and environmental literacy in both basic and higher education (United Nations, 2020).

By systematically mapping global and regional developments, this study not only identifies scientific priorities but also exposes policy gaps and collaboration imbalances that remain underexplored. In doing so, it contributes to bridging the persistent science–policy divide in environmental governance, providing evidence-based insights that can inform more inclusive and interdisciplinary approaches to tackling plastic pollution.

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66. Declarations

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70.
James Brian Flores: Conceptualization, Methodology, Data Analysis, Writing – Original Draft.
71. Mark Donald S. Oja: Data Curation, Validation, Writing – Review & Editing.
72. Ingrid M. Uy: Data Curation, Writing – Review & Editing.
73. Marie Khul Cabalo Langub: Validation, Writing – Review & Editing.

74. All authors have read and approved the final manuscript.
75. **Ethical Approval**
This is not applicable. This study does not involve human participants or animal subjects.
76. **Consent to Participate**
This is not applicable

77. **Consent to Publish**

All authors consent to the publication of this manuscript.

78. **Competing Interests**

No potential conflict of interest was reported by the author(s). The authors declare that they do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

79. **Data Availability Statement**

The bibliometric dataset analyzed during this study was retrieved from the Scopus database. Processed data generated and analyzed in this study are available from the corresponding author upon reasonable request.