

# Mapping Global Research Trends on Marine Plastic Pollution: A Bibliometric Analysis of Legal and Policy Frameworks

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DOI: <https://dx.doi.org/10.47772/IJRISS.2025.909000563>

Received: 11 September 2025; Accepted: 16 September 2025; Published: 17 October 2025

## ABSTRACT

Marine plastic pollution (MPP) stands as one of the significant environmental challenges of the twenty-first century, shaping debates on sustainability, biodiversity protection, and climate change resilience. Although scientific research on plastics has expanded rapidly, comparatively less attention has been devoted to the intellectual and thematic evolution of legal and policy-oriented research in this field. To address this gap, this bibliometric study systematically examines the intellectual, thematic, and structural development of MPP scholarship, specifically focusing on legal and policy frameworks between 2015 and 2025. Drawing on 406 publications retrieved from the Scopus database, the study pursues four objectives: (1) to analyse the intellectual and thematic evolution of MPP research addressing legal and policy dimensions over the past decade; (2) to identify key contributors and collaboration patterns; (3) to explore dominant thematic trends and emerging conceptual structures through keyword co-occurrence and network mapping techniques; and (4) to highlight persisting research gaps. Using bibliometric tools, including Harzing's Publish or Perish, OpenRefine, and VOSviewer, the analysis reveals a marked increase in scholarly output, peaking in 2023–2024. The findings outline a three-phase trajectory: an emergent stage (2015–2017), a consolidation phase (2018–2021), and an acceleration phase (2022–2025), aligned with global policy milestones such as the EU Single-Use Plastics Directive and the UNEA resolution on a global plastics treaty. With growing participation from Southeast Asia, authors and institutions from China, the United States, India, and Europe make influential contributions. Thematic clusters highlight ecological risks, waste management, governance frameworks, and emerging linkages with sustainability and climate change. Nonetheless, significant gaps persist, particularly in aligning legal frameworks with climate commitments and strengthening enforcement in developing regions. Overall, this study provides a comprehensive mapping of MPP governance scholarship, offering valuable insights for scholars, policymakers, and practitioners seeking to advance marine sustainability and climate resilience.

**Keywords:** Marine Plastic Pollution (MPP), Legal framework, Policy, Bibliometric Analysis, Marine Sustainability

## INTRODUCTION AND BACKGROUND

Marine plastic pollution (MPP) has emerged as one of the twenty-first century's most pressing global environmental challenges. With millions of tonnes of plastics entering the oceans annually, this pervasive pollutant disrupts marine ecosystems, threatens biodiversity, and poses risks to human health through bioaccumulation in the food chain (Bonanno, 2022; Garcia et al., 2019). Beyond its ecological consequences, MPP has become a matter of global governance, prompting increasing scholarly and policy attention. The complexity of the issue spanning production, consumption, disposal, and transboundary impacts demands scientific and technological solutions and robust legal and policy frameworks capable of effectively regulating and mitigating its harms (Abalansa et al., 2020).

Over the past two decades, research on MPP has proliferated across multiple disciplines, including environmental science, law, economics, and policy studies. At the international level, legal frameworks addressing marine plastics remain fragmented, with instruments such as the United Nations Convention on the Law of the Sea (UNCLOS) and the International Convention for the Prevention of Pollution from Ships (MARPOL) offering only partial coverage (Chang & Saqib, 2025). While global negotiations advance toward a comprehensive plastics treaty, existing agreements, such as the Basel Convention and various regional initiatives, grapple with enforcement gaps and a lack of harmonisation (Raubenheimer & McIlgorm, 2018; Carlini & Kleine, 2018). National experiences also vary: Taiwan has developed an integrated waste management framework regarded as a model, whereas Indonesia struggles with fragmented regulations and weak enforcement despite notable local initiatives (Puspitawati et al., 2025; Widagdo & Anggoro, 2022). These variations underscore the need to systematically understand how legal and policy research on MPP has evolved globally.

This study situates itself within this evolving landscape by employing bibliometric methods to systematically map global scholarship on MPP, specifically focusing on legal and policy frameworks. Bibliometric analysis identifies trends, thematic clusters, and research gaps across disciplines, offering insights into the volume and intellectual structure of academic discourse (Wu, 2022; Fadeeva & Van Berkel, 2021). By applying this approach to the governance of MPP, the study not only quantifies scholarly output but also situates legal and policy discourse within broader debates on sustainability, governance, and circular economy approaches (Barrowclough & Birkbeck, 2022; Brooks & Havas, 2025).

Despite the growing urgency of MPP, bibliometric research that integrates environmental law and policy perspectives remains limited. Most bibliometric studies on plastics have focused on environmental science, material engineering, and waste management, while the legal and governance dimensions are often underexplored (Ferraro & Failler, 2020). This gap is significant because effective responses to MPP depend on technological advances and coherent, enforceable, and internationally coordinated legal and policy measures (Finska et al., 2022). Addressing this shortcoming, the present study systematically assesses how legal and policy scholarship on MPP has developed, highlighting both dominant research themes and under-represented areas.

The following research questions are proposed to guide the analysis: How has MPP research with a focus on legal and policy frameworks intellectually and thematically evolved between 2015 and 2025? Who are the key contributors (authors, institutions, and countries), and what patterns of collaboration and interdisciplinary linkages characterise scholarship in this field? What are the dominant thematic trends and emerging conceptual structures revealed through keyword co-occurrence and term mapping in MPP research? Finally, what research gaps remain, and how might they inform further scholarly inquiry to ensure comprehensive coverage of MPP's legal and policy dimensions?

To address these questions, the paper proceeds as follows. Section 2 synthesises existing literature, focusing on key international, regional, and national legal and policy developments related to MPP. Section 3 outlines the methodology, including data collection strategies, bibliometric techniques, and analytical tools. Section 4 presents the findings of the bibliometric analysis, including performance indicators, co-authorship patterns, and thematic mapping. Section 5 discusses the results in light of governance challenges and legal implications, offering critical reflections on the role of law in combating MPP. Finally, Section 6 concludes by summarising key insights, highlighting contributions, and suggesting future research and policy development directions.

## LITERATURE REVIEW

From 2015 to 2025, academic research, studies, and publications on MPP expanded rapidly. It diversified methodologically, moving from ecological impact assessments to governance-oriented analyses that foreground the plastics life cycle and the socio-economic drivers of production and consumption. Recent reviews estimate annual ocean inputs at roughly 11 million tonnes, with projections of a possible tripling by 2040 absent systemic interventions and argue for multi-sectoral responses that transcend end-of-pipe waste management (Bertolazzi et al., 2024). This period also witnessed a growing consensus around the circular economy as a strategic framework linking upstream design, product standards, and market instruments to internalise externalities and reduce primary plastic production (Bertolazzi et al., 2024; Fadeeva & Van Berkel, 2021; Barrowclough &

Birkbeck, 2022).

At the international level, a core debate concerns the adequacy and architecture of existing law. Analyses of UNCLOS and MARPOL Annex V underscore partial coverage of plastics, uneven state practice, and limited compliance mechanisms, especially for land-based sources that dominate marine inputs, prompting calls for stronger life-cycle obligations (Chang & Saqib, 2025). From 2018 onwards, attention intensifies around the UNEA process and negotiations toward a legally binding global plastic pollution instrument, with work examining options for treaty design, monitoring and reporting, funding mechanisms, and interfaces with trade and chemicals regimes; the European Union's effort to project its governance experience internationally is a recurring theme (Xu et al., 2024; Barrowclough & Birkbeck, 2022). These debates cleave between incremental strengthening of a fragmented regime complex and a more integrated agreement that imposes upstream controls and product standards (Chang & Saqib, 2025; Xu et al., 2024).

Regional and national policy studies document heterogeneous implementation trajectories and persistent enforcement gaps over 2015–2025. Comparative analyses across the G20 catalogue diverse mixes of single-use bans, extended producer responsibility (EPR), and public–private partnerships while questioning effectiveness absent standard metrics and cross-border coordination (Fadeeva & Van Berkel, 2021). In ASEAN, research highlights the “ASEAN Way” paradox: cooperation instruments exist but typically lack binding force and robust compliance machinery, constraining convergence among member states (Putri & Sabatira, 2023). Country-level work, particularly in Indonesia, details institutional fragmentation and overlapping mandates that impede coherent responses despite selective progress, while other jurisdictions are cited for more integrated frameworks (Puspitawati et al., 2025). Studies also note the salience of consumer perceptions and community practices in shaping local outcomes (Bertolazzi et al., 2024).

A parallel stream interrogates the political economy of plastics and the science–policy interface. Scholars contend that governance weaknesses arise from misaligned incentives along the plastics value chain and the persistence of downstream biases in policy design, underscoring the need to address production and consumption drivers and to adopt systems approaches (Barrowclough & Birkbeck, 2022; Brooks & Havas, 2025). Proposals for an independent scientific committee on plastic pollution aim to standardise indicators, strengthen evidence-based brokering, and provide authoritative assessments to guide state obligations and treaty negotiations (George et al., 2024). At the same time, work on the politics of MPP identifies underexplored dimensions of equity, just transition, and distribution of obligations that shape instrument choice, compliance, and legitimacy (Groot et al., 2025; Xu et al., 2024).

Notwithstanding these advances, gaps remain that warrant systematic mapping. The intellectual linkages among international law, regional cooperation, and domestic implementation are diffuse, with limited integration across legal doctrine, policy evaluation, and empirical impact assessment (Chang & Saqib, 2025; Putri & Sabatira, 2023). Comparative effectiveness studies of instruments (e.g., EPR, product standards, trade measures) are often case-based and methodologically heterogeneous, limiting generalisability (Fadeeva & Van Berkel, 2021; Puspitawati et al., 2025). Equity, just transition, and interoperability of regional standards are emergent and unevenly treated (Groot et al., 2025). To address these deficits, this study employs a bibliometric approach that combines performance analysis (including publication and citation dynamics, and leading sources) with science mapping (encompassing co-authorship networks, co-citation structures, keyword co-occurrence, and term mapping). This approach aims to delineate temporal phases (early consolidation from 2015 to 2017, acceleration with UNEA momentum from 2018 to 2021, and treaty-focused expansion from 2022 to 2025), identify influential contributors and collaborative constellations, and reveal thematic evolution along with neglected fronts to inform future legal and policy research agendas (Wu, 2022; Bertolazzi et al., 2024; George et al., 2024).

Building on these scholarly streams, it is clear that while the literature has advanced considerably in mapping marine plastic pollution, significant gaps remain in integrating legal and policy perspectives with environmental science and governance research. Addressing these gaps, particularly around treaty design, enforcement, and alignment with climate and sustainability agendas, will enrich our understanding of the field and pave the way for more robust and policy-relevant future investigations.

## METHODOLOGY

A rigorous bibliometric analysis provides a systematic and quantitative approach to examining research trends, intellectual structures, and global collaboration patterns in the interdisciplinary marine plastic pollution (MPP) field, highlighting its legal and policy dimensions. Scopus was selected as the primary data source because of its broad coverage across environmental science, law, and policy disciplines; extensive indexing of journals beyond the U.S. and Europe; and reliable author and institutional identifiers that support disambiguation and reproducibility (Falagas et al., 2008; Mongeon & Paul-Hus, 2016). Through bibliometric techniques, performance indicators such as publication output, citation impact, and author productivity reveal how scholarship on MPP governance has evolved, while science-mapping methods including co-citation analysis, bibliographic coupling, and keyword co-occurrence uncover the intellectual foundations, emerging research fronts, and thematic clusters that define the field (Small, 1973; Kessler, 1963; Zupic & Čater, 2015). Moreover, co-authorship and collaboration network analyses highlight the geographic distribution of research capacity, exposing both core-periphery dynamics and cross-regional linkages relevant to treaty negotiations and policy transfer (Waltman, 2016). By combining these methods, bibliometrics not only maps the structural and thematic evolution of MPP research but also identifies knowledge gaps, such as the alignment of plastic governance with climate change obligations and enforcement challenges in developing regions, that inform future inquiry. In this way, bibliometric analysis advances scientific knowledge by integrating fragmented contributions, supporting cumulative theorisation, and providing evidence-based insights that can guide legal and policy responses to marine plastic pollution (Donthu et al., 2021).

### Data Collection

This bibliometric study followed a PRISMA-guided workflow to ensure transparency, rigour, and reproducibility in identifying and screening relevant marine plastic pollution (MPP) literature while emphasising legal and policy frameworks.

The process began with the topic's definition, framed as *“Mapping Global Research Trends on Marine Plastic Pollution: A Bibliometric Analysis of Legal and Policy Frameworks.”* Scopus was selected as the primary database due to its extensive coverage of environmental science, law, and policy research, robust indexing of global publications, and availability of exportable metadata for bibliometric analyses. The search covered all years, all fields, and all languages, ensuring comprehensive retrieval.

At the identification stage, a structured query was developed to combine environmental terms (e.g., “marine plastic pollution”, “ocean plastic\*”, “marine litter”, “microplastic\*”, “plastic waste”) with governance-related terms (e.g., “law”, “policy”, “regulation\*”, “UNCLOS”, “MARPOL”, “treaty”, “convention\*”, “Basel Convention”, “environmental law”). This broad strategy initially retrieved 8,315 records.

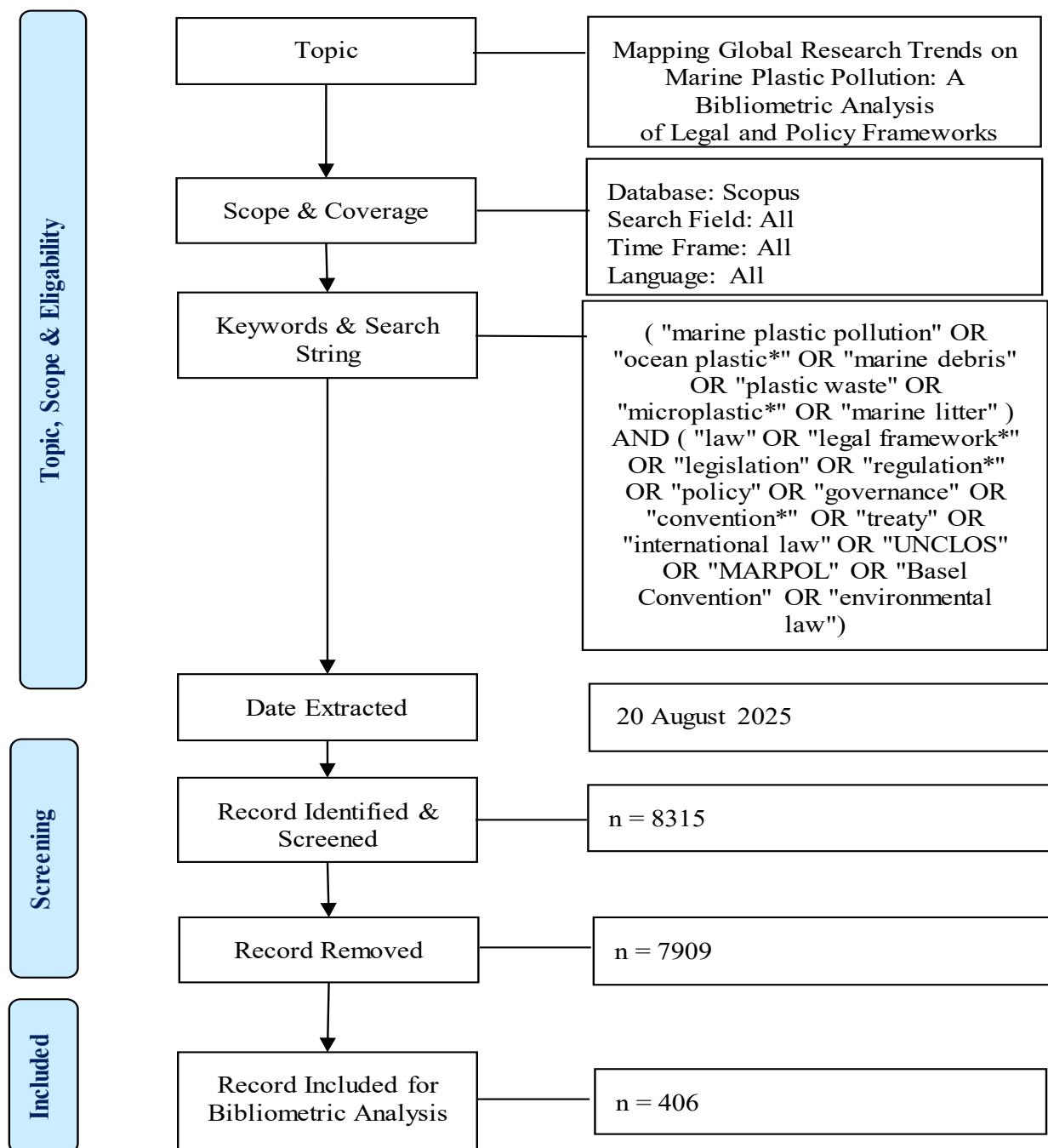
During the screening stage, duplicates were removed, and records that did not substantively address legal or policy dimensions of MPP were excluded. Exclusions also applied to non-source items (e.g., editorials, book reviews, errata) and documents lacking essential bibliographic data. After this step, 7,909 records were removed.

At the eligibility stage, the remaining records were screened by title and abstract to confirm relevance. Publications engaged with governance instruments, legal frameworks, enforcement mechanisms, or international/national policy initiatives were retained. When necessary, full-text checks were conducted to ensure substantive policy/legal focus.

Finally, a curated dataset of 406 publications (2015–2025) was established at the inclusion stage. This dataset, extracted on 20 August 2025, forms the basis of the bibliometric analysis. Performance analysis was applied to examine publication trends, citation dynamics, and prolific contributors (authors, institutions, and countries). At the same time, science mapping (using tools such as VOSViewer and Bibliometrix) was employed to analyse co-authorship patterns, keyword co-occurrences, co-citation structures, and thematic evolution.

Thus, the PRISMA flow in Figure 1 documents the systematic progression from identification to inclusion, ensuring that the final dataset accurately represents the global research landscape on MPP legal and policy

frameworks.



**Figure 1.** Flow diagram of the search strategy

## Tools

This bibliometric study employed analytical tools such as Harzing's Publish or Perish, OpenRefine, and VOSviewer to ensure the reliability, accuracy, and interpretability of bibliometric data retrieved from the Scopus database. Harzing's Publish or Perish software was utilised to generate descriptive citation metrics, such as total citations, h-index, g-index, and average citations per publication. These indicators were instrumental in assessing scholarly productivity and influence in marine plastic pollution (MPP), particularly within legal and policy frameworks (Harzing, 2007).

Following metric extraction, OpenRefine was applied as a robust data-cleaning tool to identify and resolve

inconsistencies in author names, institutional affiliations, and keyword variations. This step was essential for ensuring standardised bibliographic records and eliminating duplications or erroneous entries that could compromise the validity of subsequent analyses (Verborgh & De Wilde, 2013).

Subsequently, VOSviewer was employed for advanced bibliometric mapping and visualisation. The software enabled the construction of co-authorship, co-citation, and keyword co-occurrence networks, which revealed key research clusters, thematic trends, and collaboration patterns within the global MPP legal policy research landscape (Van Eck & Waltman, 2010). Its graphic interface allowed for the visualisation of complex bibliometric structures, highlighting intellectual linkages among authors, sources, and conceptual themes.

Collectively, these tools provided a rigorous methodological framework: Publish or Perish ensured comprehensive metric reporting, OpenRefine guaranteed data accuracy and consistency, and VOSviewer delivered insightful knowledge mapping. Their integration enhanced analytical precision and facilitated a deeper understanding of the intellectual and thematic evolution of MPP research, thereby contributing to advancing governance, sustainability, and policy scholarship.

## RESULTS AND DISCUSSION

This section presents the bibliometric results from a systematic analysis of publications on marine plastic pollution with an emphasis on legal and policy frameworks, based on the curated Scopus dataset ( $n = 406$ ; 2015–2025). The objective is to uncover the patterns, structures, and key contributors that shape this interdisciplinary research domain. By examining core indicators on publication and citation trends, prolific authors, subject areas, document types, source titles, contributing institutions, countries/regions of origin, and source types, together with science-mapping outputs on co-authorship, international collaboration, co-citation, bibliographic coupling, and keyword co-occurrence, the analysis offers a comprehensive overview of scholarly output and global research dynamics. The findings elucidate how the field has evolved over the past decade, who drives the discourse, where influential work is produced and published, and which thematic clusters and intellectual linkages define the current and emerging contours of governance research on marine plastic pollution.

### Documents Profiles

Table 1 presents the main bibliometric information of the dataset, providing a concise yet comprehensive overview of publication and citation dynamics in marine plastic pollution (MPP) research with a legal and policy focus between 2015 and 2025. Over this ten-year citation window, 406 publications generated 12,134 citations, with an annual average of 1,213.4. On a per-paper basis, the dataset records an average of 29.89 citations per publication, highlighting the field's sustained visibility and the diffusion of knowledge across multiple disciplines (Donthu et al., 2021; Waltman, 2016).

In terms of author-level productivity, the Cites\_Author value (4,141.79) and Papers\_Author (162.71) confirm a Lotka-type distribution, whereby a small number of prolific authors contribute disproportionately to output and citation impact, while a larger “long tail” produces fewer works (Lotka, 1926; Waltman, 2016). The average of 4.14 authors per paper demonstrates a strong tendency toward collaboration, a hallmark of interdisciplinary and governance-oriented research, which often involves joint efforts between legal scholars, environmental scientists, and policy analysts (Wuchty et al., 2007).

Core impact indices further corroborate the maturity of this research niche. The h-index of 56 indicates that at least 56 papers have each been cited a minimum of 56 times, while the g-index of 102 highlights the concentration of citations in a smaller set of highly influential works (Hirsch, 2005; Egghe, 2006). This dual configuration suggests both breadth through a sizeable number of consistently cited publications and depth via an elite group of foundational studies that anchor scholarly discourse.

The metrics in Table 1 reflect a field that has transitioned from early diffusion to consolidation, coinciding with global governance milestones such as the EU Single-Use Plastics Directive (2019/904) and the UNEA mandate (2022) for a global plastics treaty. By integrating productivity, impact, and collaboration indicators, the document profile offers a robust foundation for mapping the intellectual structure and global research dynamics

of MPP legal and policy scholarship (Zupic & Čater, 2015).

**Table 1.** Main information

| Main Information  | Data      |
|-------------------|-----------|
| Publication years | 2015-2025 |
| Citation years    | 10        |
| Papers            | 406       |
| Citations         | 12134     |
| Cites_Year        | 1213.4    |
| Cites_Paper       | 29.89     |
| Cites_Author      | 4141.79   |
| Papers_Author     | 162.71    |
| Authors_Paper     | 4.14      |
| h_index           | 56        |
| g_index           | 102       |

Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

### Publication Trends

Table 2 presents the annual distribution of publications on marine plastic pollution (MPP) research with a legal and policy focus from 2015 to 2025. The dataset reveals a clear trajectory of growth that can be divided into three distinct phases.

The emergent phase (2015–2017) was characterised by minimal output, with only one publication in 2015 (0.25%), five in 2016 (1.23%), and two in 2017 (0.49%). This early stage reflects a nascent scholarly community and relatively low policy salience, as global attention to MPP was still dominated by scientific assessments of ecological impacts rather than governance mechanisms (Jambeck et al., 2015; Geyer et al., 2017).

The build-up phase (2018–2021) demonstrates a steady increase in publications, with 17 papers in 2018 (4.19%), 16 in 2019 (3.94%), 21 in 2020 (5.17%), and 37 in 2021 (9.11%). This period coincided with important international developments such as UNEA-3 and UNEA-4 resolutions on marine litter and microplastics and the adoption of the EU Single-Use Plastics Directive (Directive (EU) 2019/904), which significantly elevated the governance dimension of MPP research. The rising numbers suggest that legal and policy frameworks are becoming recognised as areas of inquiry within the broader plastic pollution discourse (Raubenheimer & McIlgorm, 2018; Dauvergne, 2018).

The acceleration phase (2022–2025) marks the most significant growth, with 68 publications in 2022 (16.75%), 59 in 2023 (14.53%), peaking at 100 in 2024 (24.63%), and 80 in 2025 (19.70%). These years account for over three-quarters of the total output ( $\approx 76.6\%$ ). This surge aligns closely with the UNEA-5.2 resolution of 2022 to begin negotiations for a legally binding global plastics treaty, which galvanised scholarly engagement with treaty design, compliance mechanisms, and intersections with climate change and sustainability (UNEP, 2022; Simon et al., 2021). The 2024 peak likely reflects treaty momentum and the increasing integration of circular economy and extended producer responsibility (EPR) frameworks into national and regional policy debates (Kirchherr et

al., 2018; Barrowclough & Birkbeck, 2022).

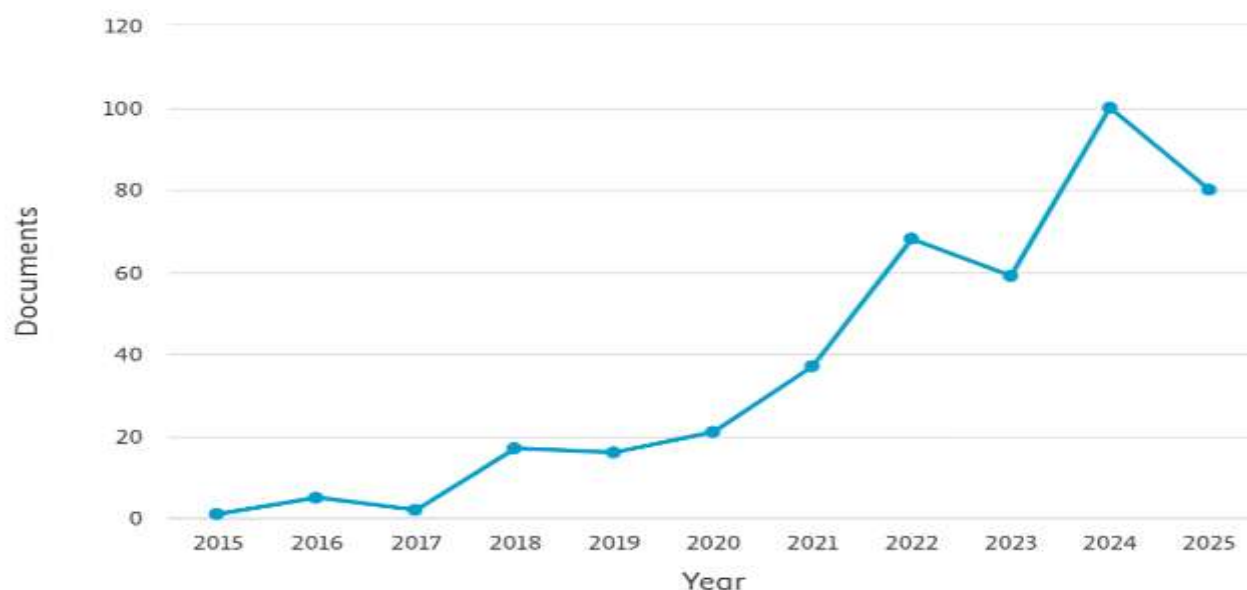
Overall, the annual publication trends in Table 2 illustrate the transition of MPP research from a marginal scholarly concern to a consolidated and rapidly expanding field at the science–policy interface. The alignment of publication growth with key international policy milestones underscores the strong coupling between global governance initiatives and academic output, suggesting that legal and policy scholarship on MPP is highly responsive to international negotiations and treaty processes (Donthu et al., 2021; Zupic & Čater, 2015).

**Table 2.** Publication by Year

| Year         | TP         | %           |
|--------------|------------|-------------|
| 2015         | 1          | 0.25%       |
| 2016         | 5          | 1.23%       |
| 2017         | 2          | 0.49%       |
| 2018         | 17         | 4.19%       |
| 2019         | 16         | 3.94%       |
| 2020         | 21         | 5.17%       |
| 2021         | 37         | 9.11%       |
| 2022         | 68         | 16.75%      |
| 2023         | 59         | 14.53%      |
| 2024         | 100        | 24.63%      |
| 2025         | 80         | 19.70%      |
| <b>Total</b> | <b>406</b> | <b>100%</b> |

Notes: TP = total number of publications; % = percentage

**Documents by year**



**Fig. 2:** Publications Over Time (2015-2025)

Source: Generated by the author(s) using Scopus database

## Most Active Authors

Table 3 presents the most active authors contributing to marine plastic pollution (MPP) with a legal and policy focus between 2015 and 2025. The data show a characteristic Lotka-type distribution, where a few highly productive scholars contribute disproportionately to the literature, while a long tail of authors produce fewer publications (Lotka, 1926; Waltman, 2016).

Maes, T., Raubenheimer, K., and Walker, T. R. are at the forefront, each with five publications (1.23%). Their work collectively anchors the field's interdisciplinary discourse. Maes has been particularly influential in empirical assessments of marine litter monitoring and policy implications (Maes et al., 2018). Raubenheimer is widely recognised for his contributions to international plastics governance, particularly by integrating global treaties such as the Basel Convention and MARPOL into plastic waste regulations (Raubenheimer & McIlgorm, 2018). Walker has bridged environmental science and governance through critical analyses of plastic pollution impacts, circular economy measures, and the socio-political challenges of policy implementation (Walker, 2021).

The second tier includes Chang, Y.-C., Dijkstra, H., Mendenhall, E., and van Beukering, P., each with four publications (0.99%). Chang is notable for examining international maritime law and the gaps in UNCLOS and MARPOL regarding plastics (Chang & Saqib, 2025). Dijkstra and Mendenhall have an advanced understanding of governance frameworks, particularly in multilateral negotiations and institutional design. Van Beukering's work focuses on the economics of marine litter and cost-benefit assessments of policy interventions, underscoring the role of economic instruments in governance (van Beukering et al., 2021).

A third tier of contributors, such as Ali, I., Anouzla, A., Aziz, F., Barbir, J., Dauvergne, P., Duijndam, S., Duncan, E. M., Farrelly, T., Galgani, F., Godley, B. J., Graham, R. E. D., Hardesty, B. D., and Kamaruddin, H., each authored three publications (0.74%). Their contributions represent diverse thematic foci. For example, Dauvergne (2018) critically examined the political economy of plastic pollution, highlighting why global governance efforts often fail. Galgani and Godley have provided ecological perspectives, connecting marine science with policy responses (Galgani et al., 2015). Hardesty's research emphasises the role of community engagement and citizen science in tackling marine debris (Hardesty et al., 2017). Meanwhile, Kamaruddin contributes from a Southeast Asian perspective, situating Malaysia within the regional and international debates on plastic governance.

These authors' tiers illustrate the field's interdisciplinary nature, where law, policy, political science, economics, and marine ecology converge. The productivity concentration among a few scholars underscores the emergence of intellectual "schools of thought" and agenda-setting clusters that shape global debates on MPP governance (Donthu et al., 2021; Zupic & Čater, 2015). At the same time, the broad third tier indicates diversification and the opportunity for new entrants to shape emerging research fronts, particularly in areas such as equity, just transition, and regional governance mechanisms.

**Table 3.** Most Active Authors

| Author Name       | TP | %     |
|-------------------|----|-------|
| Maes, T.          | 5  | 1.23% |
| Raubenheimer, K.  | 5  | 1.23% |
| Walker, T.R.      | 5  | 1.23% |
| Chang, Y.C.       | 4  | 0.99% |
| Dijkstra, H.      | 4  | 0.99% |
| Mendenhall, E.    | 4  | 0.99% |
| van Beukering, P. | 4  | 0.99% |

|                |   |       |
|----------------|---|-------|
| Ali, I.        | 3 | 0.74% |
| Anouzla, A.    | 3 | 0.74% |
| Aziz, F.       | 3 | 0.74% |
| Barbir, J.     | 3 | 0.74% |
| Dauvergne, P.  | 3 | 0.74% |
| Duijndam, S.   | 3 | 0.74% |
| Duncan, E.M.   | 3 | 0.74% |
| Farrelly, T.   | 3 | 0.74% |
| Galgani, F.    | 3 | 0.74% |
| Godley, B.J.   | 3 | 0.74% |
| Graham, R.E.D. | 3 | 0.74% |
| Hardesty, B.D. | 3 | 0.74% |
| Kamaruddin, H. | 3 | 0.74% |

Note: TP = total number of publications

## Subject Area

Table 4 presents the distribution of subject areas for research on marine plastic pollution (MPP) within legal and policy frameworks between 2015 and 2025, highlighting its highly interdisciplinary nature. Unsurprisingly, environmental science dominates with 328 publications (80.79%), reflecting the centrality of ecological, pollution, and sustainability perspectives in framing MPP as both an environmental hazard and a governance challenge. This aligns with prior bibliometric studies that consistently identify environmental science as the intellectual anchor of plastic pollution scholarship (Li et al., 2021; Qi et al., 2023).

The second most prominent contributor is Social Sciences (126 publications; 31.03%), underscoring the growing importance of governance, law, and policy integration in addressing plastic pollution. This “social turn” reflects increasing scholarly attention to the role of institutions, treaties, and community participation in shaping sustainable solutions (Raubenheimer & McIlgorm, 2018; Dauvergne, 2018). Similarly, Agricultural and Biological Sciences (27.83%) and Earth and Planetary Sciences (21.43%) emphasise ecological and marine biodiversity research, demonstrating how science-driven insights on pollution pathways and ecosystem impacts are integral to shaping effective legal and regulatory frameworks (Galgani et al., 2015).

Technical and applied fields also play a substantial role. Engineering (12.32%), Energy (8.62%), and Chemical Engineering (2.96%) highlight research into waste management technologies, recycling innovations, and circular economy models. These contributions point to synergies between law, technology, and policy in addressing upstream production and downstream waste treatment (Nielsen et al., 2020). Likewise, economics, econometrics, and finance (7.88%) and business, management, and accounting (2.22%) provide essential perspectives on cost–benefit analyses, extended producer responsibility (EPR), and economic instruments in global plastic governance (Chen et al., 2020).

Health-related disciplines, including Medicine (5.67%), Biochemistry, Genetics, and Molecular Biology (5.17%), and Pharmacology, Toxicology, and Pharmaceuticals (4.93%), reflect concerns over the impacts of microplastics and nanoplastics on human health, including bioaccumulation and seafood contamination (Prata et al., 2020; Landrigan et al., 2023). Additionally, chemistry and materials science (each 2.96–4.68%) contribute advances in polymer degradation, sustainable alternatives, and toxicological analysis, which are increasingly linked to regulatory debates on safe substitutes.

The smaller shares from the arts and humanities (1.97%) and multidisciplinary outlets (1.97%) reflect an emerging interest in ethical, cultural, and cross-sectoral approaches to MPP, emphasising public values and socio-cultural narratives in shaping policy legitimacy (Andrady, 2017). Meanwhile, fields like physics and astronomy (0.99%), immunology and microbiology (0.74%), and mathematics (0.49%) play niche but supportive roles, particularly in modelling pollution dispersion, microbial interactions with plastics, and risk assessments.

The subject area distribution demonstrates that while environmental science remains the intellectual backbone, MPP research has matured into a highly interdisciplinary field, integrating law, governance, economics, engineering, and health sciences. This interdisciplinarity reflects the global recognition that addressing marine plastic pollution requires holistic, cross-sectoral frameworks that combine scientific knowledge with robust legal and policy responses (Donthu et al., 2021; Zupic & Čater, 2015).

**Table 4.** Top 20 subject areas

| Subject Area                                 | TP  | %      |
|----------------------------------------------|-----|--------|
| Environmental Science                        | 328 | 80.79% |
| Social Sciences                              | 126 | 31.03% |
| Agricultural and Biological Sciences         | 113 | 27.83% |
| Earth and Planetary Sciences                 | 87  | 21.43% |
| Engineering                                  | 50  | 12.32% |
| Energy                                       | 35  | 8.62%  |
| Economics, Econometrics and Finance          | 32  | 7.88%  |
| Medicine                                     | 23  | 5.67%  |
| Biochemistry, Genetics and Molecular Biology | 21  | 5.17%  |
| Pharmacology, Toxicology and Pharmaceutics   | 20  | 4.93%  |
| Chemistry                                    | 19  | 4.68%  |
| Computer Science                             | 19  | 4.68%  |
| Chemical Engineering                         | 12  | 2.96%  |
| Materials Science                            | 12  | 2.96%  |
| Business, Management and Accounting          | 9   | 2.22%  |
| Arts and Humanities                          | 8   | 1.97%  |
| Multidisciplinary                            | 8   | 1.97%  |
| Physics and Astronomy                        | 4   | 0.99%  |
| Immunology and Microbiology                  | 3   | 0.74%  |
| Mathematics                                  | 2   | 0.49%  |

## Document Type

Table 5 presents the distribution of document types in research on marine plastic pollution (MPP), focusing on legal and policy frameworks between 2015 and 2025. The data indicate that journal articles constitute the largest share, with 231 publications (56.90%). This dominance highlights the central role of peer-reviewed articles as the primary medium for disseminating original research, theoretical advancements, and empirical findings. Articles are significant for capturing evolving debates on marine plastics governance, treaty design, and policy implementation, as they are widely recognised for their methodological rigour and visibility in academic

discourse (Donthu et al., 2021; Zupic & Čater, 2015).

Review papers represent the second-largest category, accounting for 105 publications (25.86%). Their significant presence underscores the maturity of MPP as a research field, where scholars increasingly synthesise fragmented findings to evaluate existing governance mechanisms, ecological risks, and regulatory frameworks. Reviews play a critical role in identifying knowledge gaps, consolidating cross-disciplinary insights, and guiding future research agendas, especially in rapidly evolving areas like international treaty negotiations and circular economy measures (Xie et al., 2020).

Book chapters (13.30%) and books (0.99%) provide substantial contributions, often offering in-depth theoretical and legal analyses. These formats allow for extended engagement with international instruments such as UNCLOS, MARPOL, and the Basel Convention. They are particularly valuable for addressing multi-dimensional aspects of plastic governance beyond the constraints of journal-length publications. Book-based scholarship often bridges academic research with policymaking and serves as a long-term reference for stakeholders (Raubenheimer & McIlgorm, 2018).

Conference papers (1.97%) play a strategic but limited role, capturing emerging debates, methodological innovations, and preliminary findings before they appear in peer-reviewed journals. Conferences also provide platforms for interdisciplinary dialogue and early dissemination of policy-oriented findings, often informing international negotiations and regional governance forums (Aria & Cuccurullo, 2017).

Less frequent formats include notes (0.74%) and short surveys (0.25%). Although fewer, these documents contribute by providing concise case studies, legal commentaries, and rapid policy assessments that offer timely input into ongoing debates about law and governance.

Overall, the document type distribution indicates that MPP scholarship is dominated by rigorous, peer-reviewed outputs (articles and reviews), supported by substantial book-based contributions and complemented by conference proceedings and shorter formats. This balance reflects the academic consolidation of the field and its policy relevance, where diverse formats cater to audiences ranging from researchers to policymakers and international institutions (Donthu et al., 2021; van Nunen et al., 2018).

**Table 5.** Document type

| Document Type    | TP  | %      |
|------------------|-----|--------|
| Article          | 231 | 56.90% |
| Review           | 105 | 25.86% |
| Book Chapter     | 54  | 13.30% |
| Conference Paper | 8   | 1.97%  |
| Book             | 4   | 0.99%  |
| Note             | 3   | 0.74%  |
| Short Survey     | 1   | 0.25%  |

Notes: TP = total number of publications

## Source Title

Table 6 presents the distribution of source titles publishing research on marine plastic pollution (MPP) within legal and policy frameworks between 2015 and 2025. The results indicate that the Marine Pollution Bulletin is the most prolific source, contributing 36 publications (8.87%). This dominance is not surprising, as the journal is globally recognised for its focus on marine environmental issues and has consistently provided a platform for research on pollution impacts, mitigation strategies, and governance measures (Chen et al., 2022). Its prominence

highlights the environmental science core of MPP research and its intersection with legal and regulatory perspectives.

The Science of the Total Environment (4.68%) and Marine Policy (4.43%) are key outlets. "Science of the Total Environment" emphasises interdisciplinary integration, particularly studies bridging ecological assessments with governance frameworks, whereas "Marine Policy" specialises in policy and institutional responses to marine challenges. The latter is particularly significant for this study's focus, providing direct insights into international law, governance instruments, and sustainability policy measures (Raubenheimer & McIlgorm, 2018).

Other important interdisciplinary outlets include Sustainability (Switzerland) (3.94%) and Frontiers in Marine Science (3.45%), both of which underscore the growing interest in linking MPP to sustainable development and circular economy approaches. Similarly, Waste Management and Research (2.46%) and Environmental Pollution (2.22%) reflect the field's applied dimension, focusing on waste flows, pollution impacts, and regulatory strategies for waste reduction (Nielsen et al., 2020).

Notably, law-oriented journals such as the International Journal of Marine and Coastal Law (1.97%) and Environmental Policy and Law (0.74%) demonstrate the integration of legal scholarship into the discourse, emphasising treaty law, compliance mechanisms, and institutional arrangements under regimes like UNCLOS and MARPOL. Additionally, handbooks such as the Handbook of Environmental Chemistry (1.48%) and the Research Handbook on Plastics Regulation, Law, Policy and the Environment (1.48%) offer comprehensive syntheses, bridging environmental science and legal frameworks. These serve as long-term reference works for academics and policymakers alike.

Emerging outlets such as Circular Economy and Sustainability, Journal of Cleaner Production, and Ecological Economics reflect the expanding economic and systemic governance dimensions of MPP research, particularly concerning extended producer responsibility (EPR) and resource efficiency. The presence of regional studies in marine science and ocean and coastal management underscores the importance of region-specific governance and ecological assessments.

Overall, the source title distribution illustrates that while MPP research remains anchored in environmental and marine science journals, it is growing in diversification into sustainability, law, policy, and economics-oriented outlets. This diversification reflects the field's interdisciplinary evolution, aligning ecological science with governance innovation and global policy agendas (Donthu et al., 2021; Xie et al., 2020).

**Table 6.** Source title

| Source Title                                                                     | TP | %     |
|----------------------------------------------------------------------------------|----|-------|
| Marine Pollution Bulletin                                                        | 36 | 8.87% |
| Science of the Total Environment                                                 | 19 | 4.68% |
| Marine Policy                                                                    | 18 | 4.43% |
| Sustainability Switzerland                                                       | 16 | 3.94% |
| Frontiers in Marine Science                                                      | 14 | 3.45% |
| Waste Management and Research                                                    | 10 | 2.46% |
| Environmental Pollution                                                          | 9  | 2.22% |
| International Journal of Marine and Coastal Law                                  | 8  | 1.97% |
| International Journal of Environmental Research and Public Health                | 7  | 1.72% |
| Ocean and Coastal Management                                                     | 7  | 1.72% |
| Handbook of Environmental Chemistry                                              | 6  | 1.48% |
| Research Handbook on Plastics Regulation Law Policy and the Environment Research | 6  | 1.48% |

|                                                        |   |       |
|--------------------------------------------------------|---|-------|
| Handbooks in Environmental Law                         |   |       |
| Regional Studies in Marine Science                     | 5 | 1.23% |
| Circular Economy and Sustainability                    | 4 | 0.99% |
| Environmental Research                                 | 4 | 0.99% |
| Environmental Science and Pollution Research           | 4 | 0.99% |
| IOP Conference Series: Earth and Environmental Science | 4 | 0.99% |
| Journal of Cleaner Production                          | 4 | 0.99% |
| Journal of Environmental Management                    | 4 | 0.99% |
| Journal of Hazardous Materials Advances                | 4 | 0.99% |
| Water Switzerland                                      | 4 | 0.99% |
| Ecological Economics                                   | 3 | 0.74% |
| Environmental Monitoring and Assessment                | 3 | 0.74% |
| Environmental Policy and Law                           | 3 | 0.74% |

## Most Active Institutions

Table 7 presents the most active institutions contributing to marine plastic pollution (MPP) scholarship, focusing on legal and policy frameworks between 2015 and 2025. The results highlight a diverse set of institutions spanning Europe, Asia, Oceania, North America, and Africa, reflecting the global and transboundary nature of the problem.

At the forefront are the World Maritime University (WMU) and Dalian Maritime University (DMU), each contributing 10 publications (2.46%). WMU, under the auspices of the International Maritime Organisation (IMO), has played a central role in advancing legal and governance research on shipping, ocean governance, and international marine environmental law, positioning itself as a key hub for policy-oriented scholarship (Raubenheimer & McIlgorm, 2018). Similarly, DMU's contributions reflect China's strategic interest in maritime governance, emphasising research on legal frameworks for marine pollution and compliance challenges in heavily trafficked waters, such as the South China Sea (Chen et al., 2022).

The National University of Singapore (NUS) follows closely with nine publications (2.22%), underscoring Southeast Asia's pivotal role in MPP governance. Located along the Straits of Malacca and Singapore, one of the world's busiest shipping routes, NUS contributes significantly to studies linking legal frameworks with regional and global governance challenges (Chang & Saqib, 2025). Viet Nam National University, Ho Chi Minh City (1.72%), further reflects growing scholarly engagement from emerging Asian economies, particularly in addressing localised marine plastic challenges in developing contexts (Puspitawati et al., 2025).

European institutions also demonstrate strong engagement. Vrije Universiteit Amsterdam and its Instituut voor Milieuvraagstukken (IVM), along with the University of Exeter, University of Plymouth, and Universiteit Utrecht, each contribute between 5 and 6 publications ( $\approx 1.23$ –1.48%). These universities are known for interdisciplinary research at the intersection of marine science, environmental policy, and sustainability, often contributing to EU strategies on circular economy and marine governance (Farrelly & Shaw, 2017).

Institutions in Oceania, such as the University of Wollongong and the University of Tasmania (1.48% each), emphasise the Asia-Pacific perspective, where plastic pollution acutely impacts marine ecosystems. Similarly, Canadian institutions such as the University of British Columbia and Dalhousie University (1.23% each) reflect North America's contributions to marine conservation, environmental governance, and plastic waste management.

In Asia, Xiamen University (China), University Malaysia Terengganu, and University Kebangsaan Malaysia (UKM) provide significant contributions, with Malaysia's institutions particularly active in policy-focused studies concerning the Straits of Malacca and broader ASEAN cooperation mechanisms (Kamaruddin et al., 2023). Indonesia's Brawijaya University and the Badan Riset dan Inovasi Nasional (BRIN) also demonstrate active engagement, reflecting Indonesia's status as one of the most significant contributors to marine plastic pollution and its urgent governance challenges (Widagdo & Anggoro, 2022).

Notably, representation extends to Africa via the University of Nigeria (1.23%) and to Southern Africa via the Durban University of Technology (0.99%), signalling increased scholarly engagement in the Global South. These contributions highlight the growing recognition that MPP governance must be understood and addressed in diverse regional contexts.

Overall, the institutional distribution underscores the global, interdisciplinary, and multi-regional character of MPP research. Maritime-focused universities (WMU, DMU), legal-policy hubs in Asia (NUS, VNUHCM, Malaysia, and Indonesia), and European sustainability-focused institutions collectively anchor the field, reflecting both the universality of the MPP challenge and the necessity of cross-institutional collaboration in shaping effective legal and policy responses (Donthu et al., 2021; Zupic & Čater, 2015).

**Table 7.** Most active institutions

| Institution                                   | TP | %     |
|-----------------------------------------------|----|-------|
| World Maritime University                     | 10 | 2.46% |
| Dalian Maritime University                    | 10 | 2.46% |
| National University of Singapore              | 9  | 2.22% |
| Viet Nam National University Ho Chi Minh City | 7  | 1.72% |
| Vrije Universiteit Amsterdam                  | 6  | 1.48% |
| University of Wollongong                      | 6  | 1.48% |
| University of Tasmania                        | 6  | 1.48% |
| University of Plymouth                        | 6  | 1.48% |
| University of Exeter                          | 6  | 1.48% |
| Instituut voor Milieuvraagstukken             | 6  | 1.48% |
| Universiteit Utrecht                          | 5  | 1.23% |
| The University of British Columbia            | 5  | 1.23% |
| Dalhousie University                          | 5  | 1.23% |
| Xiamen University                             | 5  | 1.23% |
| University of Nigeria                         | 5  | 1.23% |
| Brawijaya University                          | 5  | 1.23% |
| Universiti Malaysia Terengganu                | 5  | 1.23% |
| Badan Riset dan Inovasi Nasional              | 5  | 1.23% |
| Universiti Kebangsaan Malaysia                | 4  | 0.99% |
| Durban University of Technology               | 4  | 0.99% |

## Most Active Countries

Table 8 presents the distribution of the most active countries contributing to marine plastic pollution (MPP)

research, highlighting legal and policy frameworks between 2015 and 2025. The results reflect global leadership and growing engagement from developing and emerging economies, underscoring the issue's transboundary nature.

China and the United States are at the forefront, contributing 52 publications (12.81%). China's leadership is linked to its status as the world's largest plastic producer and consumer, facing critical marine governance challenges in the South China Sea and along its extensive coastline. Chinese research often emphasises monitoring, legal responses, and international treaty engagement, particularly concerning microplastics and compliance with global frameworks (Chen et al., 2022). The United States, by contrast, demonstrates strength through interdisciplinary research that bridges environmental science, policy, and governance. U.S. scholars have played pivotal roles in global treaty debates under the United Nations Environment Assembly (UNEA) and in evaluating domestic regulatory measures, such as bans on single-use plastics (Borrelle et al., 2020).

India follows closely with 48 publications (11.82%), reflecting the urgent need to address plastic leakage in the Bay of Bengal and Indian Ocean, regions heavily impacted by waste mismanagement. Indian scholarship increasingly focuses on regulatory frameworks, waste management infrastructure, and community engagement, highlighting implementation challenges in developing contexts (Kedzierski et al., 2020). Similarly, the United Kingdom (39 publications; 9.61%) plays a central role in governance-oriented research, often tied to the European Union's legal frameworks such as the Single-Use Plastics Directive and broader marine strategy initiatives (Farrelly & Shaw, 2017).

In Southeast Asia, Indonesia (35 publications; 8.62%) and Malaysia (24 publications; 5.91%) are particularly prominent, given their geographic vulnerability and significant contributions to marine plastic leakage. Indonesian research emphasises national and regional governance challenges, such as institutional fragmentation and the role of ASEAN in fostering cooperation (Widagdo & Anggoro, 2022), while Malaysian scholarship highlights governance in the Straits of Malacca and Singapore and its linkages with climate and sustainability goals (Kamaruddin et al., 2023). Viet Nam (17 publications; 4.19%) and Thailand (15 publications; 3.69%) further illustrate ASEAN's growing academic and policy-oriented contributions, often in response to regional action plans and global treaty negotiations (Puspitawati et al., 2025).

Among developed countries, Australia (28 publications; 6.90%) contributes research that integrates marine ecology with governance frameworks, reflecting the country's position as a steward of Pacific and Indian Ocean ecosystems. Similarly, Germany (26; 6.40%), Canada (25; 6.16%), and the Netherlands (19; 4.68%) play important roles in circular economy transitions, extended producer responsibility (EPR), and treaty design. These countries often serve as innovation hubs for global plastic governance debates (Barrowclough & Birkbeck, 2022).

European representation also includes Italy (16; 3.94%), Norway (15; 3.69%), France (14; 3.45%), Greece (14; 3.45%), Sweden (14; 3.45%), and Portugal (12; 2.96%), underscoring the EU's collective role in advancing regional marine protection strategies and legal instruments (European Union, 2019). Particularly, Northern European countries take the lead in advocating ambitious global frameworks, while Mediterranean states contribute region-specific research on the impacts of marine litter.

Importantly, global South contributions are also visible. Brazil (13; 3.20%) emphasises coastal and estuarine governance in South America, while Nigeria (13; 3.20%) reflects West Africa's growing recognition of marine litter as both an environmental and regulatory challenge (Okonkwo & Nwosu, 2021). This contribution highlights the gradual globalisation of MPP research outside traditional Western hubs.

The geographical distribution reflects a highly internationalised field, shaped by high-income countries with strong research infrastructure and developing states directly impacted by plastic leakage. This balance demonstrates that marine plastic governance is a shared global priority, requiring cooperation across diverse legal, political, and socio-economic contexts (Donthu et al., 2021; Zupic & Čater, 2015).

**Table 8.** Most active countries

| Country        | TP | %      |
|----------------|----|--------|
| China          | 52 | 12.81% |
| United States  | 52 | 12.81% |
| India          | 48 | 11.82% |
| United Kingdom | 39 | 9.61%  |
| Indonesia      | 35 | 8.62%  |
| Australia      | 28 | 6.90%  |
| Germany        | 26 | 6.40%  |
| Canada         | 25 | 6.16%  |
| Malaysia       | 24 | 5.91%  |
| Netherlands    | 19 | 4.68%  |
| Vietnam        | 17 | 4.19%  |
| Italy          | 16 | 3.94%  |
| Norway         | 15 | 3.69%  |
| Thailand       | 15 | 3.69%  |
| France         | 14 | 3.45%  |
| Greece         | 14 | 3.45%  |
| Sweden         | 14 | 3.45%  |
| Brazil         | 13 | 3.20%  |
| Nigeria        | 13 | 3.20%  |
| Portugal       | 12 | 2.96%  |

## Source Type

Table 9 presents the distribution of source types contributing to marine plastic pollution (MPP) research, highlighting legal and policy frameworks. The results reveal that most publications are disseminated through journals (341; 83.99%), which dominate as the primary platform for peer-reviewed scientific and legal scholarship. This strong representation underscores the centrality of journal articles for advancing timely, evidence-based discourse, as journals ensure rigorous peer review, global visibility, and rapid dissemination of findings relevant to governance, regulation, and policy responses (Donthu et al., 2021; Mongeon & Paul-Hus, 2016). Key outlets include *Marine Pollution Bulletin* and *Marine Policy*, which provide interdisciplinary coverage linking environmental science with legal frameworks.

The second largest category is books (47; 11.58%), which remain critical in providing comprehensive treatments of complex issues such as UNCLOS, MARPOL, and the Basel Convention, as well as national and regional regulatory mechanisms. Books and edited volumes allow for in-depth exploration of legal doctrines, policy evaluation, and interdisciplinary perspectives that cannot be fully addressed within the space constraints of journal articles. Their prevalence highlights the importance of integrating marine environmental law, sustainability frameworks, and circular economy approaches into broader governance discourses (Archambault et al., 2020).

Book series (12; 2.96%) also contribute meaningfully, particularly through environmental law handbooks and

thematic collections that bring together multiple perspectives on plastics regulation, governance, and sustainability. These curated volumes provide continuity and thematic coherence across chapters as important references for academics and policymakers (Aria & Cuccurullo, 2017).

Finally, conference proceedings (6; 1.48%) account for a smaller share but play a strategic role in capturing early-stage debates and innovative methodologies. Proceedings often showcase preliminary research findings and foster dialogue among academics, practitioners, and policymakers before results are refined for publication. This pathway is particularly relevant in emerging fields such as MPP governance, where real-time discussions at global fora (e.g., UNEA, ASEAN workshops) influence the research agenda and highlight urgent policy needs (Van Eck & Waltman, 2017).

Overall, the source type distribution strongly relies on peer-reviewed journals, complemented by books and book series for deeper theoretical and legal analyses, and conference proceedings for early-stage knowledge exchange. This balance reflects the interdisciplinary and evolving nature of MPP research, where scientific evidence and legal-policy perspectives converge to address one of our time's most pressing sustainability challenges (Zupic & Čater, 2015; Donthu et al., 2021).

**Table 9.** Source type

| Source Type           | TP  | %      |
|-----------------------|-----|--------|
| Journal               | 341 | 83.99% |
| Book                  | 47  | 11.58% |
| Book Series           | 12  | 2.96%  |
| Conference Proceeding | 6   | 1.48%  |

## Languages

Table 10 presents the language distribution of publications on marine plastic pollution (MPP) with a legal and policy focus between 2015 and 2025. The analysis reveals a striking dominance of English-language publications, which account for 401 documents (98.77%). This overwhelming share reflects the role of English as the global lingua franca of scientific communication, particularly in interdisciplinary domains such as environmental science, international law, and sustainability governance (van Weijen, 2012). Publishing in English ensures wider dissemination, greater visibility in leading indexing databases such as Scopus, and higher citation potential, reinforcing its status as the preferred medium for international scholarship (Mongeon & Paul-Hus, 2016; Salager-Meyer, 2014).

In contrast, non-English contributions are marginal, with just one publication (0.25%) each in Chinese, Czech, French, Greek, and Persian. These outputs, although small in number, highlight localised or regional scholarly efforts to address MPP in diverse linguistic and cultural contexts. Such studies often cater to national policymakers, local practitioners, or academic communities that may not primarily operate in English. However, their limited global reach reflects a broader challenge of linguistic inequality in scientific publishing, where non-English research tends to receive fewer citations and less international recognition despite its local relevance (Ammon, 2010; Meneghini & Packer, 2007).

The predominance of English also mirrors broader trends in environmental law and policy research, where high-impact journals and most international collaborations are English-based, thereby shaping the global discourse and agenda-setting processes (Donthu et al., 2021). Nevertheless, the presence of non-English studies, though minimal, underscores the importance of linguistic diversity in enriching perspectives on MPP governance, particularly in non-Anglophone regions. Encouraging multilingual dissemination strategies, such as bilingual abstracts or regional open-access platforms, could enhance inclusivity and knowledge transfer, ensuring that critical legal and policy insights reach local and international stakeholders (Salager-Meyer, 2014).

In summary, while English dominates as the primary medium for global visibility and citation impact, the limited

representation of other languages reflects both the strengths and limitations of the current research landscape. A more linguistically inclusive approach could strengthen global cooperation and knowledge equity in addressing the legal and policy challenges of marine plastic pollution.

**Table 10.** Languages

| Language | TP  | %      |
|----------|-----|--------|
| English  | 401 | 98.77% |
| Chinese  | 1   | 0.25%  |
| Czech    | 1   | 0.25%  |
| French   | 1   | 0.25%  |
| Greek    | 1   | 0.25%  |
| Persian  | 1   | 0.25%  |

## Highly Cited Papers

Table 11 presents the most influential and widely cited publications in marine plastic pollution (MPP) research between 2015 and 2025, reflecting the intellectual backbone of the field. The most cited paper, Peng et al. (2018), with 589 citations, provided a pioneering case study of microplastics in freshwater sediments in Shanghai, offering critical insights into risk assessment in megacities. Closely aligned, Karbalaei et al. (2018) synthesised evidence on microplastics' occurrence, human health impacts, and mitigation strategies, attracting 510 citations and advancing the public health perspective within environmental governance. Similarly, Schnurr et al. (2018), with 439 citations, highlighted the global challenge of single-use plastics (SUPs) and evaluated policy interventions to reduce marine litter.

Other highly cited contributions broaden the scope of governance and solutions. Prata et al. (2019), with 422 citations, proposed integrated strategies for managing plastic and microplastic pollution, bridging science, policy, and practice. Crawford and Quinn (2016) also produced a foundational monograph on microplastic pollutants, now with 404 citations, establishing a baseline for subsequent empirical studies. Regionally, Barletta et al. (2019) examined estuarine systems in South America, integrating chemical and ecological analyses, while Dauvergne (2018) critically assessed the failure of global governance to stem plastic leakage, positioning plastics as a political economy issue.

More recent studies reflect the field's diversification. Filiciotto and Rothenberg (2021) explored biodegradable plastics, regulatory standards, and sustainability, while Chater and Loewenstein (2023) reframed the governance debate by criticising reliance on individual behavioural solutions. Golwala et al. (2021) highlighted solid waste streams as overlooked contributors to microplastic pollution, while Allan et al. (2021) assessed nanoplastic regulation across jurisdictions. Collectively, these highlight both ecological risks and regulatory innovations.

Importantly, Simon et al. (2021), with 190 citations, called for a binding global agreement to address the plastics life cycle, reinforcing the momentum toward the UNEA treaty process. Complementary works by da Costa et al. (2020) and Sousa et al. (2021) focused on legal frameworks and materials substitution, aligning plastics governance with circular economy goals. Regional case studies, such as Wagner (2017) on single-use bag bans in the U.S. and Wang et al. (2018) on China's management instruments, demonstrate the national dimension of policy experimentation.

Finally, landmark reports, such as Landrigan et al. (2023) and the Minderoo-Monaco Commission on Plastics and Human Health, signalled the convergence of environmental law, public health, and governance. These highly cited works, ranging from ecological science to regulatory innovation, illustrate the field's evolution toward integrated, cross-sectoral approaches that situate plastics within broader sustainability and climate agendas.

**Table 11.** Highly cited papers

| Authors                                                                                                                                 | Year | Title                                                                                                                                               | Source                                                            | Cites |
|-----------------------------------------------------------------------------------------------------------------------------------------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|-------|
| G. Peng, P. Xu, B. Zhu, M. Bai, D. Li                                                                                                   | 2018 | Microplastics in freshwater river sediments in Shanghai, China: A case study of risk assessment in mega-cities                                      | Environmental Pollution                                           | 589   |
| S. Karbalaei, P. Hanachi, T.R. Walker, M. Cole                                                                                          | 2018 | Occurrence, sources, human health impacts and mitigation of microplastic pollution                                                                  | Environmental Science and Pollution Research                      | 510   |
| R.E.J. Schnurr, V. Alboiu, M. Chaudhary, R.A. Corbett, M.E. Quanz, K. Sankar, H.S. Srain, V. Thavarajah, D. Xanthos, T.R. Walker        | 2018 | Reducing marine pollution from single-use plastics (SUPs): A review                                                                                 | Marine Pollution Bulletin                                         | 439   |
| J.C. Prata, A.L. Patrício Silva, J.P. da Costa, C. Mouneyrac, T.R. Walker, A.C. Duarte, T. Rocha-Santos                                 | 2019 | Solutions and integrated strategies for the control and mitigation of plastic and microplastic pollution                                            | International Journal of Environmental Research and Public Health | 422   |
| C.B. Crawford, B. Quinn                                                                                                                 | 2016 | Microplastic Pollutants                                                                                                                             | Microplastic Pollutants                                           | 404   |
| M. Barletta, A.R.A. Lima, M.F. Costa                                                                                                    | 2019 | Distribution, sources and consequences of nutrients, persistent organic pollutants, metals and microplastics in South American estuaries            | Science of the Total Environment                                  | 338   |
| P. Dauvergne                                                                                                                            | 2018 | Why is the global governance of plastic failing the oceans?                                                                                         | Global Environmental Change                                       | 337   |
| L. Filiciotto, G. Rothenberg                                                                                                            | 2021 | Biodegradable Plastics: Standards, Policies, and Impacts                                                                                            | ChemSusChem                                                       | 334   |
| N. Chater, G. Loewenstein                                                                                                               | 2023 | The i-frame and the s-frame: How focusing on individual-level solutions has led behavioral public policy astray                                     | Behavioral and Brain Sciences                                     | 287   |
| H. Golwala, X. Zhang, S.M. Iskander, A.L. Smith                                                                                         | 2021 | Solid waste: An overlooked source of microplastics to the environment                                                                               | Science of the Total Environment                                  | 283   |
| J. Allan, S. Belz, A. Hoeveler, M. Hugas, H. Okuda, A. Patri, H. Rauscher, P. Silva, W. Slikker, B. Sokull-Kluetgen, W. Tong, E. Anklam | 2021 | Regulatory landscape of nanotechnology and nanoplastics from a global perspective                                                                   | Regulatory Toxicology and Pharmacology                            | 250   |
| A. Lechner, D. Ramler                                                                                                                   | 2015 | The discharge of specific amounts of industrial microplastic from a production plant into the River Danube is permitted by the Austrian legislation | Environmental Pollution                                           | 208   |
| L. Anagnosti, A. Varvaresou, P. Pavlou, E. Protopapa, V. Carayanni                                                                      | 2021 | Worldwide actions against plastic pollution from microbeads and microplastics in cosmetics, focusing                                                | Marine Pollution Bulletin                                         | 204   |

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-----|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |      | on European policies. Has the issue been handled effectively?                                                                            |                                    |     |
| P.J. Landrigan, H. Raps, M. Cropper, C. Bald, M. Brunner, E.M. Canonizado, D. Charles, T.C. Chiles, M.J. Donohue, J. Enck, P. Fenichel, L.E. Fleming, C. Ferrier-Pages, R. Fordham, A. Gozt, C. Griffin, M.E. Hahn, B. Haryanto, R. Hixson, H. Ianelli, B.D. James, P. Kumar, A. Laborde, K.L. Law, K. Martin, J. Mu, Y. Mulders, A. Mustapha, J. Niu, S. Pahl, Y. Park, M.-L. Pedrotti, J.A. Pitt, M. Ruchirawat, B.J. Seewoo, M. Spring, J.J. Stegeman, W. Suk, C. Symeonides, H. Takada, R.C. Thompson, A. Vicini, Z. Wang, E. Whitman, D. Wirth, M. Wolff, A.K. Yousuf, S. Dunlop | 2023 | The Minderoo-Monaco Commission on Plastics and Human Health                                                                              | Annals of Global Health            | 196 |
| R.Y. Krishnan, S. Manikandan, R. Subbaiya, N. Karmegam, W. Kim, M. Govarthanan                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2023 | Recent approaches and advanced wastewater treatment technologies for mitigating emerging microplastics contamination – A critical review | Science of the Total Environment   | 193 |
| N. Simon, K. Raubenheimer, N. Urho, S. Unger, D. Azoulay, T. Farrelly, J. Sousa, H. van Asselt, G. Carlini, C. Sekomo, M.L. Schulte, P.-O. Busch, N. Wienrich, L. Weiland                                                                                                                                                                                                                                                                                                                                                                                                             | 2021 | A binding global agreement to address the life cycle of plastics                                                                         | Science                            | 190 |
| T.M. Karlsson, L. Arneborg, G. Broström, B.C. Almroth, L. Gipperth, M. Hassellöv                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 2018 | The unaccountability case of plastic pellet pollution                                                                                    | Marine Pollution Bulletin          | 183 |
| T.P. Wagner                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 2017 | Reducing single-use plastic shopping bags in the USA                                                                                     | Waste Management                   | 169 |
| J.P. da Costa, C. Mouneyrac, M. Costa, A.C. Duarte, T. Rocha-Santos                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2020 | The Role of Legislation, Regulatory Initiatives and Guidelines on the Control of Plastic Pollution                                       | Frontiers in Environmental Science | 157 |
| A.F. Sousa, R. Patrício, Z. Terzopoulou, D.N. Bikiaris, T. Stern, J. Wenger, K. Loos, N. Lotti, V. Siracusa, A. Szymczyk, S. Paszkiewicz, K.S. Triantafyllidis, A. Zamboulis, M.S. Nikolic, P.                                                                                                                                                                                                                                                                                                                                                                                        | 2021 | Recommendations for replacing PET on packaging, fiber, and film materials with bio-based counterparts                                    | Green Chemistry                    | 151 |

|                                                                                                           |      |                                                                                                                                                    |                               |     |
|-----------------------------------------------------------------------------------------------------------|------|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-----|
| Spasojevic, S. Thiyagarajan, D.S. Van Es, N. Guigo                                                        |      |                                                                                                                                                    |                               |     |
| J. Wang, L. Zheng, J. Li                                                                                  | 2018 | A critical review on the sources and instruments of marine microplastics and prospects on the relevant management in China                         | Waste Management and Research | 135 |
| A. Yusuf, A. Sodiq, A. Giwa, J. Eke, O. Pikuda, J.O. Eniola, B. Ajiwokewu, N.S. Sambudi, M.R. Bilad       | 2022 | Updated review on microplastics in water, their occurrence, detection, measurement, environmental pollution, and the need for regulatory standards | Environmental Pollution       | 116 |
| Z.S. Mazhandu, E. Muzenda, T.A. Mamvura, M. Belaid, T. Nhuhu                                              | 2020 | Integrated and consolidated review of plastic waste management and bio-based biodegradable plastics: Challenges and opportunities                  | Sustainability (Switzerland)  | 111 |
| S.F. Ahmed, P.S. Kumar, M. Kabir, F.T. Zuhara, A. Mehjabin, N. Tasannum, A.T. Hoang, Z. Kabir, M. Mofijur | 2022 | Threats, challenges and sustainable conservation strategies for freshwater biodiversity                                                            | Environmental Research        | 108 |
| M. Landon-Lane                                                                                            | 2018 | Corporate social responsibility in marine plastic debris governance                                                                                | Marine Pollution Bulletin     | 107 |

## Top Keywords

Table 12 presents the most frequently occurring keywords in the 406-document dataset, offering valuable insights into the thematic and conceptual structure of marine plastic pollution (MPP) research with a legal and policy lens. The most prominent keyword, “Plastic Waste” (n = 159; 39.16%), underscores the centrality of plastics as one of the fastest-growing global waste streams, associated with severe ecological, economic, and governance challenges (Geyer et al., 2017; Jambeck et al., 2015). Closely aligned, “Plastic” (34.24%) and “Plastics” (24.38%) reflect terminological variation but together signal the broad disciplinary engagement across environmental science, law, and policy.

Keywords such as “Marine Pollution” (25.86%) and “Marine Environment” (14.53%) emphasise the oceanic dimension of the problem, situating plastic waste within the broader framework of marine ecosystem degradation and biodiversity threats (Borrelle et al., 2020; Rochman et al., 2016). Relatedly, “Marine Litter” (10.84%) highlights the governance challenges of addressing debris that crosses borders, reinforcing the urgency of global cooperation under instruments like UNCLOS and the ongoing UNEA treaty process (Raubenheimer & Urho, 2020).

The rise of “Microplastics” (21.92%) and “Microplastic” (18.23%) signals growing scholarly attention to smaller particles that infiltrate aquatic ecosystems, food chains, and potentially human health. These keywords align with a shift from macro-debris studies to more complex risk assessments involving toxicology, human exposure, and legal regulation of emerging pollutants (Prata et al., 2020; Wang et al., 2021). Similarly, “Water Pollutant” (9.85%) situates plastics within broader regulatory discourses on hazardous substances.

Governance-oriented terms such as “Waste Management” (24.63%), “Recycling” (13.55%), and “Environmental Policy” (11.82%) reflect the influence of the circular economy paradigm, extended producer responsibility (EPR), and sustainable materials management in current policy debates (Kirchherr et al., 2018; Nielsen et al., 2020). The co-occurrence of these terms with “Plastic Waste” indicates that scholarship is increasingly focusing on systemic solutions beyond end-of-pipe interventions.

The inclusion of “Human” (16.50%) and “Nonhuman” (10.84%) points to the framing of plastic pollution as a planetary health issue, affecting both ecological systems and human well-being through pathways such as

seafood contamination and bioaccumulation (Landrigan et al., 2023). Similarly, “Environmental Monitoring” (17.24%) highlights the importance of surveillance, data harmonisation, and metrics for effective governance and compliance.

Finally, meta-terms such as “Article” (17.49%) and “Review” (11.58%) suggest that bibliographic indexing practices capture publication formats as keywords, reflecting the consolidation of knowledge in both primary research and syntheses.

Overall, the keyword distribution reveals a multi-dimensional research landscape: (i) ecological and scientific dimensions (microplastics, marine pollution, monitoring); (ii) governance and policy dimensions (waste management, environmental policy, marine litter); and (iii) human–environmental interfaces (human, nonhuman, planetary health). These findings demonstrate how research has evolved toward integrating law, policy, and sustainability in addressing marine plastic pollution.

**Table 12.** Top Keywords

| Keywords                 | TP  | %      |
|--------------------------|-----|--------|
| Plastic Waste            | 159 | 39.16% |
| Plastic                  | 139 | 34.24% |
| Marine Pollution         | 105 | 25.86% |
| Waste Management         | 100 | 24.63% |
| Plastics                 | 99  | 24.38% |
| Microplastics            | 89  | 21.92% |
| Microplastic             | 74  | 18.23% |
| Article                  | 71  | 17.49% |
| Environmental Monitoring | 70  | 17.24% |
| Plastic Pollution        | 70  | 17.24% |
| Human                    | 67  | 16.50% |
| Marine Environment       | 59  | 14.53% |
| Recycling                | 55  | 13.55% |
| Pollution                | 51  | 12.56% |
| Environmental Policy     | 48  | 11.82% |
| Review                   | 47  | 11.58% |
| Plastic Pollution        | 46  | 11.33% |
| Marine Litter            | 44  | 10.84% |
| Nonhuman                 | 44  | 10.84% |
| Water Pollutant          | 40  | 9.85%  |

Figure 3 illustrates the most frequently occurring keywords in the bibliometric dataset, visually emphasising terms central to marine plastic pollution (MPP) scholarship. The largest and most dominant keyword, “Plastic”, reflects the centrality of plastics as the overarching research focus, consistent with global concerns over their persistence, ecological impacts, and socio-economic consequences (Geyer et al., 2017; Jambeck et al., 2015). Closely related terms “Pollution” and “Waste” signal the framing of MPP as both an environmental hazard and a governance challenge, situating plastic pollution within broader discourses of waste management, sustainability, and policy intervention (Borrelle et al., 2020).

Keywords such as “Marine”, “Marine Pollution”, and “Marine Litter” emphasise the oceanic dimension of the problem, underlining the detrimental effects of plastic leakage into marine ecosystems and the governance difficulties associated with transboundary debris (Raubenheimer & Urho, 2020). The prominence of “microplastic” and “microplastics” highlights the growing scientific focus on smaller plastic particles, with rising concern about their impacts on biodiversity, food webs, and human health (Prata et al., 2020; Wang et al., 2021). Similarly, “Debris” captures the persistence of macro- and mesoscale plastics that require robust regulatory and cleanup responses.

Governance-related terms such as “policy”, “management”, “law”, “regulation”, and “governance” point to the increasing scholarly recognition that technological and ecological solutions alone are insufficient without effective regulatory frameworks. These keywords suggest an expanding research frontier where legal instruments (e.g., UNCLOS, MARPOL Annex V, the Basel Convention) and policy tools (e.g., extended producer responsibility, the circular economy) are analysed for their role in mitigating MPP (Chang & Saqib, 2025; Xu et al., 2024). The inclusion of “Sustainability” and “Climate” further reflects an emerging conceptual integration of plastic pollution within the global sustainability and climate resilience agenda, aligning with calls for systemic transformation (Kirchherr et al., 2018).

Other frequently observed terms, "Recycling", "Ecosystem", "Economy", "Circular Economy", and "Health", highlight the interdisciplinary nature of MPP research, which spans environmental science, law, economics, and public health. These terms demonstrate how research has evolved to link plastic pollution with environmental degradation, socio-economic transitions, and planetary health concerns (Landrigan et al., 2023).

In summary, the keyword distribution from Figure 3 reveals three core thematic clusters: (i) ecological and scientific dimensions (microplastics, marine litter, ecosystem impacts), (ii) legal and governance frameworks (law, regulation, policy, governance), and (iii) sustainability linkages (circular economy, climate, health). Together, these clusters underscore the multidimensional nature of MPP scholarship and its evolution toward an integrated, interdisciplinary research agenda.



**Fig. 3: Top Keywords**

## Co-Authorship Analysis

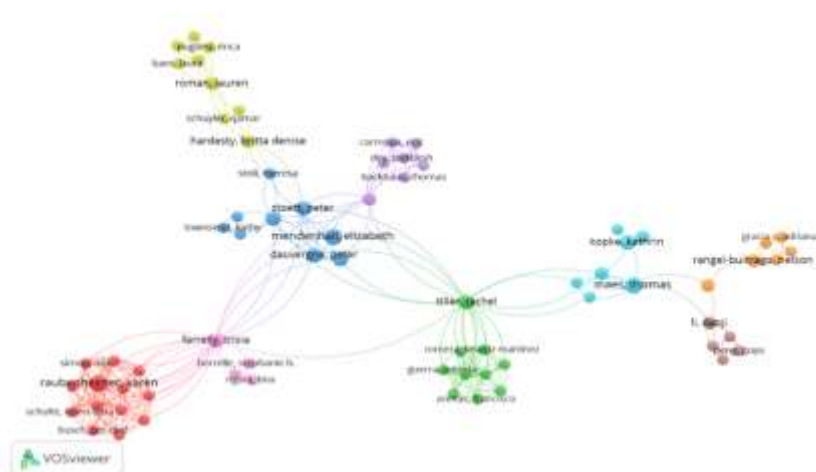
Figure 4 illustrates the co-authorship network of marine plastic pollution (MPP) research focusing on legal and policy frameworks, as generated through VOSviewer. The visualisation highlights distinct clusters of collaboration, where node size indicates the author’s productivity, and link thickness represents the strength of co-authorship ties (van Eck & Waltman, 2010). The figure demonstrates the importance of collaborative research in this emerging field, underscoring the role of transnational and interdisciplinary partnerships in shaping the intellectual landscape.

Several key clusters emerge prominently. The red cluster, led by Raubenheimer, Karen, is one of the most cohesive, reflecting scholarship centred on global governance and plastic treaty negotiations, with collaborators such as Simon, Busch, and Schulte. Similarly, the blue cluster brings together scholars like Mendenhall,

Elizabeth; Dauvergne, Peter; and Stoett, Peter, whose works often link environmental governance and international law. These authors act as intellectual bridges, connecting ecological research with legal and institutional analysis. The green cluster, represented by Tiller, Rachel and collaborators such as Romera, Guerra, and Arenas, focuses on sustainability, marine management, and socio-ecological systems, highlighting the integration of governance with ecosystem approaches. Another significant node is Maes, Thomas, in the light blue cluster, whose work links empirical marine pollution studies with policy-related implications, often collaborating with Kopke and others in European contexts.

Peripheral yet important groups, such as Li Daoji, Peng Guyu (brown cluster), Rangel-Buitrago, and Gracia (orange cluster), suggest regional research concentrations, particularly in Asia and Latin America. These clusters indicate growing contributions from the Global South, which remain less connected to dominant European and North American networks but play a vital role in diversifying the discourse.

The co-authorship analysis reveals that while a core group of scholars dominates knowledge production, the field is becoming increasingly interdisciplinary and geographically diverse. The connections among clusters highlight the importance of integrating ecological science with governance, law, and policy perspectives to address MPP comprehensively. However, fragmented or isolated nodes indicate the need for greater inclusivity and collaboration, particularly with institutions from developing regions where MPP challenges are acute (Donthu et al., 2021; Zupic & Čater, 2015).



**Fig. 4. Co-authorship analysis**

Source: Generated by the authors using VosViewer

### Co-Occurrence of the Keywords

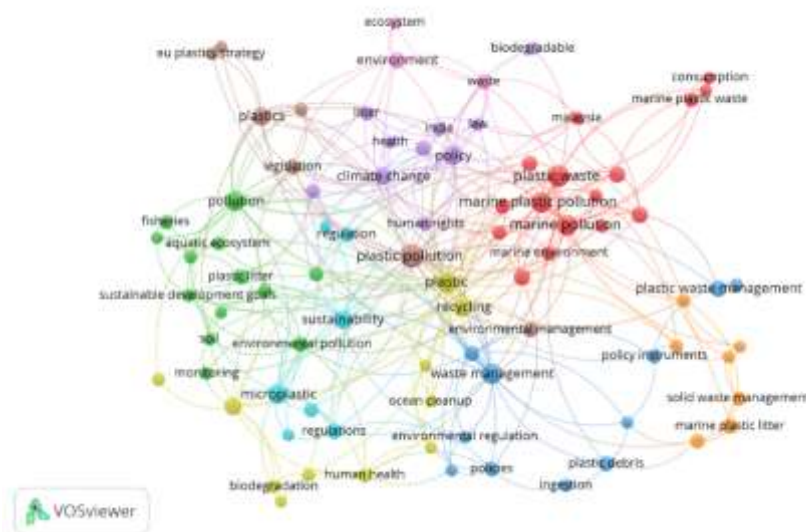
Figure 5 presents the co-occurrence network of keywords in marine plastic pollution (MPP) research, focusing on legal and policy frameworks, generated through VosViewer. The visualisation maps how frequently keywords appear together across publications, thereby uncovering the field's thematic structure and conceptual linkages (van Eck & Waltman, 2010). Node size represents keyword frequency, while link strength reflects co-occurrence intensity. The clustering of terms illustrates distinct thematic domains that define the intellectual landscape of MPP research.

The analysis reveals several major clusters. The red cluster, dominated by terms such as '*marine plastic pollution*', '*marine pollution*', '*plastic waste*', and '*marine environment*', reflects plastic pollution's ecological and environmental dimensions, with strong ties to governance challenges. This cluster highlights how research often frames MPP as an urgent marine environmental issue linked to waste generation and mismanagement. The green cluster, anchored around *pollution*, *aquatic ecosystems*, *fisheries*, *plastic litter*, and *sustainable development goals*, underscores the ecological impacts of plastics on biodiversity and links to global sustainability agendas, particularly the SDGs.

Meanwhile, the blue cluster emphasises governance and regulation, with keywords such as '*waste management*', '*environmental management*', '*environmental regulation*', and '*policies*'. This indicates the central role of institutional frameworks and legal instruments in addressing MPP, particularly through waste regulation and policy instruments. Similarly, the yellow cluster, which includes terms like *microplastics*, *biodegradation*, *monitoring*, and *human health*, focuses on micro-level impacts, by emphasising monitoring technologies, risk assessments, and health consequences.

Other smaller clusters capture region-specific and policy-related themes. For instance, *the EU plastics strategy* and *legislation* illustrate the European Union's leadership in plastic governance. In contrast, terms like '*policy*', '*climate change*', '*law*', and '*governance*' reflect the broader integration of MPP into international environmental law and climate frameworks. The presence of *Malaysia* and *India* as standalone nodes demonstrates the increasing attention to country-level implementation challenges, particularly in the Global South.

Overall, the co-occurrence analysis highlights that MPP research is inherently multidimensional, spanning environmental science, law, governance, and socio-economic considerations. Thematic clusters reflect a progression from ecological and technical assessments toward integrated governance approaches that combine regulation, circular economy principles, and international cooperation. Nevertheless, the fragmented connections between some clusters—such as those linking legal frameworks to microplastic risk assessments—indicate persistent gaps in bridging science and policy, which future research should address (Donthu et al., 2021; Zupic & Čater, 2015).



**Fig. 5. Co-occurrence of the keywords**

Source: Generated by the authors using VosViewer

### Citations by documents

Figure 6 illustrates the citation network of highly influential documents in marine plastic pollution (MPP) research with a legal and policy orientation, generated using VOSviewer. Each node represents a document, with node size reflecting citation frequency and link strength denoting bibliographic coupling or co-citation relationships (van Eck & Waltman, 2010). The visualisation enables the identification of seminal works, intellectual clusters, and temporal shifts in scholarly impact.

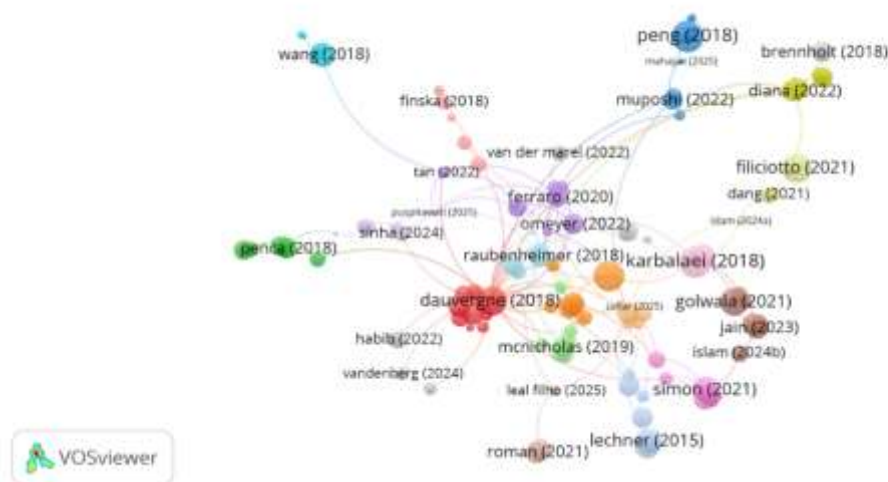
At the core of the network, papers by Dauvergne (2018), Raubenheimer (2018), and Karbalaei et al. (2018) emerge as highly cited and well-connected nodes. Dauvergne (2018) critically examined the failure of global governance in tackling plastic pollution, a work that has since become foundational in linking MPP to international environmental governance (Dauvergne, 2018). Similarly, Raubenheimer (2018) focused on legal

instruments and policy approaches, emphasising treaty-based solutions that strongly align with ongoing global treaty negotiations. Karbalaee et al. (2018) advanced understanding of the human health impacts of microplastics, bridging environmental science with policy-relevant debates on risk regulation.

Documents published between 2018 and 2021 dominate the citation landscape, reflecting the surge of scholarship that coincided with international milestones such as the EU Single-Use Plastics Directive (2019) and the UN Environment Assembly's (UNEA) push toward a global plastics treaty (UNEP, 2022). For example, McNicholas (2019) and Ferraro (2020) contributed to discussions on governance frameworks and policy innovation, while Filiciotto and Rothenberg (2021) highlighted biodegradable plastics and regulatory challenges, attracting significant interdisciplinary attention.

The peripheral nodes, such as Wang (2018), Penca (2018), and Brennholt (2018), indicate important but highly specialised contributions that often focus on regional or technical contexts. Recent works like Sinha (2024), Islam (2024a, 2024b), and Leal Filho (2025) are beginning to enter the citation network, signalling emerging research lines on governance mechanisms, socio-political drivers, and the integration of MPP in broader sustainability and climate policy frameworks.

The structure of the citation network suggests a three-phase intellectual trajectory: (1) early problem recognition and governance critique (2015–2017), (2) rapid expansion of foundational governance and risk studies (2018–2021), and (3) diversification into interdisciplinary sustainability-oriented themes (2022–2025). The centrality of governance-focused documents within the network confirms that legal and policy scholarship is increasingly recognised as integral to MPP debates, rather than merely complementary to natural science research (Prata et al., 2019; Dauvergne, 2018).



**Fig. 6. Citations by documents**

Source: Generated by the authors using VosViewer

### Co-Citations by cited Authors

Figure 7 illustrates the co-citation network of the most influential authors in marine plastic pollution (MPP) research, particularly within the legal and policy framework context. Co-citation occurs when two or more authors are cited in later publications, reflecting shared intellectual influence and disciplinary connectivity (Small, 1973; Zupic & Čater, 2015). The network highlights the intellectual foundations of the field, showing which scholars' works are most frequently referenced as authoritative sources. Node size represents the frequency of citations, while link thickness indicates the strength of co-citation relationships.

The visualisation reveals three major clusters that define the intellectual structure of MPP research:

Firstly, Red Cluster is foundational research on marine pollution and governance. This cluster is dominated by

Thompson, R. C., Galgani, F., Wilcox, C., Walker, T. R., and Law, K. L., whose research collectively forms the backbone of MPP studies. Thompson pioneered microplastics research, introducing the concept to global scientific and policy discussions (Thompson et al., 2004). Geyer et al. (2017) contributed landmark work on plastic production and waste generation, quantifying its global scale. Wilcox and Galgani have advanced monitoring frameworks, while Walker has been particularly influential in bridging ecological findings with governance and regulatory implications. This cluster reflects the core scientific and legal-policy nexus shaping global MPP discourse.

Secondly, Green Cluster is a research initiative focused on Asian empirical and regional studies. Prominent authors include Li, J., Wang, J., Zhang, Y., and Liu, X., whose research focuses on case studies from Asia, particularly China, one of the world's largest plastic producers and consumers. Their studies emphasise pollution monitoring in rivers, sediments, and estuaries, highlighting the role of local governance and regional cooperation in addressing MPPs (Li et al., 2018). This cluster underscores the regionalised empirical evidence that informs national and international regulatory measures, reflecting Asia's growing role in scientific contributions and policy experimentation.

Thirdly, Blue Cluster is an interdisciplinary risk- and policy-oriented scholarship. This group centres on authors such as Koelmans, A. A., Lusher, A. L., Galloway, T. S., and Booth, A. M., who integrate toxicology, environmental chemistry, and legal-policy dimensions. Koelmans has advanced modelling of microplastic fate and risk (Koelmans et al., 2017), Lusher has contributed key monitoring methodologies, while Galloway has linked microplastic exposure to ecological and human health risks (Galloway et al., 2017). Their strong co-citation reflects the interdisciplinary turn in MPP scholarship, integrating natural science with governance, regulation, and health concerns.

The co-citation analysis also highlights bridging scholars such as Dauvergne, P., whose critical work interrogates the failures of global governance regimes for plastics (Dauvergne, 2018), and Raubenheimer, K., who has contributed legal perspectives on treaty design and global negotiations. Their presence indicates the increasing integration of policy critique and international law into what was once a predominantly ecological research field.

The co-citation network demonstrates that MPP research is built upon a robust scientific foundation, now expanding into governance, legal frameworks, and sustainability linkages. It reveals three intellectual pillars: (1) foundational science-policy integration, (2) regional empirical evidence, and (3) interdisciplinary approaches linking ecology, law, and human health. This intellectual structure underscores the field's maturation into a more holistic and policy-relevant body of scholarship, particularly in the ongoing negotiations for a global plastics treaty (UNEP, 2022).

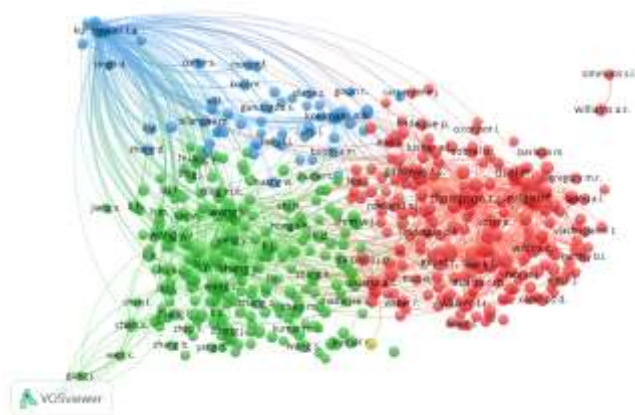


Fig 7. Citations by cited authors  
Source: Generated by the authors using VosViewer

## Network Visualisation of terms of Title and Abstract (binary counting)

Based on Figure 8, the network visualisation of terms extracted from titles and abstracts using binary counting provides a structured view of how marine plastic pollution (MPP) research has evolved over the last decade

(2015–2025). Binary counting, which considers the presence of a term only once per document, highlights the breadth of conceptual associations while reducing bias from repetition within single texts (Zupic & Čater, 2015). The visualisation reveals several prominent clusters that map the intellectual and thematic contours of the field.

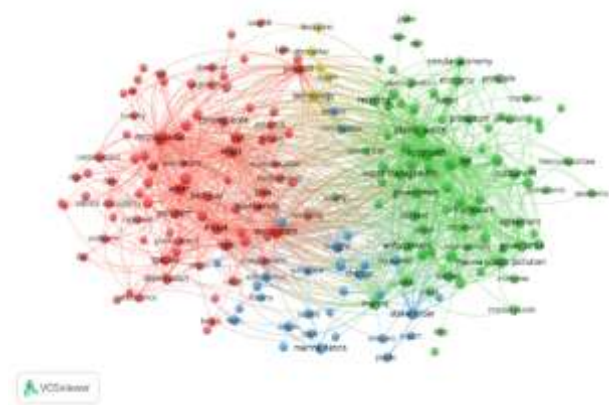
The red cluster is anchored by *microplastic*, *pollutant*, *risk*, *effect*, *species*, *ecosystem*, and *biodiversity*. This cluster represents the ecological and toxicological dimension of MPP research, focusing on the pathways and consequences of microplastic contamination in marine and freshwater systems. Studies within this cluster emphasise organism ingestion, distribution in sediments and soils, and biodiversity loss (Thompson et al., 2004; Galloway et al., 2017). It underscores the early scientific framing of MPP as primarily an ecological and health risk.

The green cluster centres on governance-oriented terms, including *plastic waste*, *law*, *enforcement*, *framework*, *governance*, *circular economy*, and *international law*. This reflects the growing scholarly attention to legal and policy mechanisms to regulate plastic waste at national, regional, and global levels. Key debates include treaty design under the UNEA plastics process, extended producer responsibility (EPR), and the integration of circular economy principles into governance systems (Dauvergne, 2018; Raubenheimer & Urho, 2020). The strong co-occurrence of *law* with *plastic waste* and *governance* illustrates the deepening link between environmental law and policy instruments in tackling plastic pollution.

The blue cluster connects terms such as '*marine debris*', '*stakeholder*', '*public*', '*education*', '*change*', and '*survey*', representing societal and participatory dimensions. This cluster recognises that MPP solutions require regulatory measures, public engagement, stakeholder collaboration, and behavioural shifts. Research here highlights citizen science, awareness campaigns, and community-driven monitoring as vital complements to formal governance (Borrelle et al., 2020).

The yellow cluster is oriented around terms like '*technology*', '*product*', '*biodegradable*', and '*alternative*', signalling innovation-oriented research. This reflects the increasing interest in technological interventions, sustainable materials, and product redesign as upstream solutions to reduce plastic leakage. This emerging focus on eco-innovation and biodegradable alternatives highlights a shift toward preventive approaches within the broader governance debate (Filiciotto & Rothenberg, 2021).

Overall, the network demonstrates the interdisciplinary nature of MPP research, linking ecological risk assessment, governance and legal frameworks, stakeholder engagement, and technological innovation. The visualisation also shows the field's evolution from an initial ecological framing to an integrated approach combining law, policy, and sustainability with science and technology. Such mapping reinforces the role of bibliometrics in identifying thematic convergence and emerging research frontiers, revealing underexplored areas such as enforcement gaps in developing regions and integration of MPP governance with climate change commitments (Donthu et al., 2021).



**Fig. 8. Network visualisation of terms of title and abstract (binary counting)**

Source: Generated by the authors using VosViewer

## DISCUSSION

This bibliometric analysis provides a comprehensive overview of the intellectual, thematic, and structural evolution of marine plastic pollution (MPP) research, specifically focusing on legal and policy frameworks between 2015 and 2025. The findings reveal the trajectory of scholarly contributions over the past decade and the key actors, thematic foci, and emerging conceptual structures that define this growing interdisciplinary field.

The temporal analysis highlights three distinct phases of intellectual development. During the emergent stage (2015–2017), scholarship was primarily focused on ecological risk assessments and microplastic monitoring, often with limited engagement in governance debates (Thompson et al., 2004; Galloway et al., 2017). This shifted during the consolidation period (2018–2021), when policy integration became more visible, catalysed by milestones such as the EU Single-Use Plastics Directive and the UNEA's 2022 resolution to negotiate a global treaty (Dauvergne, 2018; Raubenheimer & Urho, 2020). By the acceleration phase (2022–2025), MPP research adopted a systemic orientation, increasingly linking plastics governance with circular economy strategies, extended producer responsibility (EPR), and climate change obligations (Filiciotto & Rothenberg, 2021; Simon et al., 2021). This thematic broadening demonstrates a field-wide transition from scientific assessments to more integrated legal-policy frameworks aimed at sustainability.

The analysis further identifies a relatively small but influential cohort of authors, such as Peter Dauvergne, Karen Raubenheimer, Thomas Maes, and Trisia Farrelly, whose contributions have bridged ecological evidence with governance frameworks. Leading institutions, including the World Maritime University, Dalian Maritime University, and the National University of Singapore, emerged as central nodes within global co-authorship networks. Country-level data reveal strong leadership from China, the United States, and India, reflecting their dual roles as high-output research hubs and major plastic-producing economies. Collaboration networks also highlight growing participation from Southeast Asian universities. However, overall patterns remain skewed toward Global North dominance, leaving developing regions under-represented despite their heightened vulnerability to plastic pollution impacts (Jambeck et al., 2015; Brooks & Havas, 2025).

Keyword co-occurrence and term mapping analyses uncovered four dominant thematic clusters that structure the field; the first centres on the ecological and toxicological dimensions of microplastics, biodiversity, and pollutant pathways. The second emphasises governance, with keywords such as 'law', 'policy', 'enforcement', 'circular economy', and 'international law', reflecting the integration of legal scholarship into global sustainability debates (Raubenheimer & Urho, 2020). A third cluster captures societal and behavioural perspectives, linking governance to public participation, education, and stakeholder engagement (Borrelle et al., 2020). Finally, an innovation-oriented cluster highlights biodegradable plastics, product redesign, and technological interventions. Together, these clusters demonstrate the growing interdisciplinarity of MPP research, weaving together environmental sciences, law, economics, and technology to address the multifaceted plastic crisis.

Despite these advances, the analysis highlights important research gaps. Empirical evaluations of policy effectiveness remain limited, with most studies examining EPR, bans, or trade restrictions on a case-by-case basis, limiting generalisability (Fadeeva & Van Berkel, 2021). Furthermore, the intersection of MPP governance with climate change frameworks remains underdeveloped, even though plastics are increasingly recognised as significant contributors to greenhouse gases (Zheng & Suh, 2019). Persistent enforcement challenges in developing regions raise questions of capacity, equity, and legitimacy, while justice issues such as fair burden-sharing and just transition pathways for plastic-dependent economies are only beginning to surface in scholarly discourse (Groot et al., 2025). Addressing these gaps will require cross-regional, interdisciplinary studies integrating legal analysis with empirical assessments and explicitly connecting plastics governance with climate and equity agendas.

Beyond ecological, waste management, and governance dimensions, MPP research increasingly intersects with broader international law domains. For example, plastics governance is inseparable from climate change law, given the greenhouse gas emissions associated with plastic production and disposal (Zheng & Suh, 2019). It also links to international trade law, particularly through debates on plastic waste exports, transboundary movements, and compliance with the Basel Convention's amendments (Raubenheimer & McIlgorm, 2018). Further, human

rights frameworks, including the right to health and a clean environment, are emerging as normative anchors in litigation and advocacy around plastic pollution (Okonkwo & Nwosu, 2021). These intersections illustrate that effective governance of plastics requires environmental regulation and alignment with climate, trade, and rights-based regimes, underscoring the inherently interdisciplinary nature of the field.

While this bibliometric analysis highlights thematic clusters and collaboration patterns, it is equally important to assess the effectiveness of the legal and policy frameworks identified. Existing governance instruments remain fragmented, with limited enforcement capacity in many jurisdictions. For instance, although the Basel Convention was amended to regulate plastic waste trade, persistent cases of illegal transboundary shipments to Southeast Asia reveal gaps in compliance and monitoring (Raubenheimer & McIlgorm, 2018). Similarly, Indonesia's national regulations on marine litter face challenges of weak institutional coordination and limited enforcement capacity, undermining their practical impact (Widagdo & Anggoro, 2022). By contrast, Taiwan's integrated waste management framework demonstrates how cohesive policies and strong institutional capacity can advance marine plastic governance (Puspitawati et al., 2025). These examples illustrate that while scholarly attention to legal frameworks has grown, their real-world implementation and effectiveness vary significantly across regions. This underscores the need for future research that combines bibliometric mapping with case-based legal analysis, offering a more nuanced understanding of governance performance and actionable strategies for policymakers.

## CONCLUSION AND RECOMMENDATIONS

This bibliometric study has provided a comprehensive mapping of marine plastic pollution (MPP) research, with particular emphasis on legal and policy frameworks between 2015 and 2025. By analysing 406 publications from the Scopus database, the study traced the intellectual and thematic evolution of MPP scholarship, identified key contributors and collaboration networks, and uncovered dominant thematic clusters, including ecological risks, waste management, governance frameworks, and emerging intersections with sustainability and climate change. The findings reveal a three-phase trajectory of research development, with an acceleration phase coinciding with global policy milestones such as the EU Single-Use Plastics Directive and the UNEA resolution to negotiate a plastics treaty. Influential contributions have been concentrated in China, the United States, India, and Europe, with increasing participation from Southeast Asia.

Despite this progress, notable gaps remain. Scholarship has yet to align MPP legal frameworks with broader climate commitments sufficiently, and enforcement challenges undermine regulatory effectiveness in developing regions. Moreover, while this analysis maps trends, it does not critically evaluate existing instruments' outcomes, limiting its immediate utility for policymakers.

To address these limitations, future research should focus on three key areas. First, greater attention must be given to interdisciplinary linkages with climate change law, international trade, and human rights, as these intersections are increasingly central to shaping global plastic governance. Second, comparative assessments of legal instruments, including extended producer responsibility schemes, product standards, and international agreements, are needed to evaluate effectiveness, transferability, and regulatory gaps across jurisdictions. Finally, longitudinal studies should monitor the development and effectiveness of emerging frameworks, most notably the UNEA plastics treaty, to ensure scholarly insights remain timely and policy relevant.

Overall, this study advances understanding of the intellectual and structural landscape of MPP governance research, offering enduring insights for scholars, policymakers, and practitioners. By integrating bibliometric evidence with interdisciplinary, comparative, and evaluative approaches, future research can more effectively inform the design of robust, enforceable, and globally coherent legal frameworks that advance marine sustainability and climate resilience.

## ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Kedah State Research Committee, UiTM Kedah Branch, for the generous funding provided under the Tabung Penyelidikan Am. This support was crucial in facilitating the research and ensuring the successful publication of this article.

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