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Bibliometric Analysis of Microplastic Pollution Monitoring in Water Bodies

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ABSTRACT

This study presents a bibliometric analysis of research on microplastic pollution monitoring in water bodies to identify intellectual structure, collaboration patterns, and thematic evolution within the field. Data were retrieved from a scientific database and analyzed using bibliometric mapping techniques with VOSviewer, focusing on co-authorship, co-occurrence of keywords, co-citation, and country-level collaboration networks. The results reveal that research activity is highly concentrated around core themes such as microplastic occurrence, polymer identification, aquatic ecosystem contamination, and ecotoxicological impacts. Keyword analysis shows a strong emphasis on environmental monitoring, pollution pathways in freshwater and marine systems, and biological exposure through ingestion and toxicity. The co-authorship and institutional networks indicate the presence of several well-established but partially fragmented research groups, with limited cross-cluster integration. At the country level, China, the United States, and India emerge as dominant contributors and central hubs in global collaboration networks, while European and other regions form distinct secondary clusters. The study highlights a transition in the research landscape from descriptive monitoring toward more advanced analytical approaches, including risk assessment and standardized detection methodologies.

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1. INTRODUCTION

The problem of microplastic pollution is recognized as one of the most urgent environmental problems of the twenty-first century because of its extensive distribution, long-term existence, and possible environmental and human health impacts. Microplastics can be described as particles of plastic materials measuring less than 5 mm in diameter which are generated by the disintegration of larger plastic objects (secondary microplastics) or are produced in the form of small plastics in the course of production of certain goods (primary microplastics) [1]. The fast increase in plastic production around the world along with poor waste disposal practices is leading to the growing presence of microplastics in water bodies. Rivers, lakes, estuaries, reservoirs, and seas are recognized as the sources and ways of transportation of microplastics [2].

Water bodies have a significant function in the distribution and transformation of microplastics within various environmental compartments. Freshwater bodies serve as conveyors, transferring land-based plastic pollutants to coastal and marine areas, as well as reservoirs storing microplastics in sediments, surface waters, and living things [3], [4]. There is plenty of evidence that microplastics have been found in rivers, lakes, groundwater, drinking water, and sewage treatment plants [5], [6]. The steady input of microplastics into aquatic environments poses the risk of adverse impact on ecosystem functioning since these substances may affect aquatic life and cause physical harm, physiological stress, decreased reproductive abilities, and trophic transfer [7].

Apart from the impact on ecology, microplastics have posed another concern for the welfare of public health and sustainability of environment. Research studies have shown that microplastics have the capability to adsorb and transfer harmful chemicals such as heavy metals, organic persistent pollutants, and pathogens, thus increasing the risk of contaminants affecting both aquatic organisms and humans [8], [9]. With microplastics being found in water used for consumption, food items like sea foods and even in human tissue samples, the health concerns associated with microplastics have been brought to forefront in scientific and policy circles [10].

Microplastic contamination has spurred a considerable rise in scientific studies conducted within the last two decades. The participation of researchers from many different fields, such as environmental science, ecology, chemistry, hydrology, toxicology, and environmental engineering, has been crucial for the development of methods for the monitoring and analysis of microplastics. Innovations in sampling approaches, spectroscopic analysis techniques, such as Fourier Transform Infrared Spectroscopy (FTIR), Raman spectroscopy, remote sensing, and machine learning-based image analysis, have been made in order to improve monitoring practices [11]–[13]. Consequently, the number of studies concerning microplastic monitoring has grown tremendously, creating an ever-evolving multidisciplinary field of science.

In the face of the rising number of articles on the subject, there is a growing necessity of systematic evaluation of development, structure, and recent tendencies in scientific studies concerning monitoring of microplastic pollution. Bibliometric analysis can be regarded as a quantitative method of studying scientific literature, helping to identify publication tendencies, influential scientists, collaboration networks, leading organizations, productive countries, scientific hot spots, and theme development in a certain scientific domain [14]. As opposed to a conventional literature review, the use of bibliometrics provides the general panorama of intellectual structure and knowledge base of a certain research field. Bibliometric analysis of the research on the topic of monitoring of microplastic pollution in water bodies can give information about its development and the main areas of investigation.

While there have been many scientific works that deal with the monitoring of microplastics pollution in water bodies, the growing literature on this subject has become rather disjointed, as it is spread across several academic fields, geographical areas, and methods used. In their current state, previous scientific works tend to concentrate only on some aspects of microplastics pollution monitoring; consequently, the general understanding of intellectual framework and research dynamics in this area is poor. Additionally, there is an insufficient number of sources about publication tendencies, significant contributors, collaboration dynamics, thematic clusters, and further research directions in microplastic pollution monitoring research. The lack of bibliometric analysis makes it impossible for scientists and decision makers to reveal the gaps in science, measure its progress, and define further research priorities in this area. For this reason, it is necessary to conduct a systematic bibliometric analysis to map out the development of microplastic pollution monitoring studies in water bodies.

2. METHODS

In this study, a bibliometric analysis approach was adopted to explore the scientific evolution of the microplastic pollution monitoring in water bodies. Data were collected from the Scopus database since this particular database is known for providing wide coverage of peer-reviewed scientific literature from different scientific disciplines and has been widely used in bibliometric analysis research. The data collection was carried out through the use of specific keywords pertaining to the topic of microplastic pollution monitoring in the aquatic environment. These include terms such as "microplastic pollution," "microplastic monitoring," "water bodies," "freshwater," "river," "lake," and other relevant terms. The search was limited to journal articles, conference papers, and review articles within the selected time frame. Information obtained included title, abstract, keywords, authors, affiliation, year of publication, source title, and citation. Duplicate and irrelevant articles were excluded from the data set after the data collection stage.

Bibliometric mapping analysis was conducted using the VOSviewer, a popular software program for the creation and visualization of bibliometric networks [15]. VOSviewer was applied for the analysis of publication trends and the creation of network maps based on the connections such as co-authorship, co-citation, bibliographic coupling, and keyword co-occurrence. The application helped in identifying important research clusters, significant authors, prominent institutions, prolific countries, and dominant themes in the research area of microplastic pollution monitoring in water bodies. Moreover, the technique of overlay visualization was applied to analyze the time evolution of research themes, whereas density visualization was applied to detect developed and emergent themes in research.

3. RESULTS AND DISCUSSION

3.1 Keyword Co-Occurrence Network Visualization

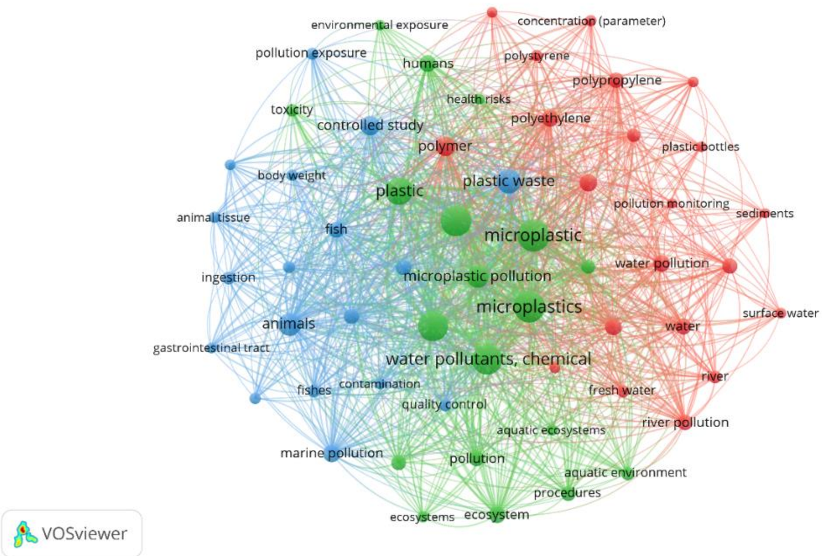

Figure 1. Network Visualization
Source: Data Analysis, 2026

Figure 1 illustrates the intellectual structure of research on microplastic pollution monitoring in aquatic environments. At the center of the network, the terms "microplastic", "microplastics", and "plastic" appear as the most dominant and highly connected nodes. This central positioning indicates that the literature is strongly concentrated around microplastics as a core environmental contaminant, with extensive interlinkages to both environmental media (water, sediment) and biological systems. The density of connections suggests a mature and rapidly expanding research field with high thematic integration rather than fragmented subtopics.

The green cluster represents the core environmental systems and ecological context of microplastic pollution. Keywords such as water pollutants, chemical, aquatic ecosystems, ecosystem, pollution, and aquatic environment dominate this cluster. This indicates that a substantial portion of the literature focuses on environmental distribution, transport mechanisms, and ecological system-level impacts. The presence of terms like quality control and procedures also suggests methodological attention toward environmental monitoring frameworks. Overall, this cluster reflects macro-level environmental assessment and ecosystem-based perspectives.

The red cluster is primarily associated with sources, materials, and environmental compartments where microplastics originate or accumulate. Terms such as polyethylene, polypropylene, polystyrene, plastic bottles, sediments, surface water, river pollution, and water pollution dominate this group. This cluster reflects the material composition of microplastics and their environmental pathways, especially in freshwater and riverine systems. It highlights a strong research emphasis on identifying polymer types and tracing their distribution across different water bodies, indicating a source-to-sink analytical approach in microplastic studies.

The blue cluster focuses on biological impacts and exposure pathways. It includes terms such as fish, animals, ingestion, gastrointestinal tract, animal tissue, and toxicity. This suggests that a significant branch of the literature investigates the ecological and biological consequences of microplastic exposure, particularly through trophic transfer and ingestion by aquatic organisms. The inclusion of controlled study and body weight indicates experimental and toxicological research designs aimed at quantifying health and physiological impacts.

The network reveals a well-structured research domain organized into three interconnected dimensions: environmental systems (green), pollution sources and material composition (red), and biological impacts (blue). The strong interconnectivity among clusters indicates that microplastic research is inherently interdisciplinary, bridging environmental science, chemistry, and ecotoxicology. The central dominance of "microplastic" as a node confirms its role as a unifying concept, while the surrounding clusters reflect the field's evolution toward integrated monitoring, source tracking, and impact assessment in water bodies.

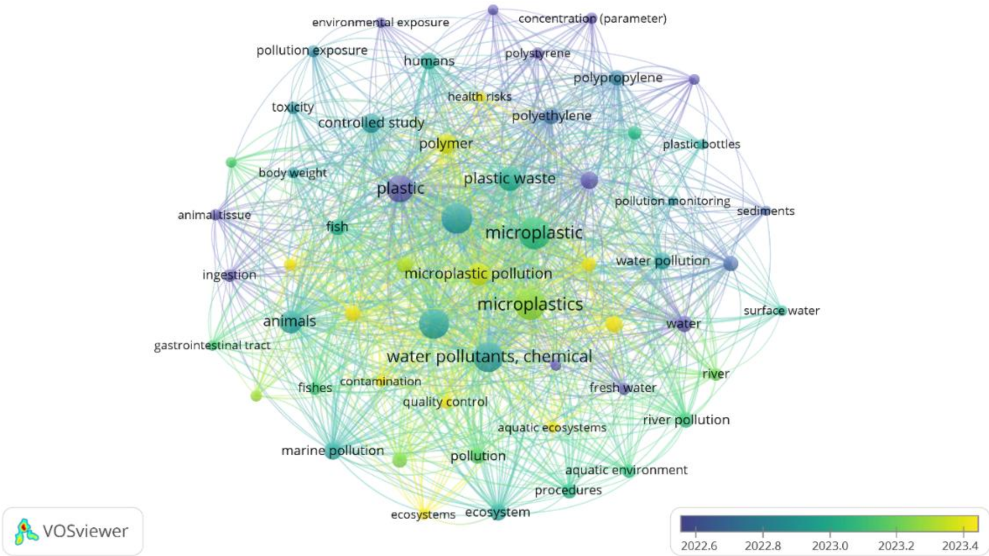

Figure 2. Overlay Visualization
Source: Data Analysis, 2026

Figure presents a bibliometric structure of research on microplastic pollution monitoring in water bodies, with "microplastic," "microplastics," and "plastic waste" functioning as dominant central nodes. These high-frequency and highly connected terms indicate that the field is strongly centered on the characterization, distribution, and monitoring of microplastics as a core environmental contaminant. The dense interconnections across the network suggest a highly interdisciplinary knowledge base, where environmental science, chemistry, toxicology, and aquatic ecology converge into a unified research domain.

The map can be interpreted into several thematic clusters. The central and green–yellow region represents core environmental systems and pollution frameworks, including terms such as water pollutants, chemical, aquatic ecosystems, pollution, and ecosystem. This reflects system-level environmental monitoring and ecological assessment. The red–purple cluster on the right is dominated by polymer types and pollution sources such as polyethylene, polypropylene, polystyrene, plastic bottles, and environmental compartments like surface water, river pollution, and sediments, indicating strong emphasis on material identification and environmental pathways. The blue cluster on the left highlights biological and toxicological dimensions, including fish, animals, ingestion, gastrointestinal tract, and toxicity, showing concern for ecological and health impacts of microplastic exposure.

The overlay visualization (2022.6–2023.4) indicates a relatively recent and still-evolving research frontier. More recent topics tend to concentrate around monitoring techniques, pollution exposure, and polymer-specific tracking (e.g., polypropylene, polyethylene), suggesting a shift toward more precise analytical and material-based investigations. Earlier or more established themes remain centered on ecological systems and organism-level impacts.

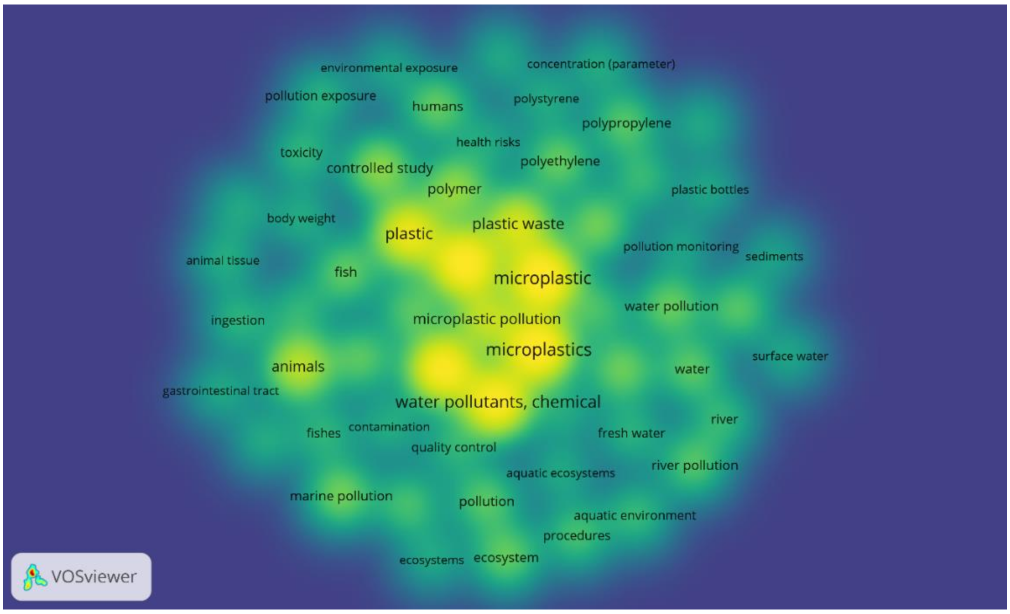

Figure 3. Density Visualization
Source: Data Analysis, 2026

Figure 3 indicates that research on microplastic pollution in water bodies is highly concentrated around a small set of dominant thematic cores. The brightest regions are centered on "microplastic," "microplastics," "plastic waste," "plastic," and "water pollutants, chemical", showing that the literature is primarily driven by studies focusing on occurrence, distribution, and environmental presence of microplastics in aquatic systems. The surrounding high-density zones connecting to fish, animals, ingestion, and toxicity suggest that ecotoxicological concerns remain a major pillar of the field, particularly regarding biological exposure pathways and organism-level impacts.

In terms of thematic structure, the heat distribution shows a gradual diffusion from core environmental monitoring topics toward more specific subdomains such as polymer identification (polyethylene, polypropylene, polystyrene), environmental compartments (river, surface water, sediments), and human/environmental exposure (health risks, pollution exposure, controlled study). The green-yellow concentration around the center reflects active and highly developed research areas, while the cooler peripheral zones indicate less intensive or emerging topics such as procedural standardization and broader ecosystem-level analysis.

3.2 Citation Analysis

Table 1. Top Cited Documents

Citations	Authors and Year	Title
1349	[16]	Trophic level transfer of microplastic: Mytilus edulis (L.) to Carcinus maenas (L.)
1290	[17]	Microplastic particles cause intestinal damage and other adverse effects in zebrafish Danio rerio and nematode Caenorhabditis elegans
1065	[4]	Occurrence of microplastics in raw and treated drinking water
1051	[18]	Microplastics en route: Field measurements in the Dutch river delta and Amsterdam canals, wastewater treatment plants, North Sea sediments and biota

982	[19]	A Review of Microplastics in Table Salt, Drinking Water, and Air: Direct Human Exposure
954	[2]	Microplastic pollution, a threat to marine ecosystem and human health: a short review
653	[20]	Surgical face masks as a potential source for microplastic pollution in the COVID-19 scenario
595	[21]	A meta-analysis of the effects of exposure to microplastics on fish and aquatic invertebrates
523	[22]	Detection and Analysis of Microplastics in Human Sputum
521	[23]	Microplastics and environmental pollutants: Key interaction and toxicology in aquatic and soil environments

Source: Scopus, 2026

3.3 Authorship Visualization

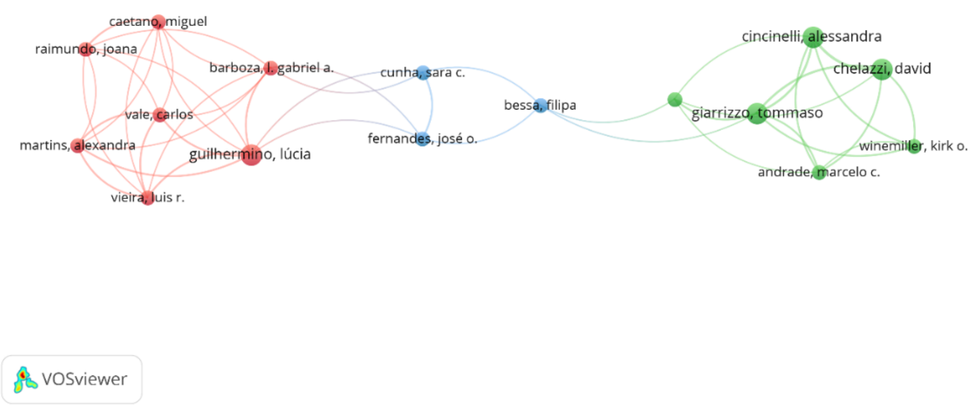

Figure 4. Author Visualization
Source: Data Analysis, 2026

Figure 4 represents a co-authorship structure in microplastic-related research, revealing three clearly separated collaboration clusters. The red cluster on the left is a relatively dense group of closely interconnected authors (e.g., Barboza, Gabriel A., Guilhermino, Lúcia, Vieira, Luís R., Martins, Alexandra), indicating a well-established research team with strong internal collaboration, likely focused on ecotoxicology and environmental toxicology themes. The green cluster on the right (including Chelazzi, David, Cincinelli, Alessandra, Giarrizzo, Tommaso, Winemiller, Kirk O., Andrade, Marcelo C.) represents another highly cohesive research group with strong intra-cluster collaboration, suggesting a parallel but distinct research network, often associated with aquatic ecosystem studies and microplastic environmental distribution. The blue cluster acts as a bridging structure, with authors such as Bessa, Filipa, Fernandes, José O., and Cunha, Sara C. connecting the two major clusters, indicating intermediary collaboration roles that facilitate knowledge exchange between otherwise separate research communities.

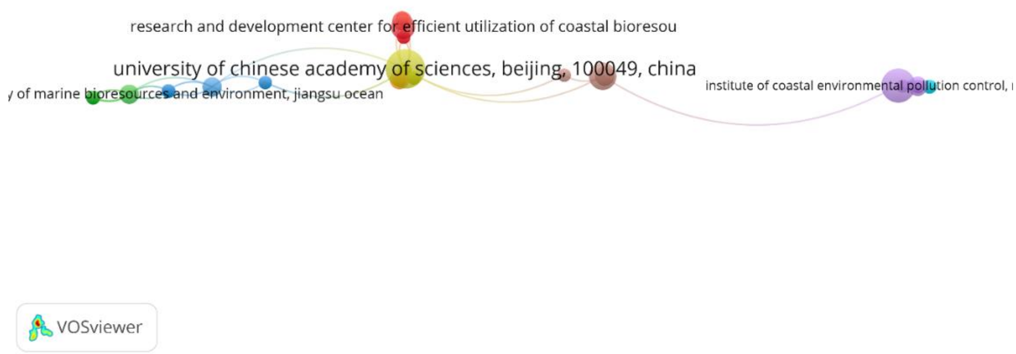

Figure 5. Institution Visualization
Source: Data Analysis, 2026

Figure 5 indicates a highly centralized structure dominated by Chinese research entities, with the University of Chinese Academy of Sciences (Beijing) functioning as the primary hub. This institution exhibits the strongest connectivity, linking multiple specialized centers such as the Research and Development Center for Efficient Utilization of Coastal Bioresources, Jiangsu Ocean-related marine biosciences/environment unit, and other affiliated marine and coastal research institutes. The structure suggests that microplastic research within this dataset is strongly driven by coordinated national-level research programs, particularly under the Chinese Academy of Sciences system, rather than a widely distributed international institutional network. The right-side node, represented by the Institute of Coastal Environmental Pollution Control, appears as a secondary but still connected cluster, indicating a semi-independent research stream that maintains collaboration with the central hub through limited but significant links. The linear and chain-like connectivity pattern suggests a relatively hierarchical collaboration model, where knowledge and research output are concentrated in a core institution and disseminated to affiliated laboratories and institutes.

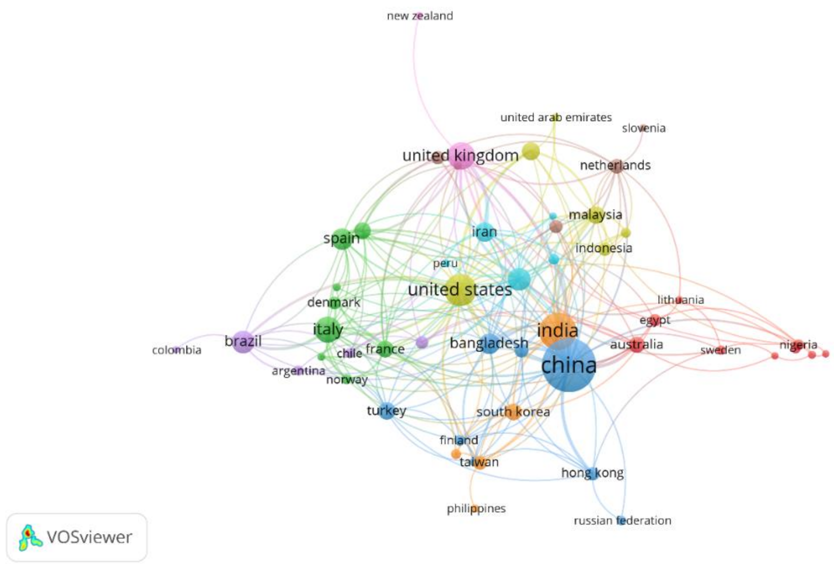

Figure 6. Country Visualization

Source: Data Analysis, 2026

Figure 6 shows that China, the United States, and India act as the main global hubs in microplastic pollution research, with China positioned as the most dominant node in terms of both size and connectivity. China exhibits extensive collaborative links with multiple regions, particularly the United States, India, and several Asian countries (e.g., Malaysia, Indonesia, South Korea, and Taiwan), indicating its central role in coordinating and producing research output in this field. The United States also functions as a strong intermediary hub, maintaining broad connections across Europe, Asia, and developing regions, which reflects its bridging role in global research dissemination and collaboration. The network further reveals distinct regional clusters: a European cluster (e.g., United Kingdom, Italy, Spain, France, Netherlands, Denmark), a Southeast and East Asian cluster (China, India, Malaysia, Indonesia, Hong Kong), and a smaller but connected Latin American cluster (Brazil, Chile, Argentina, Colombia). Africa and some developing regions (e.g., Nigeria, Egypt) appear more peripheral, indicating lower centrality and fewer collaborative ties.

4. CONCLUSION

The bibliometric analysis of microplastic pollution monitoring in water bodies reveals a rapidly expanding and highly interdisciplinary research field, characterized by strong integration of environmental science, toxicology, and material science. The intellectual structure is dominated by core themes such as microplastic occurrence, polymer identification, aquatic ecosystem contamination, and biological impacts, with a clear evolution from general pollution detection toward more advanced monitoring techniques, exposure assessment, and risk evaluation. Co-authorship and institutional analyses indicate the presence of several well-established but partially fragmented research clusters, with key researchers and institutions acting as bridges between distinct scientific communities. At the global level, research output is highly concentrated in a few leading countries—particularly China, the United States, and India—which serve as central hubs connecting both developed and developing regions, while European and other regional clusters contribute significantly but remain comparatively decentralized.

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