Review Article

Access this article online

Quick Response Code:

Website: www.jehp.net

DOI: 10.4103/jehp.jehp_503_24

Unveiling the nexus: A bibliometric analysis of nano plastic's health impact

Alok Singh, Vanisree Ramanathan[1], Ujjwal Kumar[2], Shailesh Tripathi[3], Sheikh Mohd Saleem[4], Deep Shikha[5], Poonam Kushwaha[6], Sudip Bhattacharya[2]

Department of Community Medicine, Faculty of Medicine and Health Sciences (missing), Faculty of Naturopathy and Yogic Sciences, SGT University, Gurugram, Haryana, India, [1]Department of Public Health, Dr. Vishwanath Karad MIT World Peace University, Pune, Maharashtra, India, [2]Department of Community and Family Medicine, All India Institute of Medical Sciences, (AIIMS, Deoghar), Jharkhand, India, [3]Department of Hospital Administration, RIMS, Ranchi, Jharkhand, India, [4]Public Health Expert, International NGO, New Delhi, India, [5]Department of Community Medicine, HIMS, Dehradun, Uttarakhand, India, [6]Department of Community Medicine, Rama Medical College Hospital & Research Centre, Kanpur, UP, India

Address for correspondence:
Dr. Sudip Bhattacharya, All India Institute of Medical Sciences (AIIMS, Deoghar), Jharkhand, India. E-mail: drsudip81@gmail.com

Received: 16-03-2024
Accepted: 08-07-2024
Published: 28-02-2025

Abstract:

Plastics are integral to daily life due to their flexibility, durability, low viscosity, and poor conductivity. However, UV exposure, weathering, and biodegradation fragment plastics into microplastics and nano plastics, forming a heterogeneous mix categorized as large microplastics (5 mm to 1 mm), small microplastics (1 mm to 1 μm), and nano plastics (<1 μm). Concerns over the health impacts of micro and nano plastic (MNP) pollution have spurred extensive research, revealing increased disease susceptibility. Recent studies, analyzed using tools like Biblioshiny and Vos viewer software, have focused on authorship, journal sources, geographic origins, and emerging trends in MNP research. Data from the SCOPUS database (January 1, 2015 to January 3, 2024) analyzed via Biblioshiny and Microsoft Excel revealed 478 articles, with a steady annual increase in publications and references, highlighting growing interest in nanoplastics' health impacts. China leads in publications and collaborations, with eight of the top ten contributing institutions located there, alongside Spain and Serbia. Chinese authors also dominate the top ten published papers in leading journals, five of which are prominent in Environmental Science. This study presents the first visual metametrological analysis of the connection between nanoplastics and human health using bibliometric techniques. By examining global research on nanoplastics' health implications, we can better understand the current research landscape and set priorities for future studies.

Keywords:

Health hazards, micro plastic, nano plastic

Introduction

Plastics have seamlessly integrated into our daily lives owing to their distinctive physical and chemical properties such as flexibility, imperishability, low density, and poor electrical conductivity.[1,2] Not only are plastics economical but also they have supplanted wood and metal in nearly every aspect of modern life.[3] However, their nonbiodegradable nature means they take centuries to decompose, leading to a pervasive contamination of the natural environment with plastic waste, including discarded bags, bottles, and containers. This pollution has escalated into a critical global concern, causing environmental strain and irreparable damage to ecosystems.[4] Projections for 2050 indicate that global plastic waste in landfills and the environment could reach nearly 12,000 million metric tons, underscoring the urgency of addressing this issue.[5] Exposure to UV radiation, weathering, or biodegradation causes plastics to fragment into microplastics or nanoplastics, classified as large microplastics (5 mm to 1 mm), small microplastics (1 mm to 1 μm), or nano plastics (<1 μm). The escalating concern over the potential health repercussions of micro and nano plastic (MNP) pollution has fueled extensive research, given their widespread use and potential adverse effects on human health and the environment. MNPs, a subset of microplastics, are predominantly generated through the breakdown of larger plastics or emitted from various sources

How to cite this article: Singh A, Ramanathan V, Kumar U, Tripathi S, Saleem SM, Shikha D, *et al*. Unveiling the nexus: A bibliometric analysis of nano plastic's health impact. J Edu Health Promot 2025;14:59.

such as electronics, paints, or adhesives. They enter the human body through inhalation, ingestion, or skin contact, crossing physiological barriers and dispersing into different organs.[6,7] Numerous studies have revealed MNPs' detrimental effects on various human organs, from the heart to the placenta, with evidence suggesting dietary intake as a common route of exposure.

MNPs are prevalent in food, drinking water, and plastic food packaging, posing risks that vary by demographic factors such as age, gender, diet, and lifestyle. Wildlife species also ingest MNPs, contributing to the contamination of the food chain and posing a significant threat to food safety.[8] Inhalation of airborne MNPs, originating from sources like synthetic textiles or waste incineration, presents another significant exposure route, particularly for industrial workers.[2,9]

Efforts to mitigate dermal exposure to MNPs have gained momentum with the banning of microbeads in personal care products and detergents in several countries.[10] Bibliometric analysis of literature systems and properties offers valuable insights into knowledge structures and research trends, aiding in forecasting future research trajectories and assessing the progress of different countries, institutes, authors, and fields. This study aims to illuminate the landscape of nanoplastics and human health, offering new perspectives and recommendations for future research endeavors.

Materials and Methods

Data source

The online SCOPUS database was utilized for data retrieval, given its widespread adoption as the primary database in medical research.

Search strategy

This study conducted a literature search using the keywords "Nanoplastics" AND "Human Health." The literature retrieved using these keywords and published within the timeframe from January 1, 2015 to January 3, 2024 was included in the analysis.

Analysis

All references and search results were exported in CSV format. The literature pertaining to nanoplastics and human health, including the number and types of documents, countries, and institutions involved, was thoroughly analyzed. Additionally, the relationships among countries, institutions, and authors were examined. An analysis of the journals in which the searched literature was published was also conducted. Keywords used within this literature were scrutinized as well. Subsequently, the collected data were imported into Biblioshiny (version 4.2.2; Institute for Statistics and Mathematics, Vienna, Austria; www.r-project.org), VOS viewer (version 1.6.18; Centre for Science and Technology Studies, Leiden University, Leiden, the Netherlands), and Microsoft Office Excel 2021 (Redmond WA, USA) for further analysis. Biblioshiny was employed for the visualization and analysis of sources, authors, and documents. Various bibliometric indicators were assessed through Biblioshiny to evaluate the output of countries, authors, institutions, and journals.[11] The number of articles served as a key metric for productivity evaluation. The impact within the academic community was gauged by total citations, while local citations were utilized to assess the impact within specific fields. These metrics constituted the primary dimensions for evaluating the quality of research. Additionally, the h-index, reflecting the number of papers (h) that have been cited at least h times, was employed as an indicator combining productivity and impact. Furthermore, three field plots, country/institutional collaboration plots, and affiliation/authors' production over time were generated using Biblioshiny. Country co-occurrence mapping was facilitated through VOS viewer, renowned for its proficiency in knowledge mapping visualization.

Results

Analysis of trends of publication and research

A total of 478 papers related to nanoplastic and human health in the SCOPUS were searched. From January 1, 2015 to January 3, 2024, a total of 478 articles with the subject terms "Nanoplastic" and "human health" were retrieved from the SCOPUS, which consisted of the following article types: Article 248 (51.9%), Review 181 (37.9%), Book Chapter 35 (7.3%), Conference paper 4 (0.8%), Note 3 (0.6%), Short Survey 3 (0.6%), and Book 2 (0.4%) editorial 2 (0.4%). There were 182 papers in 2023, with the most significant amount of literature published compared to 127 in 2022, 70 in 2021, and approximately 51 in other years. The increase in academic papers on nanoplastics and human health might be connected to the global burden and fear of the spread of NCDs in recent years. The average citations per year increased in 2016; since then, the average citation per year has decreased. In 2017, the average number of citations per article was 57.4. In 2018, it was 53.8. In 2019, it was 29.9. In the year 2020, it was 27.6. In 2021, it was 12.8; in 2022, it was 8.1; in 2023, it was 2.2; and in 2024, the average citation per article was 0.2.

Analysis of the leading countries and regions

The publications were grouped according to the regions of the authors, and the number of publications and citations from different countries were ranked. Sixty-five nations contributed to developing and publishing knowledge, with China (162) being the most active. In terms of citation rankings, China ranked first with

a total of 3947 citations, whereas those from Portugal had the highest average number of citations (235.1 per article). The top ten prolific countries in this field include China, Portugal, Spain, Italy, USA, Switzerland, France, Germany, the United Kingdom, and Canada. It is clear that China had the most significant influence in this field. Of the total 299 collaborations, China was the country that initiated and participated in the most collaborations, that is, 60. The collaborations were mainly concentrated between China and several other countries like USA, Australia, Canada, Pakistan, UK, Korea, Hong Kong, and Germany. The thickest line connecting China and USA signified the highest level of collaboration between these two countries. Other collaborations with significant activity included Australia, Canada, Pakistan, UK, Korea, Hong Kong, and Germany. There were relatively few collaborative relationships involving other countries in this field.

Analysis of authors and institutions

In the studies on nanoplastic and its impact on human health, a total of 792 institutes were involved. The top ten productive institutions are UNIVERSITAT AUTÒNOMA DE BARCELONA (51) ranking first, followed by GUANGDONG OCEAN UNIVERSITY (50) and SHANDONG UNIVERSITY (46), OCEAN UNIVERSITY OF CHINA (36), NANKAI UNIVERSITY (30), SOUTH CHINA AGRICULTURAL UNIVERSITY (27), BEIJING (26), FUDAN UNIVERSITY (24), UNIVERSITY OF KRAGUJEVAC (23), and UNIVERSITY OF MILAN(20). UNIVERSITAT AUTÒNOMA DE BARCELONA led in nano plastics research for human health. It was later on started by the UNIVERSITAT AUTÒNOMA DE BARCELONA but had consistently published articles, eventually becoming the most productive institution in the field. Figure 1 by VOS Viewer shows the status of collaboration between current institutions through bibliometric coupling between them. The ten most productive authors in the field, according to a number of articles, were LI Y (21), WANG J (16), WANG X (14), ZHANG Y (13), LI J (11), WANG Y (10), ZHANG J (10), LI Z (9), LIU Y (9), and WANG B (8). H-Index and G-Index are mixed quantitative measures that consider both the amount and quality of academic work and are used for bibliometric assessments to measure academic impact.[12] LI Y was the most prominent scholar as per H index and G index, with the highest number and quality of publications, followed by WANG X [Table 1]. Comparing the authors' publishing output over time, most papers published by ZHANG Y and LIU Y took the longest study periods, whereas LI Y started their research later and contributed more significantly in the latter years. All the top ten authors continued to contribute in this field in 2023 and 2024. Figure 2 uses a three-field plot diagram to illustrate the pattern of authors' publications in different related topics and journals. The research keywords of the top ten authors included nanoplastic, microplastics, human health, polystyrene, toxicity, cytotoxicity, polystyrene nanoplastics, oxidative stress, nanoplastics, plastic pollution, adsorption, soil,

Table 1: Index signifying prominent scholars

Element	h_index	g_index	m_index	TC	NP	PY_start
LI Y	8	21	1.600	694	21	2020
ZHANG Y	8	13	1.333	667	13	2019
LIU X	7	8	1.750	172	8	2021
WANG L	7	9	1.750	465	9	2021
WANG X	7	9	1.750	92	14	2021
CHEN J	6	8	1.200	114	8	2020
HERNÁNDEZ A	6	7	1.200	267	7	2020
LIU J	6	8	1.500	137	8	2021
LIU Y	6	9	1.000	277	9	2019
MARCOS R	6	7	1.200	267	7	2020

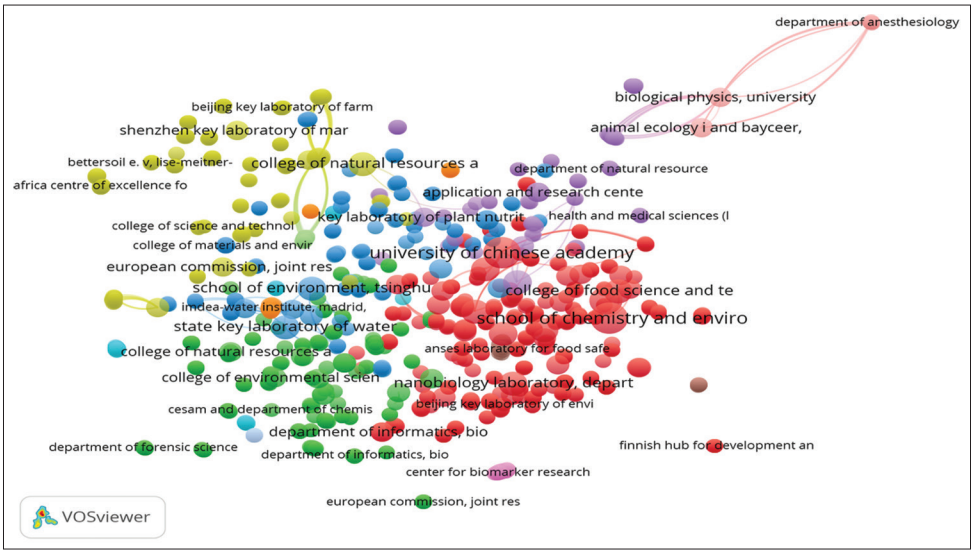

Figure 1: Status of collaboration between current institutions through bibliometric coupling between them

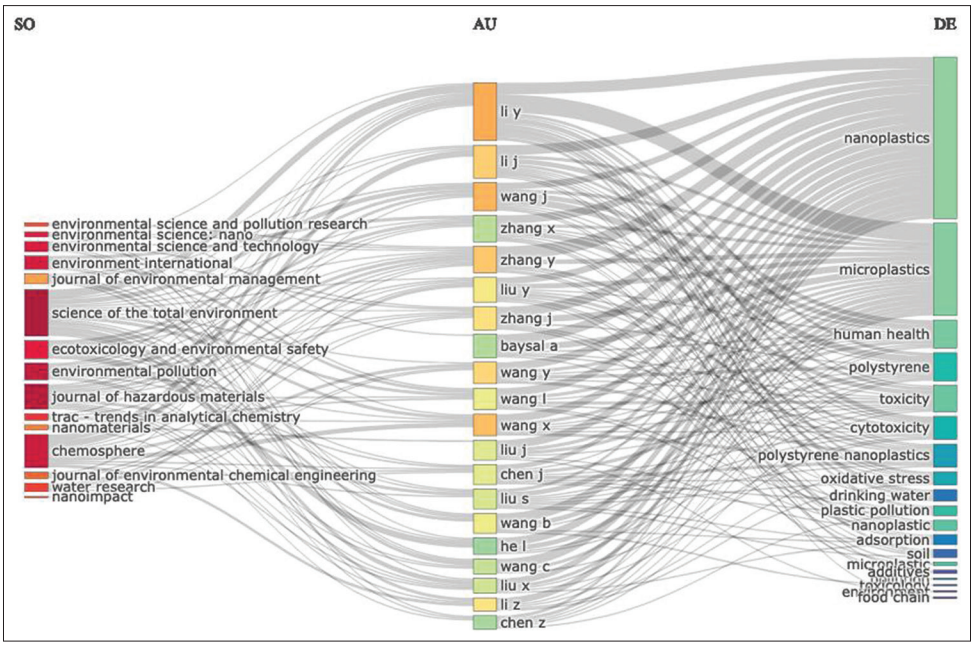

Figure 2: Three field plot

microplastics, additives, food chain, and environment. Their research was typically published in journals such as Environmental Science and Pollution Research, Environmental Science, Nano, Environmental Science and Technology, Environmental International, Journal of Environmental Management, Ecotoxicology and Environmental Safety, Environmental Pollution, Journal of Hazardous Material, TRAC Trends in Analytical Chemistry, Nanomaterials, Chemosphere, Journal of Environmental and Chemical Engineering, Water Research, and Nano Impact. Among them, Science of Total Environment became the top journal in the field of nanoplastic and the impact on human health was the most frequently selected by authors.

Analysis of journal distribution

In total, 197 journals contributed to the publication of literature on nanoplastic and human health. The specific number of publications of the leading ten journals includes Science of the Total Environment (50), Journal of Hazardous Materials (25), Environmental Pollution (24), Chemosphere (22), Environment International (13), Environmental Science and Technology (13), Ecotoxicology and Environmental Safety (12), Environmental Science: Nano (12), Environmental Research (10), and TRAC – Trends in Analytical Chemistry (08). Science of the Total Environment had the highest publication output, followed by Journal of Hazardous Material, Environmental Pollution, and Chemosphere. In addition, the best-ranked journals also had the highest H-index and the highest number of citations, suggesting that they are at the forefront of research in this area. Before 2021, Environmental Pollution was the top-ranked journal in terms of output. After 20121, Science of the Total Environment saw a significant increase in output, surpassing Environmental Pollution to become the most productive journal in the field.

Analysis of keyword evolution

In the period from 2015 to 2024, the most frequently used keywords were analyzed for their usage over the period from 2015 to 2024, and the results include Human, Microplastic, Nanoplastic, Plastic, and toxicity. The keyword 'human and microplastics' got the attention of the researcher working on this topic, and its usage has increased with time. The same trend has been seen in the past 3 years for humans. Plastics is the keyword, with a strong presence before 2021 but low visibility between 2021 and 2023.

Discussion

The increasing number of publications on nanoplastics and human health over the past decade highlights a growing academic and societal concern regarding their potential impact. The sharp rise in research output in recent years may be attributed to heightened awareness of environmental pollution and its implications for non-communicable diseases. This surge in publications reflects a rapid expansion of the field, indicating an increasing scientific effort to understand the complex interactions between nanoplastics and biological systems. However, the declining trend in average citations per article over time suggests a potential shift in research focus, possible saturation of foundational studies, or an increase in exploratory works that have yet to gain significant traction.

The geographic distribution of research contributions reveals a strong concentration in certain regions, with a few countries dominating both publication volume and citations. China emerges as the most prolific contributor, a trend commonly observed in rapidly growing scientific fields where national funding and policy support drive research initiatives. However, despite high output, the citation impact is more evenly distributed, with countries like Portugal exhibiting a higher average citation rate, indicating a strong influence of fewer, highly impactful studies. The collaborative landscape shows China as a central player, engaging in extensive international partnerships, particularly with the United States, which underscores the global nature of nanoplastics research. Despite these collaborations, the relative lack of widespread global participation suggests that more efforts are needed to engage a broader spectrum of research communities to achieve a more comprehensive understanding of the issue.

Institutional contributions are similarly concentrated, with a few leading universities driving much of the research. Universitat Autònoma de Barcelona has played a key role, maintaining a consistent presence in the field and establishing itself as a major knowledge hub. The prominence of Chinese institutions further aligns with the country's dominant role in publication volume. A closer look at authorship trends reveals that a small group of researchers has contributed extensively to the field, with certain authors emerging as pivotal figures based on productivity and citation impact. This pattern suggests an evolving core group of experts shaping the discourse, yet the field would benefit from broader participation and interdisciplinary integration to foster more diverse perspectives and methodologies.

The journal distribution analysis indicates that research on nanoplastics and human health has found a strong foothold in environmental and toxicology journals. Science of the Total Environment has become the most prominent outlet for publications, surpassing earlier leading journals such as Environmental Pollution. The shift in dominant publication venues suggests that the field is experiencing dynamic changes in its dissemination channels, possibly reflecting an expansion into interdisciplinary research spaces. The strong correlation between journal ranking and citation metrics further indicates that research in high-impact journals tends to shape the trajectory of scientific inquiry in this domain.

The evolution of keywords over time provides further insight into how research focus has changed. Initially, broader terms such as "plastics" had a dominant presence, but in recent years, more specific terms such as "nanoplastics" and "toxicity" have gained prominence. The increased association with terms like "human" and "microplastics" signals a growing emphasis on the direct implications for human health, rather than solely environmental concerns. This shift suggests that scientific inquiry is moving toward a more applied focus, addressing public health risks associated with nanoplastics rather than purely ecological impacts. However, the decline in visibility of certain foundational keywords highlights a potential need for maintaining a balanced approach that integrates both fundamental and applied research.

Overall, while the field of nanoplastics and human health research has seen remarkable growth, several challenges remain. The declining citation trend warrants further exploration to assess whether it is due to an oversaturation of similar studies or a need for more innovative and interdisciplinary approaches. The geographic and institutional concentration of research suggests that increased international collaboration and diversification could enhance the field's global impact. Moreover, the evolution of research themes indicates an encouraging shift toward human health concerns, but sustained efforts are needed to translate findings into practical interventions and policy measures. Addressing these challenges will be crucial in ensuring that the field continues to generate meaningful and actionable scientific insights.

Limitations

This bibliometric visualization marks a pioneering effort in its domain. Nonetheless, it comes with certain noteworthy limitations. The study exclusively incorporates relevant literature from the Scopus core database, thereby excluding pertinent literature from other search engines such as PubMed or Google Scholar. Given Biblioshiny's heavy reliance on the Scopus database, it served as the primary data source for software analysis, with other databases seldom utilized for this purpose. The absence of automated duplicate entry removal across different databases hinders simultaneous analyses across multiple databases, posing a constraint. Moreover, the study's merging of near synonyms introduces subjectivity that may potentially lead to analysis errors.

Conclusion

Analysis of articles and reviews published from 2015 to 2024 indicates that China and USA stand out as the leading contributors in the realm of nanoplastics and human health.

Recommendations

Drawing from the existing state and trajectory of research in this field, we propose that forthcoming investigations prioritize topics such as Toxicity, Oxidative Stress, Food Chain, Water Pollution, and Chemicals. Furthermore,

our study identifies the journals and institutions that have published a higher volume of articles, along with highlighting patterns of coauthorship among organizations, authors, and countries. Moving forward, it is imperative for future research endeavors to foster increased collaboration among diverse countries and organizations.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Lamichhane G, Acharya A, Marahatha R, Modi B, Paudel R, Adhikari A, *et al*. Microplastics in environment: Global concern, challenges, and controlling measures. Int J Environ Sci Technol (Tehran) 2023;20:4673-94.
2. Ali N, Katsouli J, Marczylo EL, Gant TW, Wright S, Bernardino de la Serna J. The potential impacts of micro-and-nano plastics on various organ systems in humans. EBioMedicine 2024;99:104901.
3. Karmakar GP. Regeneration and recovery of plastics. Encycl Mater Plast Polym 2022;3:634-51.
4. Rajendran D, Chandrasekaran N. Journey of micronanoplastics with blood components. RSC Adv 2023;13:31435-59.
5. Global Waste to Grow by 70 Percent by 2050 Unless Urgent Action is Taken: World Bank Report [Internet]. Available from: https://www.worldbank.org/en/news/press-release/2018/09/20/global-waste-to-grow-by-70-percent-by-2050-unless-urgent-action-is-taken-world-bank-report. [Last accessed on 2024 Mar 14].
6. Kumar V, Singh E, Singh S, Pandey A, Bhargava PC. Micro- and nano-plastics (MNPs) as emerging pollutant in ground water: Environmental impact, potential risks, limitations and way forward towards sustainable management. Chem Eng J 2023;459:141568.
7. Dube E, Okuthe GE. Plastics and micro/nano-plastics (MNPs) in the environment: Occurrence, impact, and toxicity. Int J Environ Res Public Health 2023;20:6667.
8. Kiran BR, Kopperi H, Venkata Mohan S. Micro/nano-plastics occurrence, identification, risk analysis and mitigation: Challenges and perspectives. Rev Environ Sci Biotechnol 2022;21:169-203.
9. Choudhury A, Simnani FZ, Singh D, Patel P, Sinha A, Nandi A, *et al*. Atmospheric microplastic and nanoplastic: The toxicological paradigm on the cellular system. Ecotoxicol Environ Saf 2023;259:115018.
10. Feng Y, Tu C, Li R, Wu D, Yang J, Xia Y, *et al*. A systematic review of the impacts of exposure to micro- and nano-plastics on human tissue accumulation and health. Eco Environ Health 2023;2:195-207.
11. Bibliometrix - Biblioshiny [Internet]. Available from: https://www.bibliometrix.org/home/index.php/layout/biblioshiny. [Last accessed on 2024 Mar 14].
12. Costas R, Bordons M. The h-index: Advantages, limitations and its relation with other bibliometric indicators at the micro level. J Informetr 2007;1:193-203.