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RESEARCH ARTICLE

From Environment to Health: A One Health Landscape of Research on Selected Artificial Materials

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Elisa Murgioni[1], Francesca Morelli[2], Enrico Ravera[2,3], Antonio Rosato[2,3]

[1]Centro di Risonanze Magnetiche, Universita degli Studi di Firenze, Sesto Fiorentino, Tuscany, 50019, Italy
[2]Consorzio Interuniversitario Risonanze Magnetiche di Metallo Proteine, Sesto Fiorentino, Tuscany, 50019, Italy
[3]Dipartimento di Chimica "Ugo Schiff", Universita degli Studi di Firenze, Sesto Fiorentino, Tuscany, 50019, Italy

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Abstract

Background

The risks for human, animal and ecosystem health associated with some artificial materials raise increasing concern, especially for particles at the micro- and nano-scale. This bibliometric study seeks to map the current research landscape focusing on Micro and Nanoplastics, Bioplastics, Plastic Additives, and Metals/Metal Oxides. We adopted the One Health approach to prioritize the corresponding literature, which entails considering multidisciplinary effects on the Environment, Food, and Health domains. Our work also supports the identification of service gaps and technological needs for investigations focusing on these research areas.

Methods

The selection of the articles to be analyzed was conducted through both manual-searches and a systematic approach using queries in the Web of Science™ Core Collection database. In the systematic approach, articles were initially selected based on publication year, followed by refinement using targeted keywords, boolean operators, and truncated terms. After assessing the relevance of the articles, a database with 813 entries was compiled. These articles were comprehensively classified to facilitate the subsequent analysis, according to parameters such as research domain, thematic focus, technologies, as well as the types and dimensions of the materials studied.

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1. **Mingming Han**, University Sains Malaysia, Penang, Malaysia

2. **Yoorae Noh**, Michigan State University, East Lansing, USA

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Results

We observed that whereas micro-scale research dominates the current literature, in the Health sector there is great attention on the possible hazards of nanoparticles. From a technological perspective, microscopy techniques are widely used across all the addressed scientific domains, whereas other approaches have a marginal utilization. We believe that the latter finding is due to the cost and difficulty of maintaining some high-end equipment.

Conclusion

This bibliometric analysis offers a comprehensive overview of current research on micro- and nano-scale material particles from a health perspective, highlighting thematic interconnections, methodological gaps, the critical need for standardized protocols and broader access to advanced technologies, which could be addressed through enhanced collaboration among Research Infrastructures.

Plain language summary

This contribution presents an overview of current research on a group of artificial materials at the micro- and nano-scale that were chosen for their potential significant role in health. It focuses on suggesting prospects for future research, showing links across diverse fields of study, and expanding knowledge to improve the opportunities offered by Research Infrastructure to European scientists. In particular, this study addresses research on Micro and Nanoplastics, Bioplastics, Plastic Additives, and Metals/Metal Oxides within the framework of the One Health perspective. The latter emphasizes the interconnectedness of research in the domains of human and animal Health, Food and Environment. To achieve this, we collected relevant scientific articles using two methodologies: manual searches and a structured search in the Web of Science™ Core Collection database. The structured search employed specific keywords and filters to automatically identify the articles to be included in our work. The articles retrieved by manual searches were organized into a database categorized by scientific focus areas, types of materials studied, and technologies used.

Our results highlight a significant increase in the number of publications across the selected research domains. In particular, most studies focus on micro-scale artificial material. When it comes to scale, research in the Health sector places strong emphasis on the potential risks associated with nano-scale. Microscopy techniques are the most commonly used, while other advanced instruments are used less frequently, likely due to their high cost and maintenance requirements. These findings may provide valuable insights for the future development of Research Infrastructures.

Keywords
One Health; Artificial Materials; MNPs; Micro and Nanoplastics; Bibliometric research; Environment; Health; Food

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Corresponding author: Antonio Rosato (antonio.rosato@unifi.it)

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Introduction

Anthropogenic activities have profoundly impacted human, animal, and environmental health, presenting a significant scientific challenge of growing complexity and urgency. The rapid acceleration of industrialization and the widespread use of artificial materials have been major contributors to environmental degradation, leading to cascading effects on public health and ecosystem stability. In 2022, the European Union alone generated 2,233 million tonnes of waste —equivalent to 4,991 kg pro capite— originating from economic activities and households (Eurostat Statistics). These numbers illustrate the magnitude of human impact on the environment during the so-called "Anthropocene era". Such impact is a significant driver of pollution, exacerbating interconnected health issues and weakening ecosystem resilience[1]. The urgency of addressing these systemic challenges is underscored by data from the World Health Organization (WHO), which estimates that 24% of global deaths are linked to preventable environmental risks (WHO - World health organization).

A critical concern is the pervasive and increasing presence of micro- and nano-scale artificial materials, particularly Micro and Nanoplastics (MNPs). Ten years ago MNPs were included in the UNEP Year Book, a publication that highlights emerging environmental issues, significant events, and developments (UNEP year book). To date, MNPs have been extensively studied as a significant category of pollutants due to their ubiquitous presence across various systems, including the airborne environment[2,3] marine environments[4,5], terrestrial habitats[6,7] and agricultural soil[8,9]. Due to their small size, these materials are intrinsically prone to uptake in both environmental and biological systems, and thus can easily infiltrate and disrupt ecosystems[10]. Beside their pervasive and increasing presence, MNPs have a significant potential of impact on health as they can harbor a variety of endogenous chemical additives[11,12]. Plastic additives are a diverse group of chemical compounds added to plastic products to give them their unique physical-chemical properties. They are not chemically bound within the polymers and can be persistent and biologically active. As plastics in the environment break down to smaller particles, the additives contained therein might be released as fragmentation proceeds from the meso to micro and nano scale. The ecotoxicological effects of plastic additives represent another growing concern, as well as a significant knowledge gap[13,14].

From a biological perspective, MNPs pose a significant risk to human health, with several pathways for their entry into the body through ingestion, inhalation, or skin absorption. The micro- and nano-scale of these particles enable them to cross biological barriers, potentially bypassing the body's natural defenses and leading to systemic exposure[15]. As an example, the gastrointestinal tract has been identified as a pathway for the absorption of MNPs[16] and, as reported in the review of 17, a potential vector for intestinal inflammation and inflammatory bowel disease. The increasing interest in MNPs and their potential impact on various health conditions has also extended to neurological aspects, with numerous studies investigating their role in neurotoxicity[18]. Recently Campen *et al.*, 2025[19] highlighted an alarming increase in MNPs concentrations in both the brain and liver, with levels in the brain being 7–30 times higher than in the liver or kidneys, particularly in dementia cases. MNPs have been implicated in cardiovascular events[20] and the development of antibiotic-resistant bacteria[21], underscoring the growing concern about their potential impact on human health. Exposure assessments across various food sources indicate significant intake levels of MNPs. For example, the daily exposure level to micro-plastics from fruits and vegetables reaches a number of 10^5–10^6 particles/kg body weight[22]. From these figures, assuming an adult weighing 70 kg and a particle mass of 10^{-8} g, the annual intake of microplastics would be approximately 118 g. A comparable amount can be ingested by drinking mineral water from plastic bottles. To alleviate plastic pollution, biodegradable plastics (bioplastics) were introduced as an environmentally friendly alternative to conventional plastics. Bioplastics are used to manufacture food packaging, disposable tableware, and biomedical delivery containers, and their manufacturing has kept growing over the years. Nonetheless, some recent studies investigating the possible impact of bioplastics on humans and animal models show that they might trigger inflammation[23] and other adverse effects[24]. The microplastics generated through their deterioration processes and their toxicological effects when ingested warrant further in-depth study[25].

Despite the current increase of interest in micro- and nano-scale material particles, considerable knowledge gaps remain in our understanding of their environmental and human health implications. This is also due to the lack of universally accepted definitions and frameworks for standards, quality assurance, accreditation, and metrology that collectively introduce further uncertainty into this complex field[26]. Addressing this requires a One Health approach, recognizing the interconnectedness of human, animal, and ecosystem health (One Health Overview). Organizations like the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the World Organization for Animal Health (OIE) endorse and promote this unified perspective to align pollution mitigation with sustainability[27]. However, interdisciplinary barriers, particularly in communication between legal, economic, and scientific sectors, hinder its implementation. The harmonization of methodologies, protocols, and approaches across disciplines would enable a shift from generating isolated knowledge to producing systematic and applicable insights that address the complexities of pollution at micro- and nano-scale[28].

The present contribution, developed within the EC Coordination Action FHERITALE (https://fheritale.eu/), employs bibliometric analysis to prove a landscape of current research on micro- and nano-scale material particles within the One Health framework. In this context, the Environment, Food and research areas are related to the domains of ESFRI, the European Strategy Forum on Research Infrastructure (http://www.esfri.eu). By integrating the Environment, Food and Health domains, the adopted methodology for collecting and analyzing research studies provides insights into research clusters, trends, and conceptual connections[13,29]. This work also aims to define

a set of recurring One Health sub-thematics and an inventory of currently employed technologies, which is crucial for identifying key technological gaps and service-related needs.

Methods

Topics selection: the definition of the thematic priorities

To narrow the focus within the broader context of addressing the effects of micro- and nano-scale material particles on human, animal, and ecosystem health, in the initial step of this work we selected a subset of critical and impactful artificial materials. This was done drawing on the expertise of the FHERITALE partners and included in a document shared within the project consortium (Milestone 4: Summary of Thematic Priorities), namely MNPs, Bioplastics, Metals/Metal oxides, and Plastic Additives. Table 1 provides a glossary of the terms used in this article.

Bibliometric investigation: manual searches and Web of Science™ search

Bibliometry is a multidisciplinary field that applies statistical approaches to the examination of scientific outputs by employing various bibliometric indicators such as articles counts, citation metrics, authors and key topics[30]. Drawing upon the methodology employed in other recent bibliometric analyses[31–33] and following the guidelines of the PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses;[34], this research was conducted using two approaches: manual searches and a systematic search through the Web of Science™ Core Collection (hereinafter referred to as WoS) database (Clarivate™ Analytics, 2023a). Manual search was initially driven by a set of free terms/keywords (available in the supplementary material); then, publications were selected when all the following inclusion criteria were satisfied: a) the research topic is related to the impact of MNPs, Bioplastics, Metals/Metal Oxides, or Plastic Additives (based on the terminology used in the papers); b) recent publication date. Those papers regarding material science/synthesis of new materials and those regarding particles larger than the micro scale were excluded. In parallel, the systematic search was conducted in the WoS database by combining a set of relevant keywords, selecting only the articles classified as "hot papers" and "highly cited papers" (see Clarivate™ Analytics definitions: 2023b and 2023c). After the removal of duplicate records, the remaining articles were filtered based on the same criteria applied in the manual search. In this process, we also identified the specific sub-thematics and technologies associated with the selected articles. In order to avoid redundancy of entries, reviews were excluded from both manual and WoS searches. The overall process of selecting the articles for analysis and appropriate categorization is referred to as full text assessment.

The flowchart in Figure 1 illustrates the steps undertaken in the bibliographic search. It is divided into four parts. The first part, "Searches", highlights the differences between manual searches and those conducted on the Web of Science. The second part, "Screening", is further divided into two phases: Screening Part 1 and Screening Part 2. The Screening Part 1 step includes the initial selection based on the last publication year and three domains: Environment, Health, and Food; the Screening Part 2 relates to the use of keyword combinations. The scheme of activities was repeated for each selected topic.

Table 1. Glossary of terms.

Articles database = Articles DB
MNPs = Micro and Nanoplastics
WoS = Web of Science™
Artificial Materials = term used to refer to the broader category of materials generated by human activity that are classified as pollutants and impactful
Selected Topics/Thematic Priorities = MNPs, bioplastics, Metals/Metal oxides, and Plastic Additives
Research domains = Environment, Food, Health
Free terms/Keywords = Keywords used in the Manual Searches
Key terms = list of terms and synonyms targeted during the initial review-based approach systematically integrated into each query
Keywords Combination = Queries generated by combining terms related to the selected topics, research domains, and key terms
Full-text assessment = A component of the bibliometric analysis in which each article was thoroughly reviewed to ensure its relevance to our work and its suitability for inclusion in the article database. Each article was assigned a label corresponding to the number of the article, authors, research domain, sub-thematics, technologies employed, dimension (scale) of the particles analyzed, types of selected topics studied.
Sub-thematics = terms to indicate the more detailed view of the research areas covered by the Articles DB, corresponding to most frequently investigated topics

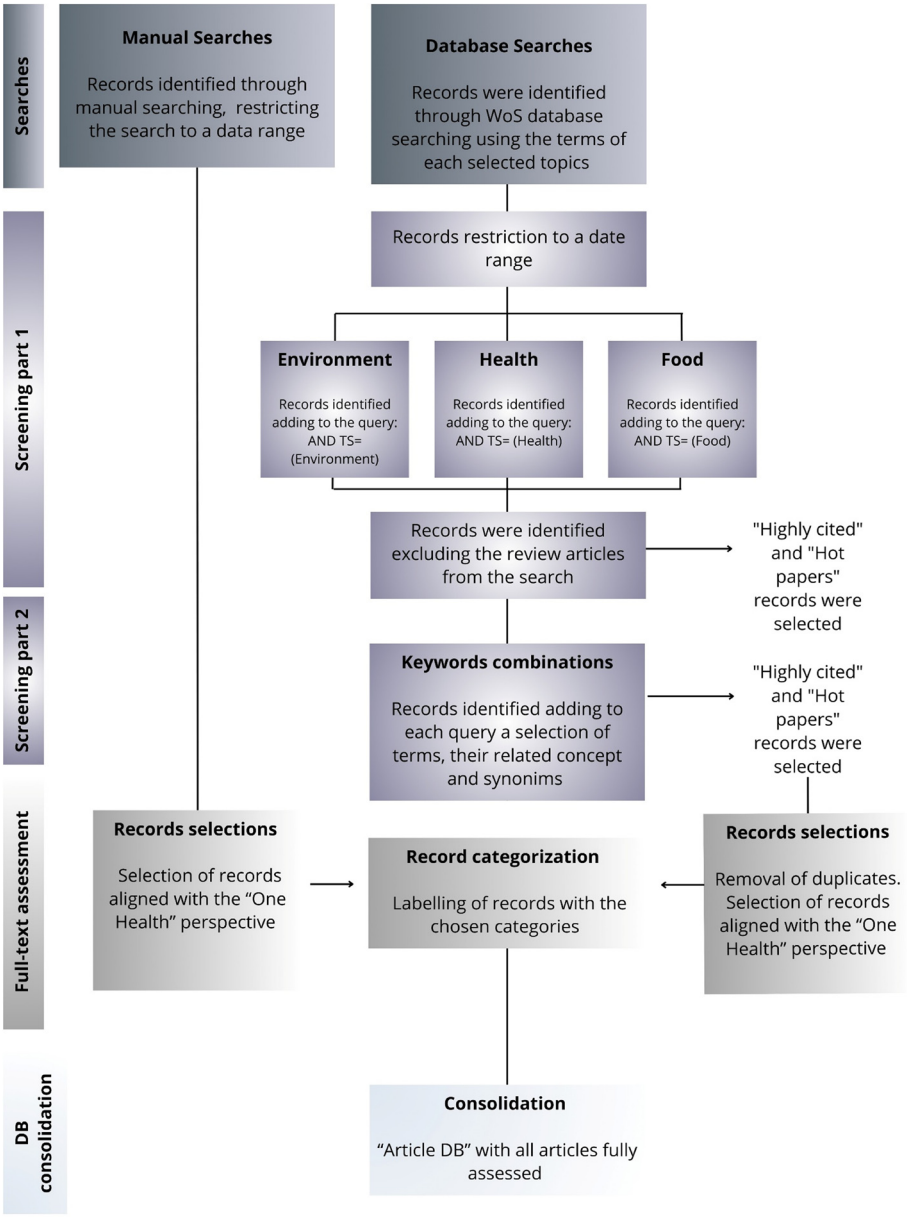

Figure 1. Flowchart of the bibliometric investigation conducted for each topic. As an example, the search string for MNPs in Screening Part 1 is (((TS=(nanoplas*) OR TS=(microplas*)) AND TS=(Environment)) AND DOP=(2020-01-01/2024-12-31)). For details on the queries used, refer to the supplementary information.

Keywords combination

In the "Keywords Combination" step, key terms were included in the search string in order to increase the likelihood of identifying relevant records aligned with the thematic areas of interest. Key terms are a list of terms and synonyms targeted during the initial review-based approach (Manual searches), informed by existing opinion papers and reports that highlight critical priority areas for research on artificial materials within the scientific community (e.g., SAPEA reports). These terms were systematically integrated into each query, with each key term flanked by synonyms and related concepts (Figure 2). Boolean operators and truncated words were used to improve the search process.

Time frame selection

For the analysis, given the extensive body of research, with a total of 121.908 articles over the last twenty-four years, we focused on the most recent five years (2020–2024) to provide an overview of the current state of research. As a time reference we adopted the 'final publication year' which in WoS refers to the most recent year in which articles are indexed and made available in the database.

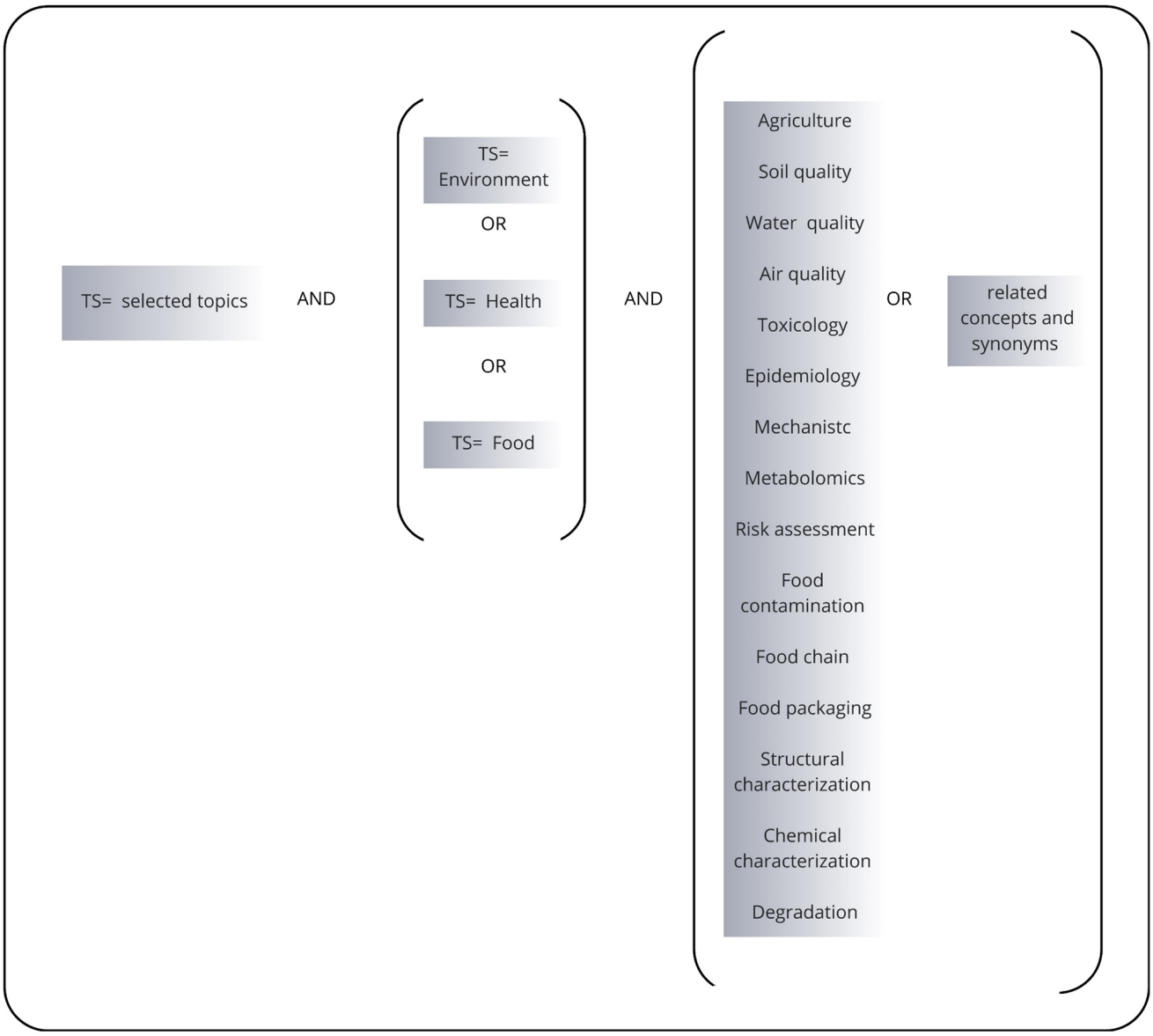

Figure 2. Representation of the Keywords combination approach. As an example, the search string for Agriculture, including its synonyms, is TS=("Agricult*") OR TS=("Agronomy") OR TS=("Farm*") OR TS=("Horticult*") OR TS=("Crop Product*") OR TS=("Cultivat*") OR TS=("Agroeco*") OR TS=("Land Use") OR TS=("Crop Science") OR TS=("Farming System*"). For details on the queries used, refer to the supplementary information.

The resulting Articles DB comprises 813 publications and is available in the supplementary material section.

Articles DB organization and categorization

The articles were included in the final database only after a full-text assessment (Figure 1). This process enabled systematic organization and classification of each entry. Due to the selection criteria, all articles possessed a transversal nature across the three research domains—Environment, Food, and Health. Consequently, each article was labeled with its most representative domain. A "Methods" category was also introduced to identify articles solely focused on methodologies, either related to chemical or structural characterization. To provide a more granular understanding of the research areas within the Articles DB, we assigned specific "sub-thematics" to each article. Furthermore, we categorized the articles based on the particle size as defined by the authors; the articles where the particle sizes were not specified or included both the micro- and nano-scales were marked with (*). We also added labels for the applied techniques, grouped in the following categories: X-Ray techniques, Magnetic Resonance techniques, Omics techniques, Optical Spectroscopy, Light Scattering, Microscopy techniques, Mass Spectrometry techniques, biological studies, and Data and Bioinformatics methodologies. In the Biological studies category, we included all techniques related to the biological and biochemical responses of living

organisms and their interactions with artificial materials, both in vivo and in vitro. The proposed structure aims to provide a rational organization of the collected articles and facilitate efficient data retrieval and analysis across the defined categories. During data analysis, each entry is counted individually, with each occurrence recorded only once.

Complementary analysis and bibliometric mapping

In parallel with the building of the Articles DB, we also performed a statistical analysis on the whole WoS database, which included a significantly larger number of articles. We also analyzed the citation topics, an additional tool available within WoS (Clarivate™ Analytics, 2020). The "Author Keywords" obtained from WoS (i.e., the terms provided by the authors during article submission to highlight the paper's main research focus and core concepts) were examined through VOSviewer[35].

Results and discussion

Time-frame analysis on publications from WoS

Figure 3 shows the number of publications over the past twenty-four years (2021-2024), revealing a significant increase in research activity on the selected topics over the last five years. This is particularly evident for MNPs, as well as for Bioplastics, underscoring the recent and rapidly growing interest in these topics. We thus decided to focus our subsequent work on the last five years of publications, to be able to detect the latest trends while maintaining a sufficiently large basis for statistics.

Analysis of the Articles DB

The analysis of the distribution of authors' affiliations across countries, based on the WoS data, reveals that Europe holds the largest share, with 353 publications (45% of the total), followed by China with 321 publications (41%), and the United States with 81 publications (10%). Within Europe, the leading countries are Italy and Germany, with 74 and 67 publications, respectively, corresponding to 9% and 8% of the total. These findings align with the results of similar studies[36,37].

The data collected in the Articles DB have been grouped across four macrodomains including the 3 research domains — Environment, Food, Health — and the Methods category. The Environment category relates to the largest share of articles, although a reduction in percentage is observed in the last two years (Figure 4). In contrast, the percentage of articles classified under the Health macrodomain shows an increase throughout the five-year period, reflecting the growing interest in the impact on Health of artificial materials at the micro- and nano-scale. Food and Methods appears to be relatively steady over the examined period with a possible exception of 2024. A potential bias might be the result of the article selection process, which was partly based on citations[38]. This approach favours the selection of older articles, which may have accumulated more citations than more recent publications. Furthermore, the citation index differs across areas of research[39], which might favour articles focusing on Health with respect to publications addressing the Environment and Food domains.

During the full-assessment phase, guided by the key terms selected for the keyword combinations, we categorized each article based on a series of macrodomain-related sub-thematics, which were identified as its primary focus (Table 2, Figure 5). This approach allowed for the identification of current key areas of interest in research on these subjects. The Environment

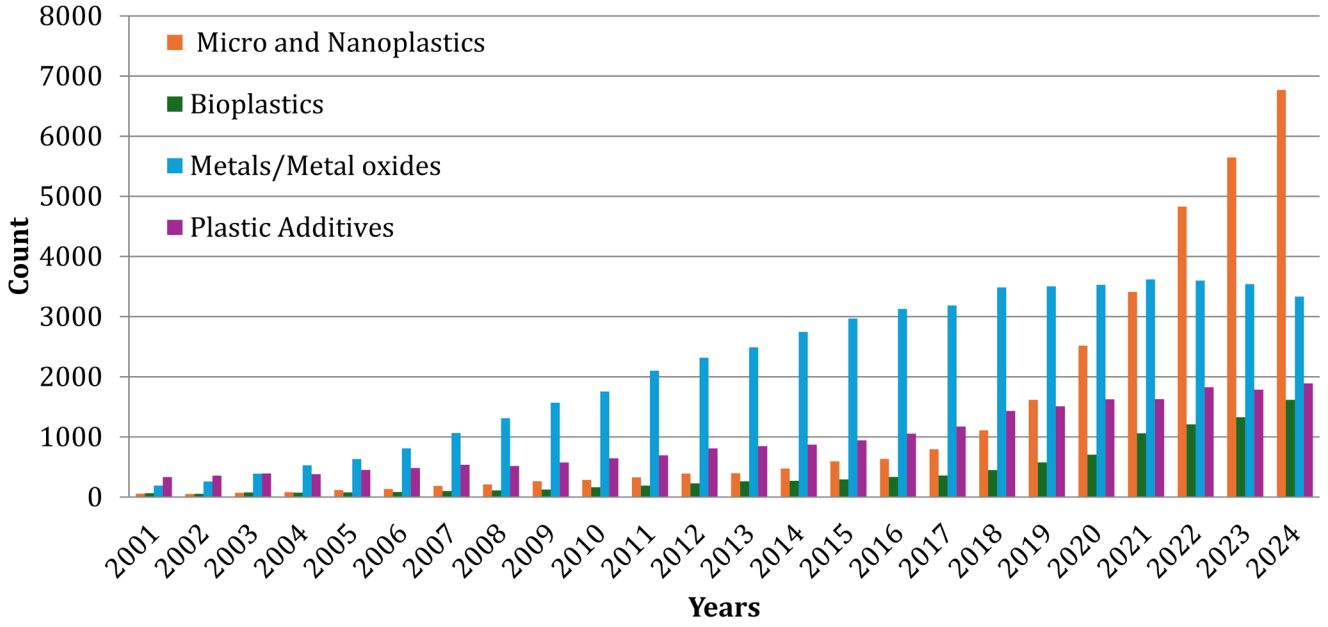

Figure 3. Chronological overview of studies on selected topics. Bar plot representing the distribution of 121,908 articles obtained from the Web of Science through queries related to the selected topics.

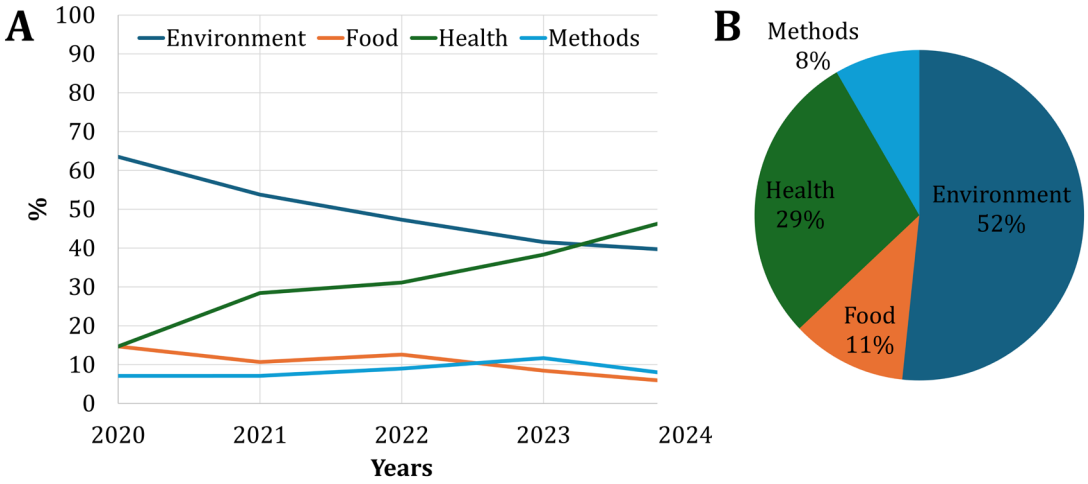

Figure 4. Macrodomains trends: chronological and percentage distribution. (**A**) Trends derived from 813 entries in the article database for the Environment, Health, Food and Methods categories (2020-2024) and (**B**) their percentage distribution over the data range selected.

Table 2. Sub-thematics.

ENVIRONMENT	HEALTH	FOOD
extraction in marine sediment samples	toxicological studies	food contamination
Impact on micro-organisms	epidemiological studies	transfer through food chain
agriculture practices	mechanistic studies	food packaging
soil quality	metabolomics	
water quality	risk assessment	
air quality		
ecosystem impact, ecosystem services		
impact on marine species		
degradation mechanism and stability assessment		

domain includes a greater number of sub-thematics than the Food and Health domains, possibly also due to the larger number of publications related to Environment in the Articles DB (Figure 4B). Several of these topics are relevant to policy, regulation, and public awareness. Toxicological studies and Degradation mechanism and stability assessment are among the most frequent sub-thematics. This can be attributed to the One Health perspective implemented in our workflow, specifically at the full-assessment stage, which emphasizes studies with an interdisciplinary nature. On the other hand, it may reflect an actual gap in research on the underrepresented sub-thematics, such as the "impact on microorganisms".

For the "Methods" category, no sub-thematics were defined, as it was introduced to identify articles focused on new methodologies and/or analytical approaches. Notably, several of the articles categorized within this latter macrodomain indicate the critical importance of standardization, as consistent and reliable data are essential for ensuring the accuracy and comparability of research outcomes. Indeed, uniform methodologies enhance the reproducibility of results[40]. Figure 6 clearly demonstrates a significant disparity in current research as represented by the Articles DB. Namely, the publications focusing on nano-scale particles are substantially fewer than those examining micro-scale materials. This can be partially explained by the fact that microparticles are easier to detect and identify.

By addressing this issue in more detail, it appears that the percentage of studies dealing with the impact of nano-particles is significantly higher in Health (Figure 7). This likely reflects the increased ease with which smaller particles interact with

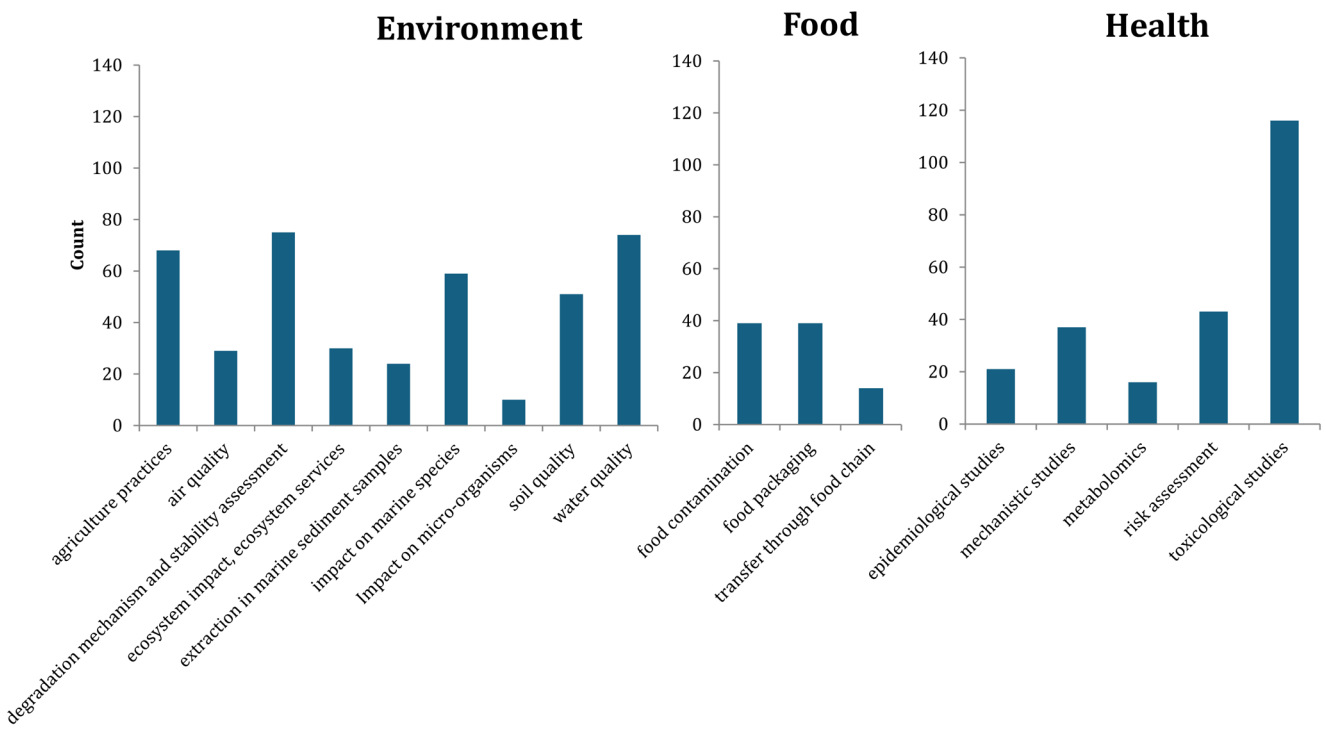

Figure 5. Occurrence of sub-thematics within their respective macrodomain.

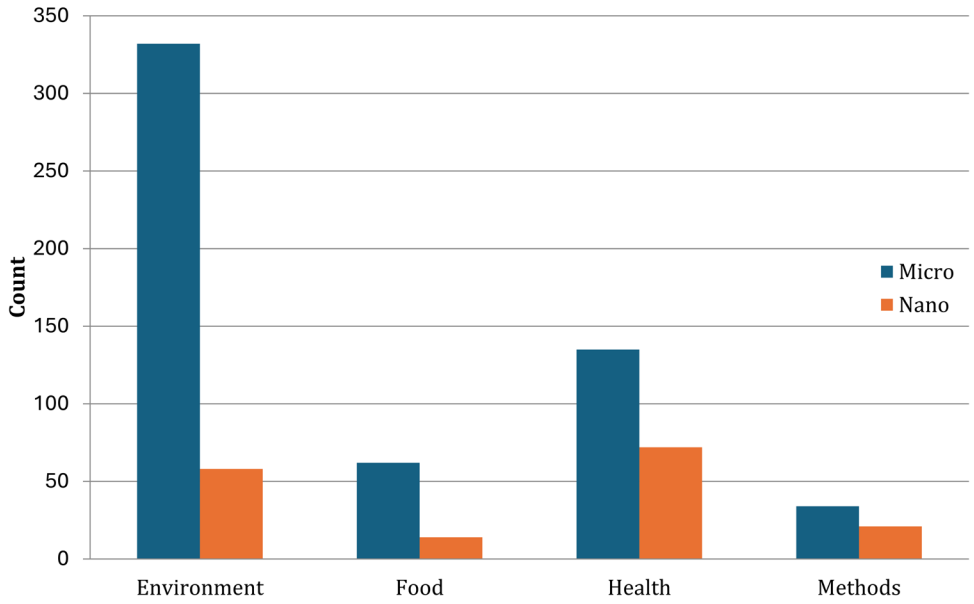

Figure 6. Distribution of the dimension along macrodomains. Distribution of the dimension of the investigated particles across macrodomains, measured by the number of corresponding publications in the Articles DB. The 85 articles marked with (*) were excluded from the analysis.

biological systems[41]. Examining the distribution of studies across the selected topics (Figure 7C, D) it appears that at the nano-scale there is a prominent focus on Metals/Metal Oxides, while studies on Bioplastics are more represented at the micro-scale.

From the sub-thematics point of view (Figure 8), we observe that sub-thematics oriented to Environment emphasize micro-scale studies. Instead, sub-thematics within the Health domain show a much higher share of studies investigating materials at the nano-scale, as for instance, toxicological and

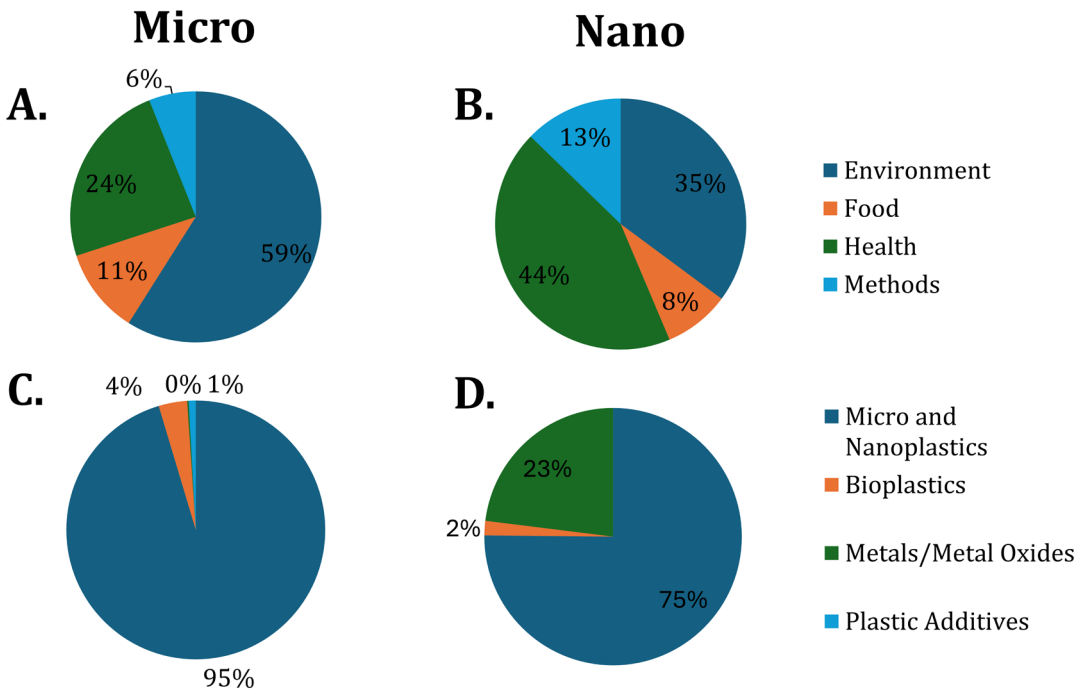

Figure 7. Domains and Selected Topics distributions within Particles dimension. Percentage of articles investigating micro- and nano-scale material particles across the different research macrodomains (**A** and **B**, respectively) and across the different selected topics (**C** and **D**, respectively). The 85 articles marked with (*) were excluded from the analysis.

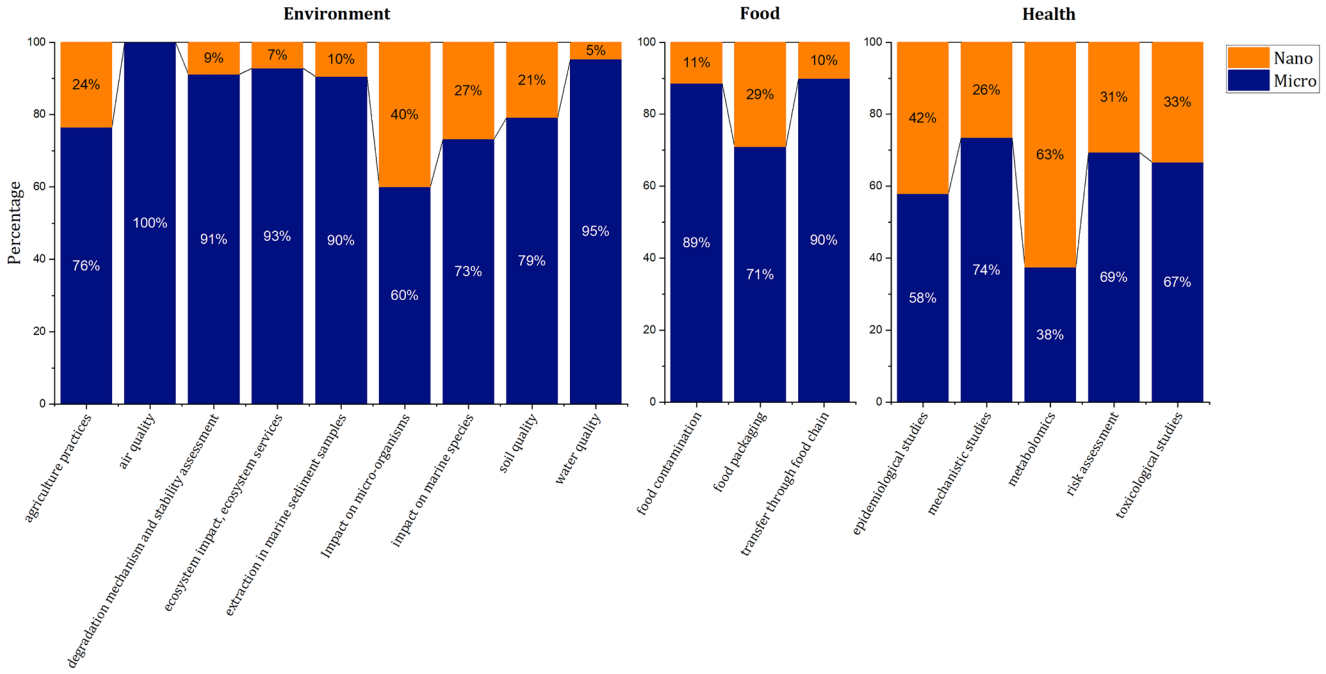

Figure 8. Dimension distribution within sub-thematics. Distribution of the dimension of the investigated particles across sub-thematics. The 85 articles marked with (*) were excluded from the analysis.

epidemiological studies, along with metabolomics, confirming the growing interest in the potential risks of nanoparticles for human health[42,43]. A closer look at the Environment-related sub-thematics show that studies focusing on the impact of artificial materials on microorganisms and marine species have a much higher percentage of nanoparticles studies with respect

to other sub-thematics. This is in agreement with the above observations on the Health domain as both sub-thematics have their focus on biological systems.

An overview on techniques

We analyzed the Articles DB with respect to the techniques employed in each article (Table 3). As expected, given their availability in most of the laboratories equipment, Microscopy and Optical Spectrometry techniques are the most commonly employed across all topics, particularly for the investigation of MNPs[44]. Other techniques, such as Mass Spectrometry and Biological techniques, appear more popular in studies addressing the impact of Plastic Additives. This may be due to their capability of studying complex chemical compositions and the biological effects of materials. While Omics techniques are evenly applied across, Light Scattering techniques and Magnetic Resonance techniques show a very narrow usage. In this context, Magnetic Resonance techniques cannot be applied to Metals due to limitations in detection, whereas the most representative Metal oxides have poor NMR sensitivity.

Considering the application of techniques in relation to the particle scale (Figure 9), we observed that biological, omics and Light Scattering techniques are more used in studies on nano- than micro-scale particles. This reflects respectively the higher absorption of smaller particles by living systems, as already noted, and the high resolving capability of Light Scattering in this scale.

Table 3. Percentage distribution of the techniques used over the selected topics.

	Micro and Nanoplastics	Bioplastics	Metals/Metal Oxides	Plastic Additives
X-Ray techniques	3	9	11	0
Magnetic Resonance techniques	2	4	0	2
Omics techniques	8	6	7	10
Optical Spectroscopy	25	29	13	17
Light Scattering	4	4	4	2
Microscopy techniques	28	26	27	22
Mass Spectrometry techniques	7	8	13	24
Biological studies	19	13	22	20
Data and Bioinformatics methodologies	4	1	3	2
Total	**100**	**100**	**100**	**100**

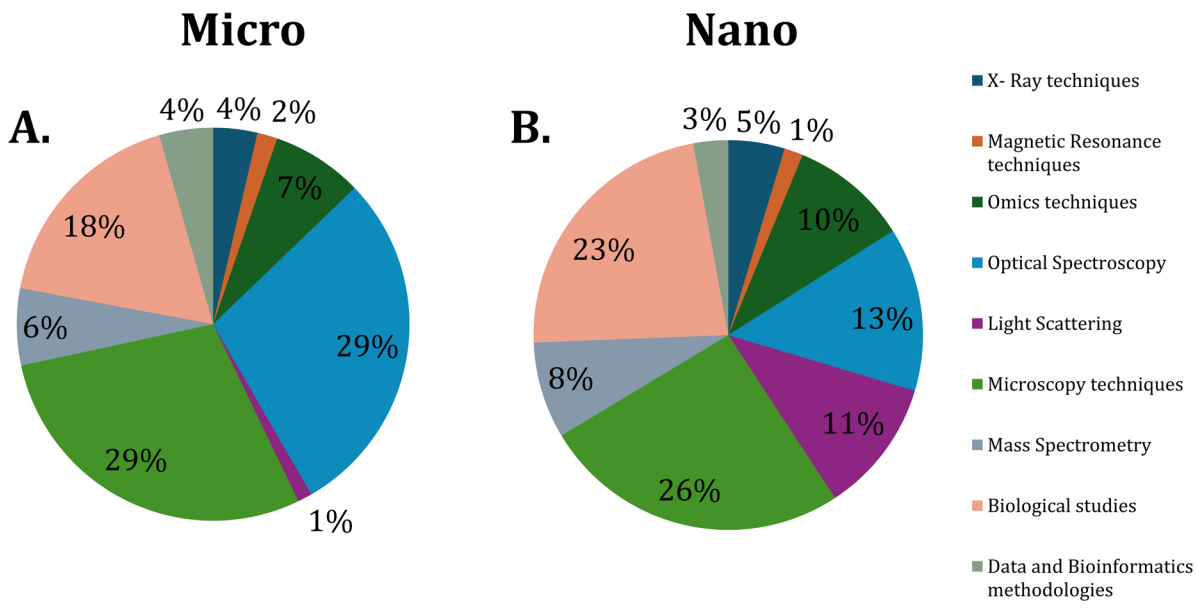

Figure 9. Percentage distribution of techniques by micro- and nano-scale. Percentage distribution of the techniques employed at the (**a**.) micro- and (**b**.): nano-scale. The 85 articles marked with (*) were excluded from the analysis.

The distribution of employed techniques across the three domains—Environment, Food and Health (Figure 10) might be representative of how each domain tailors its methodological approach to meet its specific research objectives.

A more detailed overview is provided in Figure 11, showing the use of the various analytical techniques with respect to the research sub-thematics. Optical spectroscopies (such as FT-IR and Raman) and Microscopy techniques (such as SEM and TEM), appear to be commonly employed across all the diverse macrodomains. This is in agreement with recent reviews[45,46]. Indeed, FT-IR is a powerful tool to characterize polymers, as well as capable of revealing information on their degradation and organic impurities/contaminants[47]. Instead, Microscopy techniques are extensively used in the field of MNP imaging, as they provide a relatively fast and straightforward means of assessing particle size, shape, and quantity[48].

Through an analysis of the WoS database, it was possible to correlate the research corpus of the Articles DB with the Sustainable Development Goals (SDGs), as defined by the UN (SDGs UN definition). It appears that research on artificial material is related mainly to 4 goals (Figure 12). The majority of entries in our Articles DB address 3 to 4 SDGs.

To streamline our Articles DB analysis, we employed version 1.6.20 of the VOSviewer software. By analyzing keyword co-occurrence, and by grouping related keywords into distinct clusters, VOSviewer allowed us to systematically identify frequently used and highly interconnected terms across the Articles DB. To explore the research landscape within the Articles DB, we conducted three separate analyses, focusing respectively on the Environment, Food, and Health macrodomains (Figure 13). The resulting maps demonstrated multiple interactions across the domains. Specifically, the Environment map featured health-related keywords such as “toxicity”, “ingestion”, and “risk assessment”, while the Health map included “environmental exposure”, and the Food map contained “human health”, “human exposure”, and “environmental”. These overlaps highlight the inherent interconnectedness of the topics that guided this bibliometric work.

Statistical analysis of the WoS database

Alongside the analyses of the Articles DB, we performed a statistical analysis on the comprehensive dataset generated from the initial screening queries (Figure 1). This broader analysis, encompassing a significantly larger number of results, allowed for a validation of the results presented in the previous sections over a wider dataset, through the identification of broader trends and patterns. This parallel approach confirms that the results obtained from the Articles DB are indeed representative of the wider research landscape represented in the WoS.

Figure 14 reveals a consistent increase in publication numbers across the Environment, Food, and Health macrodomains throughout the analyzed period. While the Environment research area continues to dominate in volume compared to Health and Food, as observed in Figure 4, the overall trend from the 28,341 articles represented in Figure 14 indicates a steady growth for all domains with Health exhibiting the most rapid growth trend.

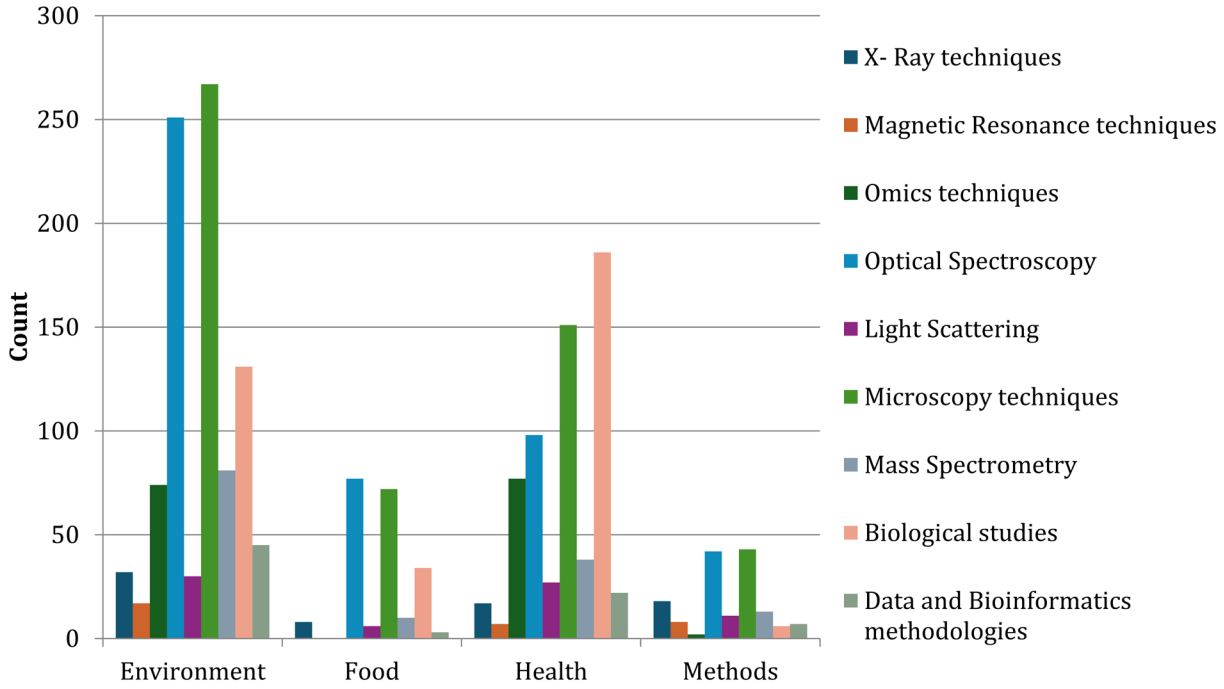

Figure 10. Distribution of employed techniques across the selected macrodomains.

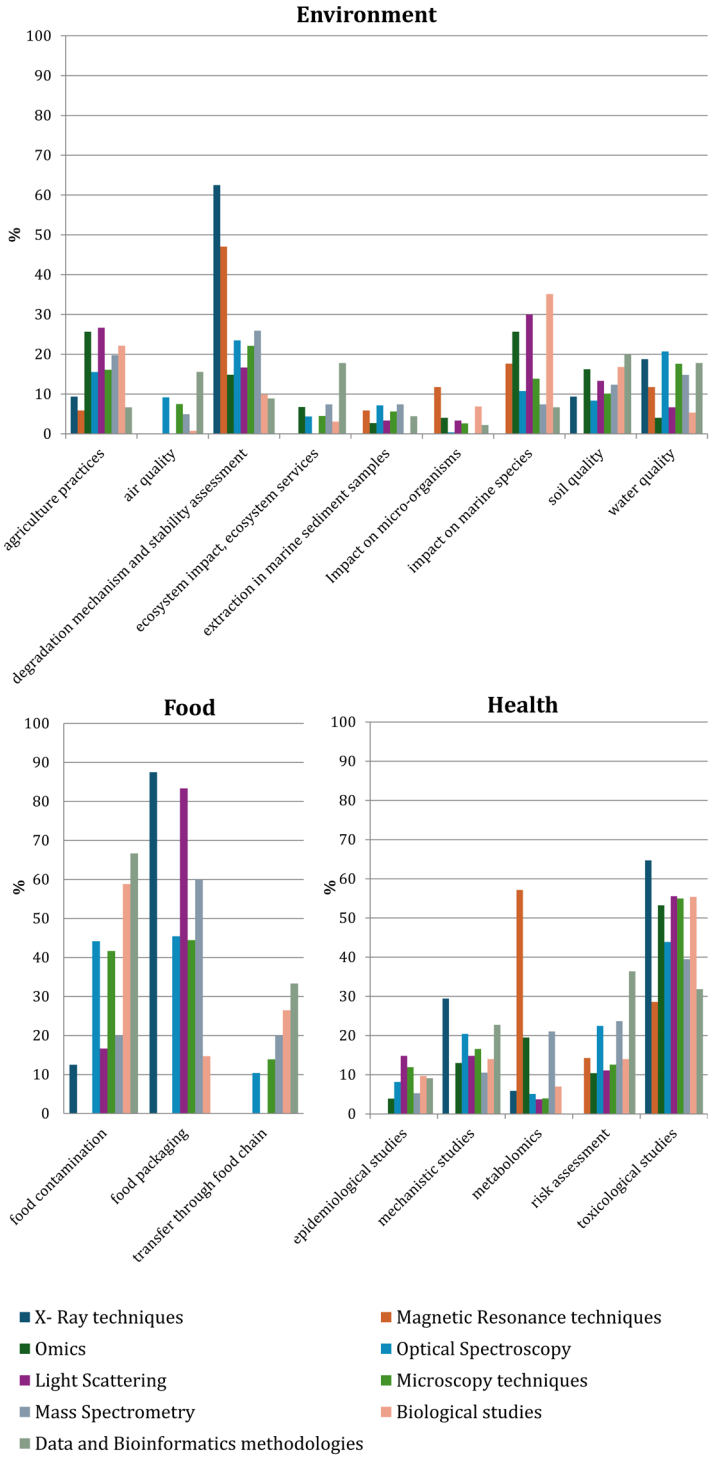

Figure 11. Distribution of employed techniques across sub-thematics areas. X-Ray techniques are primarily utilized in Food contamination, Magnetic Resonance techniques are particularly valuable in metabolomics, highlighting their utility in examining metabolic processes, while Omics techniques are applied across several fields, contributing significantly to the studies of marine species impact. Optical Spectroscopy and Microscopy techniques are notably employed in soil and water quality assessments, providing physical and chemical properties of Environment matrices. Light Scattering is employed in studies of soil and water quality to analyze particle size and dispersion. Mass Spectrometry techniques are widely applicable across all sub-topics, with a major role for risk assessment studies. Biological techniques are heavily utilized in the study of marine species' impact and toxicological studies, emphasizing their role in assessing biological effects and the Health impacts of contaminants. This analysis also shows that the Data and Bioinformatics methodologies are widely applied for toxicological studies and water quality research.



Figure 12. Sustainable Development Goals derived from the Articles DB through WoS analytics, along with their respective counts. Clean Water and Sanitation (Goal 6); Sustainable Cities and Communities (Goal 11); Responsible Consumption and Production (Goal 12); Life Below Water (Goal 14); Good Health and Well-being (Goal 3).

Figure 15 shows that the primary focus remains on MNPs, although studies focusing on Metals/Metal Oxides are comparatively more abundant. However, this representation may be distorted, as performing the Articles DB assessment it clearly emerged that the majority of articles resulting from the queries for Metals/Metal Oxides focused on different research areas that were not relevant for the One Health approach that was at the heart of our selection criteria.

Conclusions

This bibliometric study provides a comprehensive overview of the current research landscape on micro- and nano-scale material particles, from the standpoint of the potential impact on health. In particular, this bibliometric work highlighted the relations among the different research domains and supported the definition of a set of meaningful sub-thematics and methodologies that are commonly used in the field. MNPs dominate the current research focus, suggesting that they have become a central area of concern, driven by a growing recognition of their health implications beyond their known environmental ubiquity. The VOSviewer analysis further reinforces the interconnectedness of Environment, Food, and Health, demonstrating the relevance of the One Health approach.

A significant observation is the difference in the number of articles addressing micro- versus nano-scale research. Studies at the micro-scale dominate the current literature; however, in the Health domain there is considerable emphasis on the potential risks of nanoparticles. Metabolomics is the only sub-thematic that is used more at the nano-scale than at the micro-scale; epidemiological and toxicological studies are also experiencing a substantial shift in this direction. In the Environment domain, the impact of artificial materials on microorganisms, with a good attention to relevance of nano-scale materials, and on marine species has garnered significant attention. On the other hand, the analysis of the articles in the Methods category highlighted the absence of standardized approaches for the detection, characterization, and risk assessment of artificial materials, particularly at the nano-scale. This represents a critical bottleneck since it hampers the comparability and reproducibility of studies across various research contexts, thereby hindering the development of effective regulatory frameworks and risk management strategies.

Finally, this analysis also reveals aspects about the usage of technologies. We found that Microscopy techniques are widely used, whereas other approaches have a marginal utilization, such as Magnetic Resonance techniques, which, according to our results, have been employed in only 2% of studies. It is quite likely that this gap can be ascribed, at least in part, to the steep cost and difficulty of maintenance of specialized instruments. This makes them often inaccessible in public research laboratories. Research Infrastructures have a key role in promoting and enhancing the usage of cutting-edge instrumentation. Furthermore, collaborative efforts between RIs on technological aspects might lead to the development of innovative equipment and novel protocols beneficial to the entire community of current and potential new users engaged in the study of micro- and nano-scale material particles.

Ethical approval and consent

Ethical approval and consent were not required for this study.

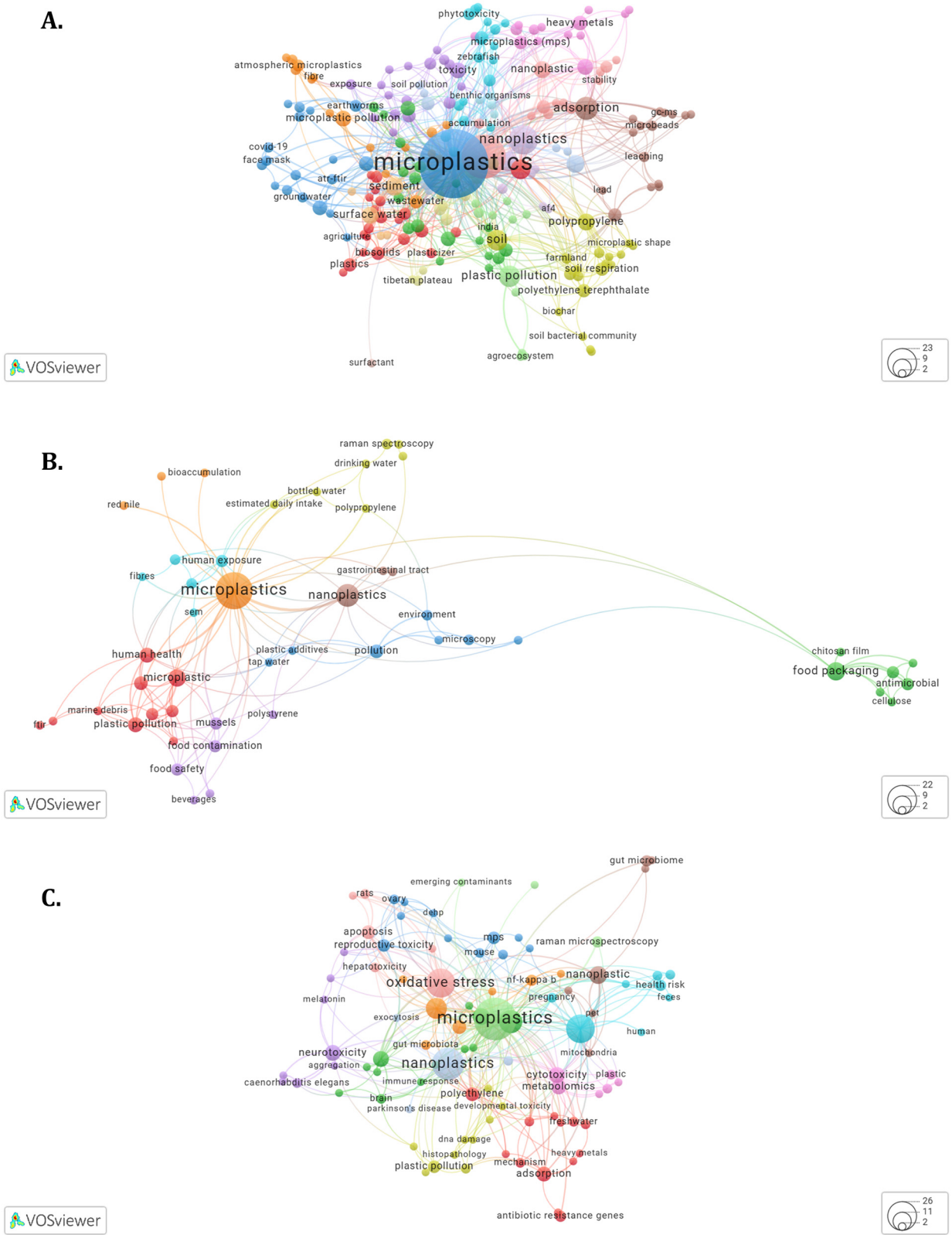

Figure 13. Maps obtained through VOSviewer from WoS Author Keywords. Nodes represent keywords (with size reflecting frequency) and the thickness of the edges indicates the strength of co-occurrence. (**A**). Environment (VOS interactive map); (**B**) Food (VOS interactive map) and (**C**) Health (VOS interactive map).

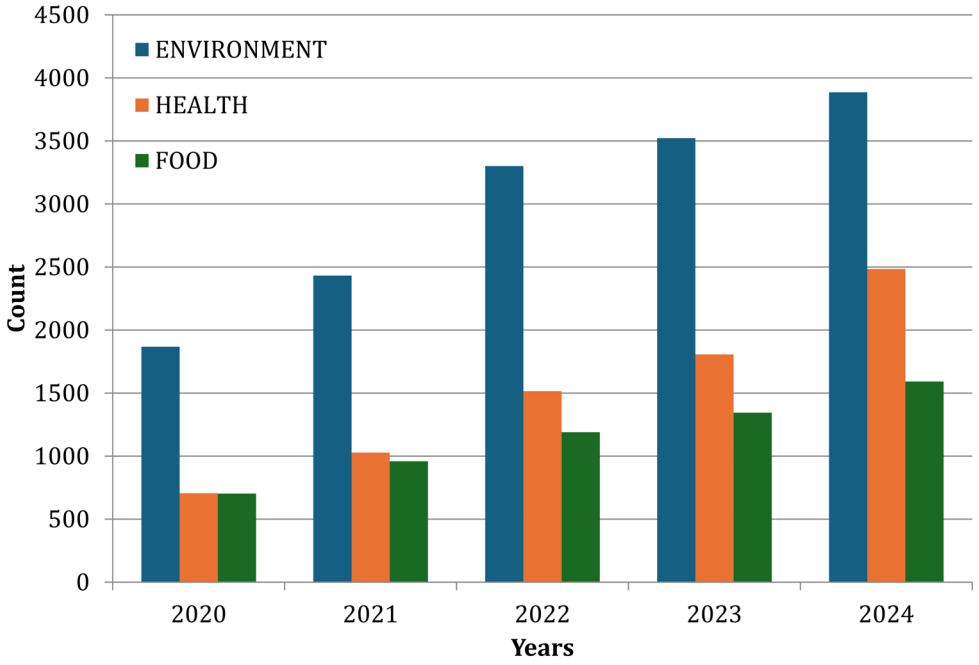

Figure 14. Overview of Research Trends from Initial WoS Screening. Trends derived from WoS analysis of the 28.341 entries from the screening 1 step. For details on the queries used, refer to the supplementary information.

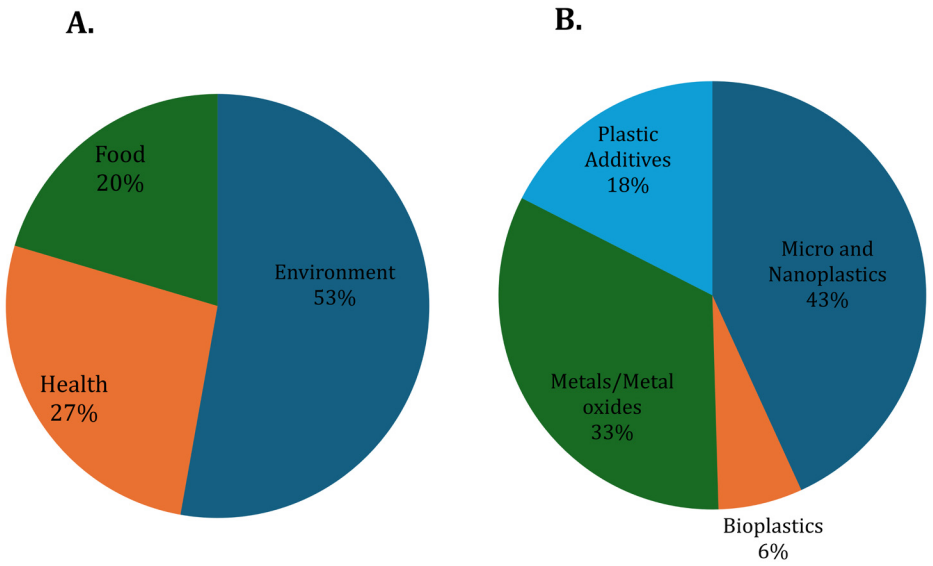

Figure 15. WoS-Derived Trends. Trends derived from WoS analysis of the 56.021 entries from the screening 1 step. (**A**) Domains; (**B**) Selected topics. For details on the queries used, refer to the supplementary information.

Data availability

The datasets generated and analyzed during the current study (Persistent Identifier: 10.5281/zenodo.15369627) and the full query history used in the Web of Science™ (Persistent Identifier: 10.5281/zenodo.15370363) are available in the Zenodo repository. These datasets support the results and analyses reported in this article.

Underlying data

Repository name: [Zenodo]. https://doi.org/10.5281/zenodo.15369627[49]

The project contains the following underlying data:

[From Environment to Health: A One Health Landscape of Research on Selected Artificial Materials - Articles DB] The raw data

Data are available under the terms of the Creative Commons Zero "No rights reserved" data waiver (CC0 1.0 Public domain dedication).

Extended data

Repository name: [Zenodo]. https://doi.org/10.5281/zenodo.15370363[50]

This project contains the following extended data:

Supplementary Material. The full query history used in the Web of Science™

Data are available under the terms of the Creative Commons Zero "No rights reserved" data waiver (CC0 1.0 Public domain dedication).

Acknowledgments

The authors acknowledge the project partners and external experts whose discussions and feedback contributed indirectly to the conceptual foundation of this article.

We thank Dr. Laurens DB Mandemaker for his suggestions on the optimal use of Web of Science™.

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http://www.doi.org/10.5281/zenodo.15370363

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Reviewer Report 09 October 2025

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?

Yoorae Noh
Michigan State University, East Lansing, Michigan, USA

This paper presents a bibliometric map of research trends linking micro/nanoplastics, bioplastics, plastic additives, and metal oxides to human, animal, and ecosystem health within the framework of a One Health framework.

By quantifying publication growth rates, key academic disciplines, key author networks, and regional contributions, it identifies key research areas in materials science, toxicology, and environmental monitoring.

This study highlights imbalances in topical connectivity and identifies gaps for future interdisciplinary integration.

This study synthesized a vast amount of literature to uncover macroscopic trends from a One Health perspective, highlighting the potential for easier identification of broad research directions and gaps.

The authors demonstrated reproducibility and reliability by clearly presenting the bibliometric approach (databases used, inclusion criteria, and keyword strategy).

However, the authors should reexamine the following specific points:

1) Some target substances (particularly microplastics) have recently received significant attention, leading to numerous experimental and review papers. The methodology used in this study may have underestimated important recent research and trends.

2) The justification and relationships among target substances were weak. The manuscript even primarily focused on "microplastics." With the wide target materials and topics, some topics were discussed only superficially, lacking in-depth mechanistic or empirical insights. For example, differences in terminology across disciplines (e.g., "microplastic pollution" versus "plastic debris") or differences in publication language may have led to the omission of relevant studies. The

authors acknowledge this as a limitation, but it is difficult to quantify its impact on the results.

3) The study treats bibliometric "hotspots" as indicators of research interest, not as evidence of scientific significance or risk. It seems that a high publication volume implies high biological or ecological significance, and this leap could make it difficult to provide stakeholders and policymakers with clear information for research funding and policymaking.

4) Sensitivity analyses could be performed to assess the robustness of network and clustering algorithms. When using co-citation, co-authorship networks, or topic clustering, parameter settings can significantly impact the results. Sensitivity analyses will help determine whether identified "hotspots" are stable or are artifacts of the method settings.

Overall, this manuscript is significant in that it provides a map of how research on specific materials is distributed across the intersections of environment, food, and health, thereby fostering the integration of disparate research nodes. However, its reliance on bibliometric methods may obscure the significance of the research, rather than simply identifying the research subject. This study could be further strengthened by incorporating additional qualitative analysis, sensitivity testing, and critical discussion of research infrastructure biases for the targeted audience.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and does the work have academic merit?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Plastic Packaging, Emerging contaminants, Micro- and Nanoplastics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 10 July 2025

https://doi.org/10.21956/openreseurope.21904.r54792

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Mingming Han
University Sains Malaysia, Penang, Malaysia

Reviewer Comment:
This manuscript presents a timely and comprehensive bibliometric analysis of recent (2020–2024) literature on micro- and nano-scale artificial materials including micro- and nanoplastics (MNPs), bioplastics, plastic additives, and metals/metal oxides framed through the One Health perspective. The study offers a valuable overview of publication trends, analytical techniques, and emerging research themes. However, several areas require refinement to enhance the analytical rigor, conceptual clarity, and policy relevance of the work.

1. Justification of Material Categories:
The rationale for selecting the four material categories MNPs, bioplastics, additives, and metals/metal oxides needs further elaboration. As presented, the manuscript appears disproportionately focused on MNPs, particularly polymers of various types (e.g., PS, PET, bioplastics), rather than offering a balanced comparative analysis across all four categories. The authors are encouraged to justify the inclusion and prioritization of these materials by referencing metrics such as environmental prevalence, human exposure potential, or regulatory significance, to reinforce the scientific foundation of the review.

2. Need for Deeper Analytical Engagement:
While the manuscript provides a solid synthesis of observable trends, it lacks a critical analysis of their broader implications. For instance, the dominance of micro-scale studies is noted but not interrogated in terms of its methodological origins (e.g., ease of detection) or its potential to bias future research and policy agendas. A more reflective discussion on the drivers and consequences of such imbalances would substantially deepen the manuscript's analytical dimension.

3. Balance Across Material Types:
The discussion is currently skewed toward MNPs, with insufficient attention given to bioplastics, additives, and metal/metal oxides. Either a more balanced treatment or a well-supported justification for the existing focus would enhance the manuscript's comprehensiveness and fairness in representing the field.

4. Recommendations and Standardization:
The recommendations provided are constructive but overly broad. Prioritizing them such as distinguishing between short-term and long-term actions would enhance their utility for researchers and policymakers. Additionally, while the need for methodological standardization is emphasized, the manuscript would benefit from proposing specific harmonization targets (e.g., size detection thresholds, toxicity markers, or analytical protocols). Given the framing of the study within the One Health paradigm, the manuscript should engage more explicitly with policy implications. Currently, the findings are not clearly connected to regulatory contexts such as EU research funding strategies, environmental legislation, or cross-sectoral risk assessment frameworks. Strengthening this linkage would increase the manuscript's translational value and

relevance to stakeholders.

5. Granularity of Data Interpretation:

The analysis could benefit from more granular interpretation of bibliometric data. For example, identifying leading institutions, regional trends, or emerging interdisciplinary linkages would provide greater insight into the evolving research landscape.

Conclusion:

In summary, while the manuscript addresses an important and emerging area of research, revisions are needed to improve balance, analytical depth, and relevance. With improvements in analytical depth, category justification, and policy integration, the manuscript could make an even more impactful contribution to the literature.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and does the work have academic merit?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Micro- and nano plastics, Environmental risk assessment, Bibliometric analysis, Policy relevance, Environmental pollutants

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.