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# Microplastics in Terrestrial Ecosystems: A Scientometric Analysis

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**Abstract:** Microplastics, as an emerging contaminant, have been shown to threaten the sustainability of ecosystems, and there is also concern about human exposure, as microplastic particles tend to bioaccumulate and biomagnify through the food chain. While microplastics in marine environments have been extensively studied, research on microplastics in terrestrial ecosystems is just starting to gain momentum. In this paper, we used scientometric analysis to understand the current status of microplastic research in terrestrial systems. The global scientific literature on microplastics in terrestrial ecosystems, based on data from the Web of Science between 1986 and 2020, was explored with the VOSviewer scientometric software. Co-occurrence visualization maps and citation analysis were used to identify the relationship among keywords, authors, organizations, countries, and journals focusing on the issues of terrestrial microplastics. The results show that research on microplastics in terrestrial systems just started in the past few years but is increasing rapidly. *Science of the Total Environment* ranks first among the journals publishing papers on terrestrial microplastics. In addition, we also highlighted the desire to establish standards/protocols for extracting and quantifying microplastics in soils. Future studies are recommended to fill the knowledge gaps on the abundance, distribution, ecological and economic effects, and toxicity of microplastics.

**Keywords:** plastic pollution; soil; publication trends; coauthorship; co-occurrence; bibliometric analysis

## 1. Introduction

Over 426 million metric tons (Mt) of plastic products were produced globally in 2018, including 359 Mt of resins, according to PlasticsEurope, and 67 Mt of synthetic fibers, according to *The Fiber Year*. Plastic production is expected to continue growing in future to meet the improving living standards of the world's population [1,2]. However, ~85% of these plastics are not recycled and enter the environment (i.e., ocean and terrestrial ecosystems) [3,4]. Plastics smaller than 5 mm are defined as microplastics [5], and their existence in the marine ecosystem was first reported in the early 1970s [6,7]. Small microplastics have become a big issue drawing global concern [8]. Because they adsorb pollutants or other chemical substances on their surface, microplastics can also be ingested by biota and accumulate in the food chain [8–12]. This is in addition to direct human exposure to microplastic-contaminated air, table salt, and drinking water [13–15]. Microplastics are also toxic to other organisms, including animals and plants, and threaten global biodiversity [16,17]. Great efforts have been devoted to studying their occurrence, adverse ecological effects, and toxicity in the marine ecosystem and coastal environment or on shorelines [18–25].

In contrast, microplastics and nanoplastics in terrestrial ecosystems are, surprisingly, less studied than marine microplastics, although "white pollution" (i.e., plastic film mulch residue that is not readily degradable) in soils, resulting from excessive use of plastic film mulch and a low recycling rate, is nothing new [9,26–33]. Unlike the straightforward methods for microplastic studies in water, it is challenging to extract and quantify microplastics from the complex organo-mineral soil matrix [9,34–37]. Other reasons why microplastics in terrestrial ecosystems are studied less may include a shortage of available test species and large variations in microplastic contamination, depending on the sites [27,38]. Similar to marine ecosystems, microplastics in terrestrial ecosystems are categorized into primary and secondary microplastics. Primary microplastics are produced for industrial abrasives and domestic applications, including plastic particles used in cosmetic products such as eye shadow, makeup foundation, facial cleansers, and toothpaste [10,39,40]. Fibers derived from laundry are another major source of primary microplastic contaminants in soil [41–43]. These microplastics may pass through the treatment plant and enter the environment [44]. The treated wastewater may be reused for irrigation [45], and the sewage sludge may be applied to agricultural soils [46–50]. Secondary plastics are associated with the breakdown of larger plastic debris into small particles over time, e.g., the application of plastic film mulching in agriculture and the associated breakdown of plastic debris [51]. Microplastics in the terrestrial ecosystem can be transferred to the ocean through river systems and threaten marine environments. To reduce the potential economic impacts of plastic pollution, the European Union has taken the initiative to ban single-use plastics and to recycle a minimum 55% of plastic packaging by 2030. The USA has banned plastic microspheres and is introducing new requirements for plastic recycling [52], while China has launched nationwide programs to monitor plastic film debris in agricultural soils and to promote the use of biodegradable polymer membrane (BPM) to replace plastic film mulching [53]. The application of BPM in agriculture has also been reported in the US and Australia [51,53,54].

There are a few reviews focusing on the various aspects of microplastics in the terrestrial ecosystem and soils, including sources, potential ecological and economic impacts, and future perspectives [10,27,44,55]. However, there is a lack of comprehensive studies on microplastics in the terrestrial ecosystem. Scientometric analysis (also referred to as science mapping or bibliometric analysis) is a useful tool to quantitatively assess the status, development, trends, and patterns of literature [56] and provide future perspectives for a variety of specific fields of science, including earth and environmental science [57,58]. This approach has been applied to give insights on agricultural water use efficiency [59], organic agriculture/farming [60,61], biochar applications [62,63], land degradation [64–66], soil pollution [67–70], soil remediation [71,72], and soil health [73]. A previous study on a similar topic analyzed issues of microplastics in the marine ecosystem with scientometric analysis [18], but no such report was found to look into the issues of microplastics in the terrestrial ecosystem, including freshwater bodies.

The objective of this study was therefore to explore the global scientific literature on microplastics in the terrestrial ecosystem based on scientometric analysis in order to track its evolution and trends. It was hoped that this study would provide information to the novice and expert alike to guide them in the study of microplastics in the terrestrial ecosystem.

## 2. Scientometric Data and Methods

Publications on microplastics in the terrestrial ecosystem used in this study were retrieved from the Web of Science Core Collection (WOSCC) on 3 October 2020. The WOSCC database consists of data beginning from publication year 1985. The query sets used for publication search are based on "topic" (TS) and "year published" (PY): TS = ((nanoplastic* OR microplastic*) AND (terrestrial ecosystem OR terrestrial system OR agroecosystem OR soil ecosystem OR soil OR land OR inland OR earthworm* OR plant*)) AND PY = (1985–2020). Only the following document types were retained for analysis: article, book, book chapter, data paper, database, note, review, and letter. The results were then downloaded and saved as a "Tab-delimited (Win)" file containing "Full Record and Cited References". This file was used for co-occurrence (e.g., density map of keywords and network maps of authors, organizations, and countries) and citation analysis (e.g., network map of scientific journals).

The cluster-based VOSviewer (version 1.6.15, https://www.vosviewer.com/) [56] was used to perform the analysis. This software enables the user to create, visualize, and explore scientific mapping in cluster format based on scientometric network data. A full counting method was used such that each coauthorship and co-occurrence had the same weight regardless of the order and number of the author in the coauthor list. Publications with 25 coauthors/countries or more were excluded from analysis by default, but no such case was found in this study. The co-occurrence analysis determined the relatedness of items (e.g., publications, researchers, keywords, and authors of interest) based on the number of publications they occurred in together. The coauthorship analysis determined the relatedness of items based on their number of coauthored publications. The citation analysis determined the relatedness of items based on the number of times they cited each other. In addition, the number of papers on terrestrial microplastics published each year was assessed. The cluster network or density visualization maps were produced by the VOSviewer (with the VOSviewer mark at the bottom left corner), and the other figures were developed with OriginPro 2017. "Link" indicates relation/connection between two items, "link strength" indicates the attribute of each link that is expressed with a positive numerical value, "network" indicates a set of items connected by their links, and "cluster" indicates sets of items included in a network map where one item can belong to only one cluster.

## 3. Results and Discussion

### *3.1. Annual Publication Trend*

The search returned a total of 877 publications pertaining to microplastics in the terrestrial ecosystem. The publications can be mainly divided into environmental science (number of publications (N= 679), environmental engineering (N = 162), marine freshwater biology (N = 106), water resources (N = 80), and multidisciplinary science (N = 36), according to the Web of Science categories. It was noted that one publication or journal may belong to two or more categories, and the sum of papers in different categories was greater than the actual number of papers. The number of publications on terrestrial microplastics was small compared with the 2882 publications that were focused on microplastics in the marine ecosystem, which was searched with query sets of "TS = ((microplastic* OR nanoplastic*) AND (marine OR ocean OR sea)) AND PY = (1985–2020)" in the WOSCC following an approach similar to that of Pauna et al. [18].

Publications on microplastics in both marine and terrestrial ecosystems have increased rapidly since 2009, but studies on the terrestrial ecosystem took longer to come out than those on the marine ecosystem (Figure 1). It is noteworthy that the 2012 publication on microplastics in the terrestrial ecosystem written by Rillig [9] started a wave of study on microplastics in terrestrial ecosystems. The number increased exponentially thereafter to 155 papers in 2019, and there were already 366 papers as of 3 October 2020 (Figure 1). This indicates that terrestrial microplastics have become a hot topic, attracting growing attention. It is expected that publications on this topic will increase remarkably in the near future.

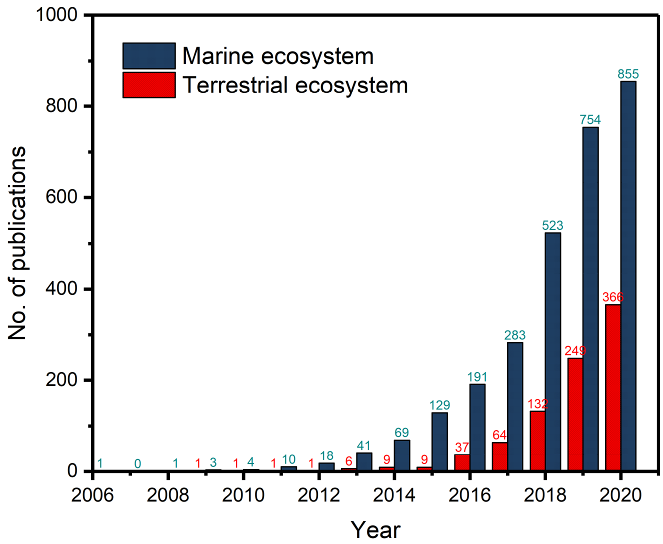
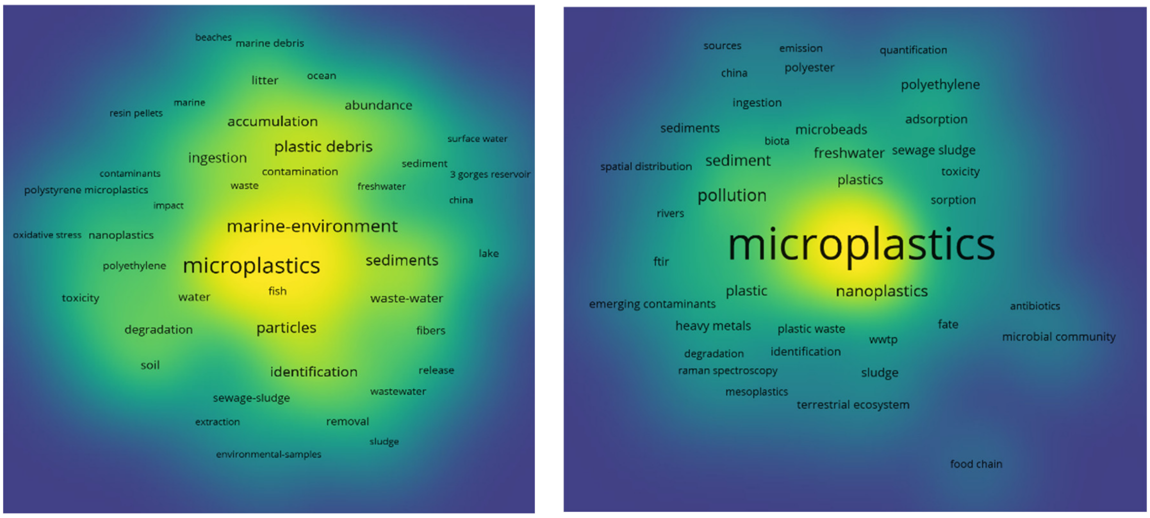



**Figure 1.** Annual publication trend of research on microplastics in the marine ecosystem (blue) and terrestrial ecosystem (red). In total, 2882 and 877 publications were distributed from 1998 to 2020 from the Web of Science Core Collection (WOSCC) database for marine and terrestrial ecosystems, respectively.

### *3.2. Co-occurrence Analysis of Keywords*

The analysis of co-occurrence of all keywords (in title, abstract, or keyword list) generated 3509 results, and 77 were selected based on the threshold of 20 co-occurrences (Figure 2a), while 2122 results were generated for author-provided keywords, and 99 met the threshold of five occurrences (Figure 2b), according to outputs generated by the VOSviewer based on the WOSCC data. The two scenarios were used to show that researchers usually highlighted the differences in the research status of microplastics in marine and terrestrial ecosystems as research rationale/background. Therefore, they demonstrated different occurrences and total link strength of keywords, such that terms often associated with marine microplastics like “fish”, “marine-environment”, “ingestion”, “sea”, “marine”, “ocean”, and “accumulation” were shown in Figure 2a, but did not appear in Figure 2b.

It was not surprising to note that “microplastics” was the keyword with the strongest total link strength (TLS) for both scenarios, as indicated by its yellow color and larger font size. Only the top five terms in titles, abstracts, and keyword lists and author-provided keyword lists were tabulated (Table 1). The proximity of keywords indicated their relatedness; the further they were from “microplastics”, the more distant the relationship or the less they were studied. For instance, microplastics in “food chain” and “sediments” and “microbial community” were less studied (Figure 2b) [74,75]. Another example was “sludge” and “sewage sludge”, which were closely related to microplastics in the “agroecosystem” (Figure 2b) [76]. Figure 2b also reveals that microplastics may associate or interact with other pollutants such as heavy metals and antibiotics [77–79]. Figure 2b also shows that current studies on microplastics in the terrestrial ecosystem focused on their sources (e.g., polyethylene, polyester, microbeads, plastic waste, sewage sludge, sludge), distribution and impact (freshwater, rivers, sediments, microbial community, degradation), transport and fate (e.g., fate, food chain, biota, ingestion, sorption, antibiotics, heavy metals), and analysis (e.g., Raman spectroscopy, Fourier transform infrared—FTIR, quantification, and identification).




(**a**) (**b**)

**Figure 2.** Density visualization of keywords co-occurrence in (**a**) title, abstract, and keyword list with minimum 20 occurrences in all 877 publications included in the Web of Science Core Collection (WOSCC) and (**b**) in keyword list provided by the authors with five occurrences. Note: The number of co-occurrences of $n$ keywords indicates the number of publications in which all $n$ keywords occur together. Font size and density (background color) of keywords are used to represent the total link strength (TLS). Greater font size indicates greater TLS, and TLS of yellow > green > blue. The distances between each of the keywords indicate the relatedness of these research topics. The top ten keywords, their occurrences, and their TLS are shown in Table 1. Links (L) and the total link strength (TLS) indicate the number of links of an item with other items and the total strength of the links of an item with other items, respectively.

**Table 1.** Occurrences and total link strength (TLS) of top ten keywords in title/abstract/keyword list with 20-occurrence threshold and in author-provided keywords with 5-occurrence threshold.

| No. | Keyword | Occurrences | TLS |
|---|---|---|---|
| | In title/abstract/keyword list | | |
| 1 | microplastics | 467 | 2467 |
| 2 | pollution | 314 | 1987 |
| 3 | marine environment | 277 | 1768 |
| 4 | plastic debris | 193 | 1240 |
| 5 | sediments | 182 | 1228 |
| 6 | particles | 163 | 1100 |
| 7 | accumulation | 147 | 996 |
| 8 | identification | 136 | 952 |
| 9 | ingestion | 121 | 799 |
| 10 | microplastic | 117 | 709 |
| | In author-provided keywords | | |
| 1 | microplastics | 333 | 446 |
| 2 | microplastic | 117 | 174 |
| 3 | soil | 40 | 78 |
| 4 | pollution | 37 | 77 |
| 5 | wastewater | 34 | 75 |
| 6 | plastic pollution | 38 | 67 |
| 7 | marine debris | 28 | 64 |
| 8 | freshwater | 24 | 57 |
| 9 | nanoplastics | 32 | 57 |
| 10 | sediment | 26 | 56 |

Initially, the study on microplastics in the terrestrial ecosystem concentrated on its source and occurrence [48,80–83]; the transport and fate in soils [84,85] and the soil–plant system [86,87]; and the test, verification, and development of analytical methods [88–90]. However, there is still a lack of analytical protocol and monitoring data on the occurrence, abundance, and distribution of microplastics in the terrestrial ecosystem under various climatic environments [26,29]. In addition, more studies should be conducted to investigate the occurrence, risk and toxicity, interactions, transport, and fate of microplastics in the terrestrial ecosystem [91,92]. Studies pertaining to the effects of microplastics are emerging for soil physical properties [92], soil macrofauna (e.g., snail and earthworms) and microbiota [93–96], plant growth [1,97], and toxicity to animal and human beings [98,99].

### 3.3. Citation Network of Authors, Countries and Organizations

A total of 3529 authors contributed to the 877 publications (Figure 3), and 44 authors published a minimum of five documents. They were composed of four clusters (i.e., four colored groups or four groups of authors that worked closely) with a total of 3484 links. The resulting citation network map reveals a high contribution from environmental scientists based on their number of publications (N), links (L), total link strength (TLS), and citations (C) as shown in Table 2. The top ten contributing authors are listed in Table 2, and they generally published eight or more papers in this field. It is noteworthy that Geissen, Huerta Lwanga, and Yang worked or studied in Wageningen University and Research and used polystyrene microbeads, which are now called "microplastics", as model colloids. It should also be noted that eminent researchers from soil physics, such as Keith Bristow, Markus Flury, and Violette Geissen have focused on the transport and fate of microplastics in agroecosystems [51]. However, there is still a call for more input in this field, and the involvement of researchers from multiple disciplines is encouraged to solve the microplastic issues in the terrestrial system with interdisciplinary collaborations [18].

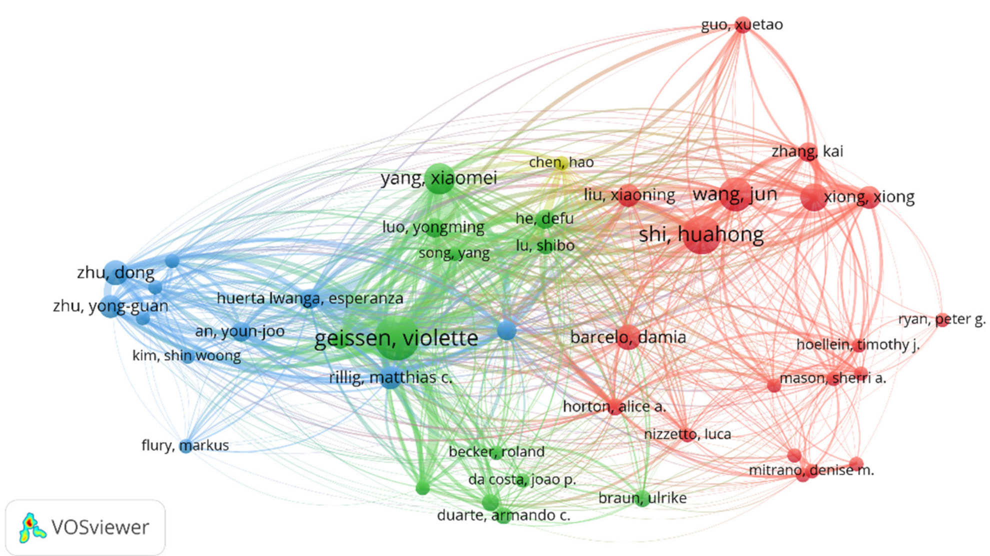



**Figure 3.** Citation network map of authors with a threshold of 5 documents per author and maximum 25 authors per publication. Researchers in the coauthorship network are linked to each other based on the number of publications they have authored jointly.

**Table 2.** Top ten authors, countries, organizations, and journals focusing on publications on terrestrial microplastics with indices of number of publications (N), links (L, the number of collaborations or lines between investigated author/country/organization/journal and others), total link strength (TLS), and citations (C). A threshold of five documents was used.

| No. | Authors | N | L | TLS | C |
|---|---|---|---|---|---|
| | Top 10 authors | | | | |
| 1 | Geissen, Violette | 16 | 39 | 591 | 906 |
| 2 | Shi, Huahong | 14 | 41 | 273 | 381 |
| 3 | Wang, Jun | 12 | 35 | 218 | 382 |
| 4 | Yang, Xiaomei | 11 | 37 | 313 | 307 |
| 5 | Wu, Chenxi | 10 | 36 | 195 | 465 |
| 6 | Zhu, Dong | 9 | 32 | 190 | 222 |
| 7 | Barcelo, Damia | 9 | 30 | 108 | 95 |
| 8 | Rillig, Matthias C. | 8 | 41 | 264 | 432 |
| 9 | Xiong, Xiong | 8 | 33 | 171 | 422 |
| 10 | Zhu, Yongguan | 8 | 32 | 159 | 194 |
| | Top 10 organizations | | | | |
| 1 | Chinese Academy of Science (CAS, China) | 59 | 61 | 1236 | 1566 |
| 2 | University of CAS (China) | 37 | 60 | 895 | 1374 |
| 3 | East China Normal University (China) | 22 | 58 | 487 | 576 |
| 4 | Wageningen University and Research (Netherlands) | 20 | 61 | 596 | 771 |
| 5 | Tongji University (China) | 15 | 54 | 327 | 301 |
| 6 | Nanjing University (China) | 13 | 55 | 255 | 225 |
| 7 | Northwest A&F University (China) | 12 | 48 | 275 | 198 |
| 8 | University of Aveiro (Portugal) | 12 | 53 | 225 | 292 |
| 9 | Tsinghua University (China) | 11 | 48 | 223 | 66 |
| 10 | Peking University (China) | 11 | 52 | 176 | 83 |
| | Top 10 countries | | | | |
| 1 | China | 271 | 39 | 5565 | 4316 |
| 2 | USA | 137 | 39 | 3819 | 5893 |
| 3 | Germany | 95 | 39 | 2845 | 3497 |
| 4 | Australia | 68 | 39 | 1886 | 1483 |
| 5 | England | 65 | 39 | 2071 | 3191 |
| 6 | Italy | 57 | 39 | 826 | 811 |
| 7 | Netherlands | 53 | 39 | 2593 | 3111 |
| 8 | Spain | 50 | 39 | 1163 | 808 |
| 9 | Canada | 30 | 39 | 859 | 1437 |
| 10 | South Korea | 30 | 37 | 724 | 454 |
| | Top 10 journals | | | | |
| 1 | *Science of the Total Environment* | 151 | 22 | 2155 | 3639 |
| 2 | *Environmental Pollution* | 111 | 23 | 1644 | 3150 |
| 3 | *Marine Pollution Bulletin* | 76 | 23 | 1056 | 3508 |
| 4 | *Environmental Science and Technology* | 55 | 23 | 1392 | 3235 |
| 5 | *Water Research* | 42 | 23 | 1315 | 2808 |
| 6 | *Chemosphere* | 40 | 19 | 519 | 682 |
| 7 | *Environmental Science and Pollution Research* | 39 | 22 | 540 | 297 |
| 8 | *Journal of Hazardous Materials* | 21 | 14 | 223 | 112 |
| 9 | *Ecotoxicology and Environmental Safety* | 10 | 13 | 164 | 82 |
| 10 | *Scientific Reports* | 10 | 10 | 202 | 517 |

A total of 3529 authors were from 1147 organizations; of these, 63 organizations met the threshold of having a minimum of five publications. The top 10 organizations contributed 11 publications or more on this theme (Table 2). It is interesting to note that 8 of the top 10 organizations are from China, which may indicate that China has invested more and more in sustainable environment [100]. In addition, the Chinese Academy of Science (CAS) and the University of Chinese Academy of Science (University of CAS) have close collaborations because the graduate students belongs to the University of CAS, while their supervisors are affiliated with the CAS and some of them may teach in the University of CAS as well (Table 2).

There were 40 out of 77 countries that published a minimum of five publications on microplastics in terrestrial ecosystems. These countries were grouped into four clusters (Figure 4), where China, the USA, and Mexico had the strongest collaborative relationship based on their joint publications and the proximity of their nodes.

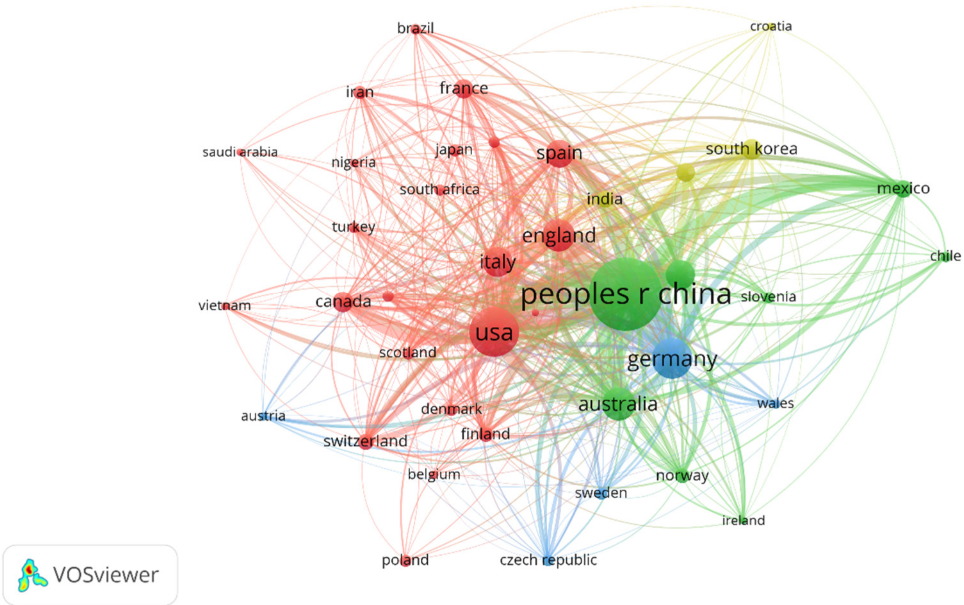



**Figure 4.** Citation network map of countries with a threshold of a minimum of 5 publications and a maximum of 25 countries per publication. Countries in the coauthorship network are linked to each other based on the number of publications they have authored jointly.

### *3.4. Most Used Journals and Citation Network of Journals*

There were 24 out of 178 journals with publications on terrestrial microplastics that met the threshold of a minimum of five publications (Figure 5). Science of the Total Environment, Environmental Pollution, Environmental Science and Technology, and Water Research and Marine Pollution Bulletin have the strongest citation relationship, as they belong to the same cluster and as evidenced by the thick link between them. Publications with these journals are also highly cited, with over 2800 total citations (Table 2).

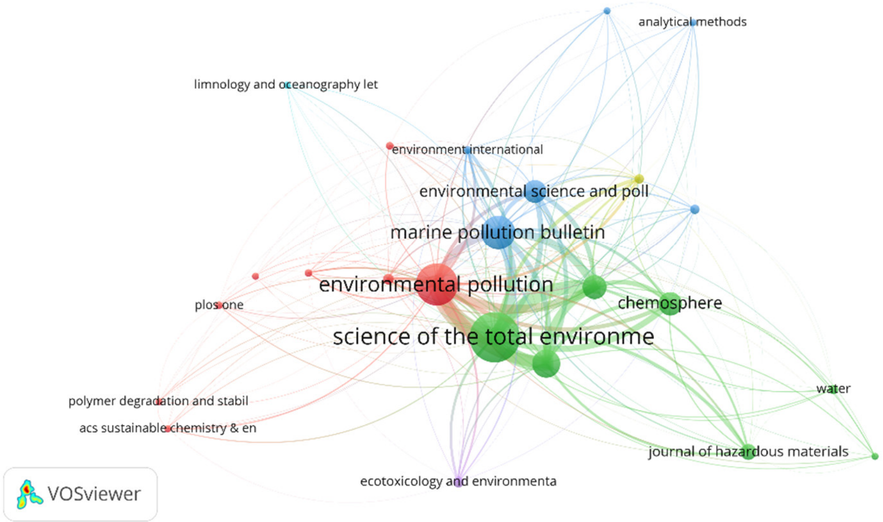



**Figure 5.** Citation network of journals with a threshold of a minimum of five publications.

### 3.5. Citation Network of Highly Cited Papers

The number of citations of the 877 publications range from 0 to over 1250 times based on the WOSCC database as of 3 October 2020. Of the 877 publications, 68 were cited over 100 times, and the citation network is shown in Figure 6. The bigger the circle of a paper, the more times it was cited. The most cited paper was that of Geyer et al. [2], which described the production, use, and end-of-life fate of plastics produced on a global scale and had 1255 citations; it was followed by a paper by Eerkes-Medrano et al. [101] that reviewed microplastics in freshwater systems and had 588 citations. Many of the other highly cited papers (e.g., with between 300 and 500 citations) generally pertain to microplastics in freshwater [29,102–105]. Rillig's seminal paper [9] that initiated the study of microplastics in terrestrial ecosystems is a perspective paper that is not included in the database but is also highly cited (>400 citations). Rillig and Lehmann [5] highlighted the shifts in microplastic studies from ecotoxicology to ecosystem effects and feedbacks, including effects on soil properties [92,106] and soil biota [107,108].

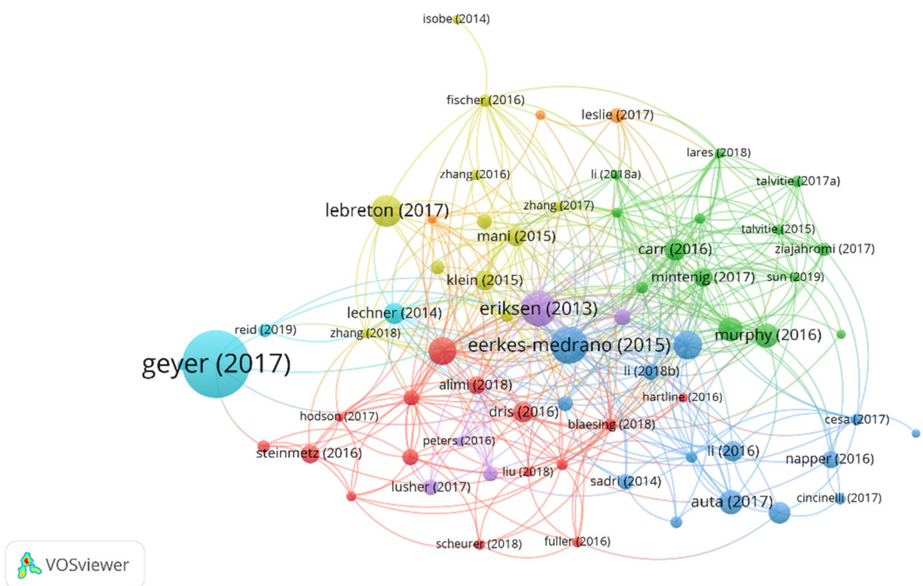



**Figure 6.** Citation network of 68 publications with total citations greater than or equal to 100.

## 4. Conclusions and Perspectives for Future Studies

The global scientific literature on microplastics in the terrestrial ecosystem was explored with scientometric software (i.e., VOSviewer), based on data from the Web of Science Core Collection. The small number of publications (N = 877) and considerable increase in the number of annual publications indicate that this is an emerging research field. It is drawing growing attention, and more publications on this topic are expected in the coming years. This study identified the top authors, organizations, countries, and journals focusing on terrestrial microplastics. The most influential publications on this topic were also analyzed through the citation network of papers. The scientometric method provided a useful tool for conducting comprehensive reviews.

Compared to the marine ecosystem, issues of microplastics in terrestrial ecosystems and soils are usually ignored, given the fact that they might be the main source for plastics emissions to rivers and oceans [38,102,109]. Considering the low recycling rates (i.e., ~15%) for plastic products, disseminating recycling technology and improving the demand for recycled plastics are the keys to reducing the source of microplastics entering the environment. There is a desire to develop reliable equipment and to establish standards/protocols for extracting and quantifying microplastics in soils [38]. Researchers with an interdisciplinary background are encouraged to work on terrestrial microplastics. For instance, accurate, sensitive, cost effective, and harmonized detecting methods and high-throughput sample processing are required for a better understanding of the transport, fate, and transformation of microplastics in soils. Future research should address the knowledge gap on the abundance, distribution, magnitude of ecological and economic effects, and toxicity of microplastics in drylands, deserts, grasslands, forests, and tundra, in addition to the agricultural system and freshwater, which receive the most attention. Furthermore, stricter measures should be adopted to control the use of plastic products. Although biodegradable polymers are assumed to be an alternative in agriculture, their risk should also be assessed, considering the difficulties in removing the plastic waste from soils. Moreover, studies are currently mostly laboratory-based. Studies that investigate microplastics in a natural environment, with and without controlled conditions, are needed. International cooperation in microplastic research is needed, as microplastic pollution is an international problem of mounting concern.

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## References

1. National Academies of Sciences Engineering Medicine. *Closing the Loop on the Plastics Dilemma: Proceedings of a Workshop–In Brief*; The National Academies Press: Washington, DC, USA, 2020; p. 14.
2. Geyer, R.; Jambeck, J.R.; Law, K.L. Production, use, and fate of all plastics ever made. *Sci. Adv.* **2017**, *3*, e1700782, doi:10.1126/sciadv.1700782.
3. Moore, C.J. Synthetic polymers in the marine environment: A rapidly increasing, long-term threat. *Environ. Res.* **2008**, *108*, 131–139, doi:10.1016/j.envres.2008.07.025.
4. North, E.J.; Halden, R.U. Plastics and environmental health: The road ahead. *Rev. Environ. Health* **2013**, *28*, 1–8, doi:10.1515/reveh-2012-0030.

5. Rillig, M.C.; Lehmann, A. Microplastic in terrestrial ecosystems. *Science* **2020**, *368*, 1430–1431, doi:10.1126/science.abb5979.
6. Carpenter, E.J.; Smith, K.L. Plastics on the sargasso sea surface. *Science* **1972**, *175*, 1240–1241, doi:10.1126/SCIENCE.175.4027.1240.
7. Carpenter, E.J.; Anderson, S.J.; Harvey, G.R.; Miklas, H.P.; Peck, B.B. Polystyrene spherules in coastal waters. *Science* **1972**, *178*, 749–750, doi:10.1126/SCIENCE.178.4062.749.
8. Wright, S.L.; Kelly, F.J. Plastic and human health: A micro issue? *Environ. Sci. Technol.* **2017**, *51*, 6634–6647, doi:10.1021/acs.est.7b00423.
9. Rillig, M.C. Microplastic in terrestrial ecosystems and the soil. *Environ. Sci. Technol.* **2012**, *46*, 6453–6454, doi:10.1021/ES302011R.
10. Duis, K.; Coors, A. Microplastics in the aquatic and terrestrial environment: Sources (with a specific focus on personal care products), fate and effects. *Environ. Sci. Eur.* **2016**, *28*, 2, doi:10.1186/s12302-015-0069-y.
11. Lehner, R.; Weder, C.; Petri-Fink, A.; Rothen-Rutishauser, B. Emergence of nanoplastic in the environment and possible impact on human health. *Environ. Sci. Technol.* **2019**, *53*, 1748–1765, doi:10.1021/acs.est.8b05512.
12. Vethaak, A.D.; Leslie, H.A. Plastic debris is a human health issue. *Environ. Sci. Technol.* **2016**, *50*, 6825–6826, doi:10.1021/acs.est.6b02569.
13. Zhang, Q.; Xu, E.G.; Li, J.; Chen, Q.; Ma, L.; Zeng, E.; Shi, H. A review of microplastics in table salt, drinking water, and air: Direct human exposure. *Environ. Sci. Technol.* **2020**, *54*, 3740–3751, doi:10.1021/acs.est.9b04535.
14. Zhang, Y.; Kang, S.; Allen, S.; Allen, D.; Gao, T.; Sillanpää, M. Atmospheric microplastics: A review on current status and perspectives. *Earth-Sci. Rev.* **2020**, *203*, 103118, doi:10.1016/j.earscirev.2020.103118.
15. Peixoto, D.; Pinheiro, C.; Amorim, J.; Oliva-Teles, L.; Guilhermino, L.; Vieira, M.N. Microplastic pollution in commercial salt for human consumption: A review. *ECSS* **2019**, *219*, 161–168, doi:10.1016/j.ecss.2019.02.018.
16. Hu, D.F.; Shen, M.C.; Zhang, Y.X.; Li, H.J.; Zeng, G.M. Microplastics and nanoplastics: Would they affect global biodiversity change? *Environ. Sci. Pollut. Res.* **2019**, *26*, 19997–20002, doi:10.1007/s11356-019-05414-5.
17. Thiel, M.; Luna-Jorquera, G.; Alvarez-Varas, R.; Gallardo, C.; Hinojosa, I.A.; Luna, N.; Miranda-Urbina, D.; Morales, N.; Ory, N.; Pacheco, A.S.; et al. Impacts of marine plastic pollution from continental coasts to subtropical gyres-fish, seabirds, and other vertebrates in the se pacific. *Front. Mar. Sci.* **2018**, *5*, doi:10.3389/fmars.2018.00238.
18. Pauna, V.H.; Buonocore, E.; Renzi, M.; Russo, G.F.; Franzese, P.P. The issue of microplastics in marine ecosystems: A bibliometric network analysis. *Mar. Pollut. Bull.* **2019**, *149*, doi:10.1016/J.MARPOLBUL.2019.110612.
19. Wang, M.H.; He, Y.D.; Sen, B. Research and management of plastic pollution in coastal environments of China. *Environ. Pollut.* **2019**, *248*, 898–905, doi:10.1016/j.envpol.2019.02.098.
20. Sagawa, N.; Kawaai, K.; Hinata, H. Abundance and and size of microplastics in a coastal sea: Comparison among bottom sediment, beach sediment, and surface water. *Mar. Pollut. Bull.* **2018**, *133*, 532–542, doi:10.1016/j.marpolbul.2018.05.036.
21. Fauziah, S.H.; Liyana, I.A.; Agamuthu, P. Plastic debris in the coastal environment: The invincible threat? Abundance of buried plastic debris on malaysian beaches. *Waste Manag. Res.* **2015**, *33*, 812–821, doi:10.1177/0734242x15588587.
22. Isobe, A.; Kubo, K.; Tamura, Y.; Kako, S.; Nakashima, E.; Fujii, N. Selective transport of microplastics and mesoplastics by drifting in coastal waters. *Mar. Pollut. Bull.* **2014**, *89*, 324–330, doi:10.1016/j.marpolbul.2014.09.041.
23. Galloway, T.S.; Cole, M.; Lewis, C. Interactions of microplastic debris throughout the marine ecosystem. *Nat. Ecol. Evol.* **2017**, *1*, 0116, doi:10.1038/s41559-017-0116.
24. Duncan, E.M.; Broderick, A.C.; Fuller, W.J.; Galloway, T.S.; Godfrey, M.H.; Hamann, M.; Limpus, C.J.; Lindeque, P.K.; Mayes, A.G.; Omeyer, L.C.M.; et al. Microplastic ingestion ubiquitous in marine turtles. *Glob. Chang. Biol.* **2019**, *25*, 744–752, doi:10.1111/gcb.14519.
25. Auta, H.S.; Emenike, C.U.; Fauziah, S.H. Distribution and importance of microplastics in the marine environment: A review of the sources, fate, effects, and potential solutions. *Environ. Int.* **2017**, *102*, 165–176, doi:10.1016/j.envint.2017.02.013.

26. Wang, W.; Ge, J.; Yu, X.; Li, H. Environmental fate and impacts of microplastics in soil ecosystems: Progress and perspective. *Sci. Total Environ.* **2020**, *708*, 134841, doi:10.1016/J.SCITOTENV.2019.134841.
27. Ng, E.L.; Lwanga, E.H.; Eldridge, S.M.; Johnston, P.; Hu, H.W.; Geissen, V.; Chen, D.L. An overview of microplastic and nanoplastic pollution in agroecosystems. *Sci. Total Environ.* **2018**, *627*, 1377–1388, doi:10.1016/j.scitotenv.2018.01.341.
28. Horton, A.A.; Dixon, S.J. Microplastics: An introduction to environmental transport processes. *Wiley Interdiscip. Rev. Water* **2018**, *5*, doi:10.1002/wat2.1268.
29. Horton, A.A.; Walton, A.; Spurgeon, D.J.; Lahive, E.; Svendsen, C. Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities. *Sci. Total Environ.* **2017**, *586*, 127–141, doi:10.1016/j.scitotenv.2017.01.190.
30. Akdogan, Z.; Guven, B. Microplastics in the environment: A critical review of current understanding and identification of future research needs. *Environ. Pollut.* **2019**, *254*, 113011, doi:10.1016/j.envpol.2019.113011.
31. Hurley, R.; Horton, A.; Lusher, A.; Nizzetto, L. Chapter 7—Plastic waste in the terrestrial environment. In *Plastic Waste and Recycling*; Letcher, T.M., Ed.; Academic Press: Cambridge, MA, USA, 2020; pp. 163–193.
32. Hurley, R.R.; Nizzetto, L. Fate and occurrence of micro(nano)plastics in soils: Knowledge gaps and possible risks. *Curr. Opin. Environ. Sci. Health* **2018**, *1*, 6–11, doi:10.1016/j.coesh.2017.10.006.
33. de Souza Machado, A.A.; Kloas, W.; Zarfl, C.; Hempel, S.; Rillig, M.C. Microplastics as an emerging threat to terrestrial ecosystems. *Glob. Chang. Biol.* **2018**, *24*, 1405–1416, doi:10.1111/gcb.14020.
34. Bläsing, M.; Amelung, W. Plastics in soil: Analytical methods and possible sources. *Sci. Total Environ.* **2018**, *612*, 422–435, doi:10.1016/j.scitotenv.2017.08.086.
35. He, D.F.; Luo, Y.M.; Lu, S.B.; Liu, M.T.; Song, Y.; Lei, L.L. Microplastics in soils: Analytical methods, pollution characteristics and ecological risks. *TrAC Trends Anal. Chem.* **2018**, *109*, 163–172, doi:10.1016/j.trac.2018.10.006.
36. da Costa, J.P.; Paco, A.; Santos, P.S.M.; Duarte, A.C.; Rocha-Santos, T. Microplastics in soils: Assessment, analytics and risks. *Environ. Chem.* **2019**, *16*, 18–30, doi:10.1071/en18150.
37. Stock, F.; Narayana, V.; Scherer, C.; Löder, M.; Brennholt, N.; Laforsch, C.; Reifferscheid, G. Pitfalls and limitations in microplastic analyses. In *The Handbook of Environmental Chemistry*; Springer: Berlin/Heidelberg, Germany, 2020.
38. Rodríguez-Seijo, A.; Pereira, R. Small plastic wastes in soils: What is our real perception of the problem? In *Mare Plasticum—The Plastic Sea*; Springer: Cham, Switzerland, 2020; pp. 187–209.
39. Sun, Q.; Ren, S.-Y.; Ni, H.-G. Incidence of microplastics in personal care products: An appreciable part of plastic pollution. *Sci. Total Environ.* **2020**, *742*, 140218, doi:10.1016/j.scitotenv.2020.140218.
40. Fendall, L.S.; Sewell, M.A. Contributing to marine pollution by washing your face: Microplastics in facial cleansers. *Mar. Pollut. Bull.* **2009**, *58*, 1225–1228, doi:10.1016/j.marpolbul.2009.04.025.
41. Salvador Cesa, F.; Turra, A.; Baruque-Ramos, J. Synthetic fibers as microplastics in the marine environment: A review from textile perspective with a focus on domestic washings. *Sci. Total Environ.* **2017**, *598*, 1116–1129, doi:10.1016/j.scitotenv.2017.04.172.
42. Haap, J.; Classen, E.; Beringer, J.; Mecheels, S.; Gutmann, J.S. Microplastic fibers released by textile laundry: A new analytical approach for the determination of fibers in effluents. *Water* **2019**, *11*, 2088, doi:10.3390/w11102088.
43. Kelly, M.R.; Lant, N.J.; Kurr, M.; Burgess, J.G. Importance of water-volume on the release of microplastic fibers from laundry. *Environ. Sci. Technol.* **2019**, *53*, 11735–11744, doi:10.1021/acs.est.9b03022.
44. Chae, Y.; An, Y.-J. Current research trends on plastic pollution and ecological impacts on the soil ecosystem: A review. *Environ. Pollut.* **2018**, *240*, 387–395, doi:10.1016/J.ENVPOL.2018.05.008.
45. Ziajahromi, S.; Neale, P.A.; Leusch, F.D.L. Wastewater treatment plant effluent as a source of microplastics: Review of the fate, chemical interactions and potential risks to aquatic organisms. *Water Sci. Technol.* **2016**, *74*, 2253–2269, doi:10.2166/wst.2016.414.
46. Mahon, A.M.; O'Connell, B.; Healy, M.G.; O'Connor, I.; Officer, R.; Nash, R.; Morrison, L. Microplastics in sewage sludge: Effects of treatment. *Environ. Sci. Technol.* **2017**, *51*, 810–818, doi:10.1021/acs.est.6b04048.
47. Li, X.W.; Mei, Q.Q.; Chen, L.B.; Zhang, H.Y.; Dong, B.; Dai, X.H.; He, C.Q.; Zhou, J. Enhancement in adsorption potential of microplastics in sewage sludge for metal pollutants after the wastewater treatment process. *Water Res.* **2019**, *157*, 228–237, doi:10.1016/j.watres.2019.03.069.

48. Corradini, F.; Meza, P.; Eguiluz, R.; Casado, F.; Huerta-Lwanga, E.; Geissen, V. Evidence of microplastic accumulation in agricultural soils from sewage sludge disposal. *Sci. Total Environ.* **2019**, *671*, 411–420, doi:10.1016/j.scitotenv.2019.03.368.
49. Li, Q.; Wu, J.; Zhao, X.; Gu, X.; Ji, R. Separation and identification of microplastics from soil and sewage sludge. *Environ. Pollut.* **2019**, *254*, 113076, doi:10.1016/J.ENVPOL.2019.113076.
50. Zhang, J.J.; Wang, L.; Halden, R.U.; Kannan, K. Polyethylene terephthalate and polycarbonate microplastics in sewage sludge collected from the united states. *Environ. Sci. Technol. Lett.* **2019**, *6*, 650–655, doi:10.1021/acs.estlett.9b00601.
51. Filipović, V.; Bristow, K.; Filipović, L.; Wang, Y.; Sintim, H.; Flury, M. Sprayable biodegradable polymer membrane technology for cropping systems: Challenges and opportunities. *Environ. Sci. Technol.* **2020**, *54*, 4709–4711, doi:10.1021/acs.est.0c00909.
52. Scott, A. Pressured plastics firms will look to recycling. *C&EN Glob. Enterp.* **2020**, *98*, 31–31, doi:10.1021/cen-09802-cover7.
53. Braunack, M.V.; Zaja, A.; Tam, K.; Filipović, L.; Filipović, V.; Wang, Y.; Bristow, K.L. A sprayable biodegradable polymer membrane (sbpm) technology: Effect of band width and application rate on water conservation and seedling emergence. *Agric. Water Manag.* **2020**, *230*, doi:10.1016/J.AGWAT.2019.105900.
54. Adhikari, R.; Bristow, K.L.; Casey, P.S.; Freischmidt, G.; Hornbuckle, J.W.; Adhikari, B. Preformed and sprayable polymeric mulch film to improve agricultural water use efficiency. *Agric. Water Manag.* **2016**, *169*, 1–13, doi:10.1016/j.agwat.2016.02.006.
55. Qi, R.; Jones, D.L.; Li, Z.; Liu, Q.; Yan, C. Behavior of microplastics and plastic film residues in the soil environment: A critical review. *Sci. Total Environ.* **2020**, *703*, 134722, doi:10.1016/J.SCITOTENV.2019.134722.
56. van Eck, N.J.; Waltman, L. Software survey: Vosviewer, a computer program for bibliometric mapping. *Scientometrics* **2010**, *84*, 523–538, doi:10.1007/S11192-009-0146-3.
57. Hicks, D.; Wouters, P.; Waltman, L.; de Rijcke, S.; Rafols, I. Bibliometrics: The leiden manifesto for research metrics. *Nature* **2015**, *520*, 429–431, doi:10.1038/520429A.
58. Bornmann, L.; Mutz, R. Growth rates of modern science: A bibliometric analysis based on the number of publications and cited references. *J. Assoc. Inf. Sci. Technol.* **2015**, *66*, 2215–2222.
59. Velasco-Muñoz, J.; Aznar-Sánchez, J.; Belmonte-Ureña, L.; López-Serrano, M. Advances in water use efficiency in agriculture: A bibliometric analysis. *Water* **2018**, *10*, doi:10.3390/w10040377.
60. Guo, H.; Xue, Y.; Wang, W.; Wang, L. Bibliometric analysis of domestic and foreign researches on organic agriculture. *J. Food Saf. Qual.* **2019**, *10*, 5740–5747.
61. Aleixandre, J.L.; Aleixandre-Tudó, J.L.; Bolaños-Pizarro, M.; Aleixandre-Benavent, R. Mapping the scientific research in organic farming: A bibliometric review. *Scientometrics* **2015**, *105*, 295–309, doi:10.1007/S11192-015-1677-4.
62. Arfaoui, A.; Ibrahimi, K.; Trabelsi, F. Biochar application to soil under arid conditions: A bibliometric study of research status and trends. *Arab. J. Geosci.* **2019**, *12*, doi:10.1007/s12517-018-4166-2.
63. Ahmed, A.S.F.; Vanga, S.; Raghavan, V. Global bibliometric analysis of the research in biochar. *J. Agric. Food Inf.* **2018**, *19*, 228–236, doi:10.1080/10496505.2017.1403328.
64. Xie, H.; Zhang, Y.; Wu, Z.; Lv, T. A bibliometric analysis on land degradation: Current status, development, and future directions. *Land* **2020**, *9*, doi:10.3390/LAND9010028.
65. Añó-Vidal, C.; Sánchez-Díaz, J. Bibliometric analysis of the scientific production on soil erosion in andalusia (1964–2008). *Rev. Estud. Andal.* **2018**, *35*, 193–213.
66. Escadafal, R.; Barbero-Sierra, C.; Exbrayat, W.; Marques, M.J.; Akhtar-Schuster, M.; El Haddadi, A.; Ruiz, M. First appraisal of the current structure of research on land and soil degradation as evidenced by bibliometric analysis of publications on desertification. *Land Degrad. Dev.* **2015**, *26*, 413–422, doi:10.1002/ldr.2351.
67. Xu, T.; Hu, J.; Wang, L. Research progress of oil pollution on soil based on bibliometric analysis. *Front. Soc. Sci. Technol.* **2019**, *1*, doi:10.25236/FSST.2019.010801.
68. Li, C.; Ji, X.; Luo, X. Phytoremediation of heavy metal pollution: A bibliometric and scientometric analysis from 1989 to 2018. *Int. J. Environ. Res. Public Health* **2019**, *16*, doi:10.3390/IJERPH16234755.

69. Cui, M.Q.; Wu, C.; Jiang, X.X.; Liu, Z.Y.; Xue, S.G. Bibliometric analysis of research on soil arsenic during 2005-2016. *J. Cent. South Univ.* **2019**, *26*, 479–488, doi:10.1007/s11771-019-4020-z.
70. Sivasami, K. Research performance on soil pollution: A bibliometric analysis. *Int. J. Adv. Res. Dev.* **2018**, *3*, 1141–1146.
71. Hu, Y.; Han, J.; Sun, Z.; Wang, H.; Liu, X.; Kong, H. A bibliometric analysis of soil remediation based on massive research literature data during 1988–2018. *bioRxiv* **2019**, doi:10.1101/689018.
72. Mao, G.; Shi, T.; Zhang, S.; Crittenden, J.; Guo, S.; Du, H. Bibliometric analysis of insights into soil remediation. *J. Soils Sed.* **2018**, *18*, 2520–2534, doi:10.1007/S11368-018-1932-4.
73. Liu, Y.; Wu, K.; Zhao, R. Bibliometric analysis of research on soil health from 1999 to 2018. *J. Soils Sed.* **2020**, *20*, 1513–1525, doi:10.1007/S11368-019-02519-9.
74. Abbasi, S.; Keshavarzi, B.; Moore, F.; Delshab, H.; Soltani, N.; Sorooshian, A. Investigation of microrubbers, microplastics and heavy metals in street dust: A study in bushehr city, iran. *Environ. Earth Sci.* **2017**, *76*, doi:10.1007/s12665-017-7137-0.
75. Waring, R.H.; Harris, R.M.; Mitchell, S.C. Plastic contamination of the food chain: A threat to human health? *Maturitas* **2018**, *115*, 64–68, doi:10.1016/j.maturitas.2018.06.010.
76. Meng, K.; Ren, W.J.; Teng, Y.; Wang, B.B.; Han, Y.J.; Christie, P.; Luo, Y.M. Application of biodegradable seedling trays in paddy fields: Impacts on the microbial community. *Sci. Total Environ.* **2019**, *656*, 750–759, doi:10.1016/j.scitotenv.2018.11.438.
77. Zhou, Y.; Liu, X.; Wang, J. Characterization of microplastics and the association of heavy metals with microplastics in suburban soil of central China. *Sci. Total Environ.* **2019**, *694*, 133798, doi:10.1016/J.SCITOTENV.2019.133798.
78. Li, R.; Liu, Y.; Sheng, Y.; Xiang, Q.; Zhou, Y.; Cizdziel, J.V. Effect of prothioconazole on the degradation of microplastics derived from mulching plastic film: Apparent change and interaction with heavy metals in soil. *Environ. Pollut.* **2020**, *260*, 113988, doi:10.1016/J.ENVPOL.2020.113988.
79. Lu, X.-M.; Lu, P.-Z.; Liu, X.-P. Fate and abundance of antibiotic resistance genes on microplastics in facility vegetable soil. *Sci. Total Environ.* **2020**, *709*, 136276, doi:10.1016/J.SCITOTENV.2019.136276.
80. Zhang, M.J.; Zhao, Y.R.; Qin, X.; Jia, W.Q.; Chai, L.W.; Huang, M.K.; Huang, Y. Microplastics from mulching film is a distinct habitat for bacteria in farmland soil. *Sci. Total Environ.* **2019**, *688*, 470–478, doi:10.1016/j.scitotenv.2019.06.108.
81. Xu, B.; Liu, F.; Cryder, Z.; Huang, D.; Lu, Z.; He, Y.; Wang, H.; Lu, Z.; Brookes, P.C.; Tang, C.; et al. Microplastics in the soil environment: Occurrence, risks, interactions and fate—A review. *Crit. Rev. Environ. Sci. Technol.* **2019**, *50*, 2175–2222, doi:10.1080/10643389.2019.1694822.
82. Xiong, X.; Wu, C.X.; Elser, J.J.; Mei, Z.G.; Hao, Y.J. Occurrence and fate of microplastic debris in middle and lower reaches of the yangtze river—From inland to the sea. *Sci. Total Environ.* **2019**, *659*, 66–73, doi:10.1016/j.scitotenv.2018.12.313.
83. Wu, P.F.; Huang, J.S.; Zheng, Y.L.; Yang, Y.C.; Zhang, Y.; He, F.; Chen, H.; Quan, G.X.; Yan, J.L.; Li, T.T.; et al. Environmental occurrences, fate, and impacts of microplastics. *Ecotoxicol. Environ. Saf.* **2019**, *184*, 109612, doi:10.1016/j.ecoenv.2019.109612.
84. Yu, M.; van der Ploeg, M.; Lwanga, E.H.; Yang, X.M.; Zhang, S.L.; Ma, X.Y.; Ritsema, C.J.; Geissen, V. Leaching of microplastics by preferential flow in earthworm (lumbricus terrestris) burrows. *Environ. Chem.* **2019**, *16*, 31–40, doi:10.1071/en18161.
85. Yang, X.M.; Lwanga, E.H.; Bemani, A.; Gertsen, R.; Salanki, T.; Guo, X.T.; Fu, H.M.; Xue, S.; Ritsema, C.; Geissen, V. Biogenic transport of glyphosate in the presence of ldpe microplastics: A mesocosm experiment. *Environ. Pollut.* **2019**, *245*, 829–835, doi:10.1016/j.envpol.2018.11.044.
86. Wang, F.; Zhang, X.; Zhang, S.; Zhang, S.; Sun, Y. Interactions of microplastics and cadmium on plant growth and arbuscular mycorrhizal fungal communities in an agricultural soil. *Chemosphere* **2020**, *254*, 126791, doi:10.1016/J.CHEMOSPHERE.2020.126791.
87. Liu, K.; Wang, X.; Song, Z.; Nian, W.; Li, D. Terrestrial plants as a potential temporary sink of atmospheric microplastics during transport. *Sci. Total Environ.* **2020**, *742*, 140523, doi:10.1016/j.scitotenv.2020.140523.

88. Zarfl, C. Promising techniques and open challenges for microplastic identification and quantification in environmental matrices. *Anal. Bioanal. Chem.* **2019**, *411*, 3743–3756, doi:10.1007/s00216-019-01763-9.
89. Yu, J.P.; Wang, P.Y.; Ni, F.L.; Cizdziel, J.; Wu, D.X.; Zhao, Q.L.; Zhou, Y. Characterization of microplastics in environment by thermal gravimetric analysis coupled with fourier transform infrared spectroscopy. *Mar. Pollut. Bull.* **2019**, *145*, 153–160, doi:10.1016/j.marpolbul.2019.05.037.
90. Zhang, S.L.; Wang, J.Q.; Liu, X.; Qu, F.J.; Wang, X.S.; Wang, X.R.; Li, Y.; Sun, Y.K. Microplastics in the environment: A review of analytical methods, distribution, and biological effects. *TrAC Trends Anal. Chem.* **2019**, *111*, 62–72, doi:10.1016/j.trac.2018.12.002.
91. Yang, X.; Guo, X.; Huang, S.; Xue, S.; Meng, F.; Qi, Y.; Cheng, W.; Fan, T.; Lwanga, E.H.; Geissen, V. Microplastics in soil ecosystem: Insight on its fate and impacts on soil quality. In *The Handbook of Environmental Chemistry*; Springer: Berlin/Heidelberg, Germany, 2020; pp. 245–258.
92. Zhang, G.S.; Zhang, F.X.; Li, X.T. Effects of polyester microfibers on soil physical properties: Perception from a field and a pot experiment. *Sci. Total Environ.* **2019**, *670*, 1–7, doi:10.1016/J.SCITOTENV.2019.03.149.
93. Wiedner, K.; Polifka, S. Effects of microplastic and microglass particles on soil microbial community structure in an arable soil (chernozem). *Soil* **2019**, 315–324, doi:10.5194/SOIL-2019-38.
94. Lwanga, E.H.; Gertsen, H.; Gooren, H.; Peters, P.; Salanki, T.; van der Ploeg, M.; Besseling, E.; Koelmans, A.A.; Geissen, V. Microplastics in the terrestrial ecosystem: Implications for lumbricus terrestris (oligochaeta, lumbricidae). *Environ. Sci. Technol.* **2016**, *50*, 2685–2691, doi:10.1021/acs.est.5b05478.
95. Panebianco, A.; Nalbone, L.; Giarratana, F.; Ziino, G. First discoveries of microplastics in terrestrial snails. *Food Control.* **2019**, *106*, doi:10.1016/j.foodcont.2019.106722.
96. Song, Y.; Cao, C.; Qiu, R.; Hu, J.; Liu, M.; Lu, S.; Shi, H.; Raley-Susman, K.M.; He, D. Uptake and adverse effects of polyethylene terephthalate microplastics fibers on terrestrial snails (achatina fulica) after soil exposure. *Environ. Pollut.* **2019**, *250*, 447–455, doi:10.1016/J.ENVPOL.2019.04.066.
97. Qi, Y.; Yang, X.; Pelaez, A.M.; Lwanga, E.H.; Beriot, N.; Gertsen, H.; Garbeva, P.; Geissen, V. Macro- and micro-plastics in soil-plant system: Effects of plastic mulch film residues on wheat (triticum aestivum) growth. *Sci. Total Environ.* **2018**, *645*, 1048–1056, doi:10.1016/J.SCITOTENV.2018.07.229.
98. Yang, Y.F.; Chen, C.Y.; Lu, T.H.; Liao, C.M. Toxicity-based toxicokinetic/toxicodynamic assessment for bioaccumulation of polystyrene microplastics in mice. *J. Hazard. Mater.* **2019**, *366*, 703–713, doi:10.1016/j.jhazmat.2018.12.048.
99. Xu, M.K.; Halimu, G.; Zhang, Q.R.; Song, Y.B.; Fu, X.H.; Li, Y.Q.; Li, Y.S.; Zhang, H.W. Internalization and toxicity: A preliminary study of effects of nanoplastic particles on human lung epithelial cell. *Sci. Total Environ.* **2019**, *694*, 133794, doi:10.1016/j.scitotenv.2019.133794.
100. Hu, R.; Wu, J.; Hu, Y. Internal logic and development path of the "two mountains" theory for ecological civilization construction. *Chin. J. Eng. Sci.* **2019**, *21*, 151–158, doi:10.15302/j-sscae-2019.05.004.
101. Eerkes-Medrano, D.; Thompson, R.C.; Aldridge, D.C. Microplastics in freshwater systems: A review of the emerging threats, identification of knowledge gaps and prioritisation of research needs. *Water Res.* **2015**, *75*, 63–82, doi:10.1016/j.watres.2015.02.012.
102. Lebreton, L.C.M.; Van der Zwet, J.; Damsteeg, J.W.; Slat, B.; Andrady, A.; Reisser, J. River plastic emissions to the world's oceans. *Nat. Commun.* **2017**, *8*, 15611, doi:10.1038/ncomms15611.
103. Murphy, F.; Ewins, C.; Carbonnier, F.; Quinn, B. Wastewater treatment works (wwtw) as a source of microplastics in the aquatic environment. *Environ. Sci. Technol.* **2016**, *50*, 5800–5808, doi:10.1021/acs.est.5b05416.
104. McCormick, A.; Hoellein, T.J.; Mason, S.A.; Schluep, J.; Kelly, J.J. Microplastic is an abundant and distinct microbial habitat in an urban river. *Environ. Sci. Technol.* **2014**, *48*, 11863–11871, doi:10.1021/es503610r.
105. Carr, S.A.; Liu, J.; Tesoro, A.G. Transport and fate of microplastic particles in wastewater treatment plants. *Water Res.* **2016**, *91*, 174–182, doi:10.1016/j.watres.2016.01.002.
106. Machado, A.A.d.S.; Lau, C.W.; Till, J.; Kloas, W.; Lehmann, A.; Becker, R.; Rillig, M.C. Impacts of microplastics on the soil biophysical environment. *Environ. Sci. Technol.* **2018**, *52*, 9656–9665, doi:10.1021/ACS.EST.8B02212.
107. Rillig, M.C.; Machado, A.A.d.S.; Lehmann, A.; Klümper, U. Evolutionary implications of microplastics for soil biota. *Environ. Chem.* **2019**, *16*, 3–7, doi:10.1071/EN18118.

108. Rillig, M.C.; Ziersch, L.; Hempel, S. Microplastic transport in soil by earthworms. *Sci. Rep.* **2017**, *7*, 1362–1362, doi:10.1038/S41598-017-01594-7.
109. Rezaei, M.; Riksen, M.; Sirjani, E.; Sameni, A.; Geissen, V. Wind erosion as a driver for transport of light density microplastics. *Sci. Total Environ.* **2019**, *669*, 273–281, doi:10.1016/j.scitotenv.2019.02.382.

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