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Research Trends on The Presence of Microplastic Particles in The Environment and The Impact of Microplastics Around the World From 2010 - 2022: A Literature Review and Bibliometric Analysis

Muhammad Fakruhayat Ab Rashid[1], Nor Ashikin Darus[2]
[1]Geoinformatic Unit, Geography Section, School of Humanities, Universiti Sains Malaysia, 11800 USM, Pulau Pinang, Malaysia, [2]School of Education, Universiti Sains Malaysia, 11800 USM, Pulau Pinang, Malaysia.
Email: ashikinn01@gmail.com, muhammadfakruhayat97@gmail.com (Corresponding Author's Email)

Abstract
Microplastics is a pollutant that increasing and are having an effect all around the world. Microplastics pollution is mostly caused by urban and suburban areas, which eventually end up in water bodies such as rivers, lakes, seas, and oceans. Therefore, this study presents a literature review and bibliometric analysis of microplastics and impact or potential of microplastics research around the world from 2010 to 2022 in order to provide researchers and scholars around the world with an overview of the results and trends in microplastics research. A textual query on two databases; Scopus (268 papers), and PubMed (1913 papers) using the term "microplastics" OR "plastic particle" AND "impact of microplastics" OR "potential risk of microplastics" was performed on 12 May 2022 retrieving 2181 scholarly papers from 2010 to 2022 related to microplastics studies for in-depth analysis. Bibliometric analysis were performed using Rstudio software version 4.1.1 and biblioshiny for bibliometrix to visualize and analyze trends of microplastics research. This bibliometric analysis was analyzed the annual scientific publication growth, the most productive authors, most frequent word has been using, most famous journal name, and which countries has highest collaboration with other country in microplastics research. According to the findings of the analysis, microplastics studies have remarkably increases steadily from 2010 to 2021 in Scopus and PubMed databases, the country of China is the country with the highest number of scientific production, the most relevant author is Wang J in Scopus database, and Zhang Y in PubMed database, the most relevant journal is by Science Of The Total Environment in Scopus and PubMed database, the most frequent word in microplastics research is "microplastic" and "plastics", and the top most collaborations among country publishing of microplastics research were the collaboration countries between the China and United States (USA) in Scopus and PubMed databases.

Keywords: Bibliometric Analysis, Microplastics, Potential Risk, Rstudio

Introduction

Plastics are particularly popular in the industrial industry. Plastic has evolved into a substance that is necessary in everyday life. In everything from shopping bags to personal care items, our increased dependence on plastic materials has resulted in an increase in plastic garbage being dumped into the natural environment. Millions of tonnes of plastics are manufactured each year across the world, with more than 8 million metric tonnes of plastic ending up in the ocean (Kuhn et al., 2018). According to the study conducted by Kurtela and Antolovic (2019) has stated that predicted to be present in marine habitats by 2025 is a total of almost 250 million metric tonnes of plastics.

Microplastics (MPs) are often characterised as microscopic plastic particles having an upper size limit of less than 5 mm, with larger MPs are 1-5 mm and smaller Mps are 1 µm-1 mm (Barboza et al., 2019). Plastic debris is divided into four categories: macroplastics (more than 25 mm), mesoplastics (between 5 and 25 mm), microplastics (0.1 µm-5 mm), and nanoplastics less than 100 nm (Alimi et al., 2018). It is possible to get MPs from either primary sources, such as plastic things that have previously been made in microscopic size, or secondary sources such as the breakdown of bigger plastic items that have already been manufactured in microscopic size (Duis and Coors, 2016; Ryan et al., 2009).

The presence and contamination of microplastics (MPs) in marine habitats has sparked widespread concern throughout the world for the following reasons. Numerous other environmental contaminants may be attached to the surface of MPs by a variety of processes such as hydrophobic contact, electrostatic interaction, pore filling, van der Waals forces, and hydrogen bonding (Rochman et al., 2013; Rodrigues et al., 2019; Torres et al., 2021). When marine organisms erroneously consume these MPs that have been contaminated with MPs, the likelihood of hazardous chemicals being passed up the food chain increases (Wright and Kelly, 2017). Secondly, MPs consumed by marine organisms may induce growth suppression, neurotoxicity, digestive obstruction, and internal harm to the organisms swallowed by them (Alimba and Faggio, 2019). Furthermore, several studies have revealed that marine MPs may be ingested by humans as a result of the ingestion of MP-contaminated seafood, which might constitute a major hazard to the health of humans (Barboza et al., 2018; Li et al., 2020; Santillo et al., 2017; Wright and Kelly, 2017)

Due to microplastics widespread in marine habitats and freshwater systems, the potential dangers caused by microplastics to living species have recently gained increasing attention. Laboratory experiments have demonstrated that several species, including zooplankton, fish, and invertebrate larvae ingested microplastics (Cole et al., 2013; Kaposi et al., 2014; Lonnstedt and Eklov, 2016). If microplastics are swallowed by organisms, they may cause mechanical harm to the digestive tract, such as obstruction of the intestines or penetration of the intestinal wall, which may impair the organisms' ability to absorb nutrients from their environment (Duis and Coors, 2016). Marine worms' feeding activity is reduced and their energy reserves are depleted when they ingest microplastics (Wright et al., 2013). Additionally, Cole et al. observed that the presence of microplastics reduced copepod food intake, showing that microplastics are detrimental to zooplankton health (Cole et al., 2013).

Bibliometrics is the analysis measuring of texts and information. Bibliometric analysis is a popular method for discovering new information and connecting future society's needs to present research and technology. It is often used to examine key themes in technological, scientific, or social databases in a variety of contexts (Kumari et al., 2019). Bibliometric

techniques are employed in academic and professional communities in ways that go beyond lists of scientific journals and citations. Bibliometerics analysis research may expose the issue worldwide trends of microplastics. It can help in understanding microplastics development trends. Using two databases, Scopus and PubMed, our findings will aid researchers and scholars in establishing the current situation of global microplastics. This study using a software the latest version 4.1.1 of Rstudio. Rstudio is being used by a researcher to open the biblioshiny web-interface in order to do bibliometrics analysis on worldwide trends in microplastics (Fakruhayat et al., 2022).

Therefore, this article will present a literature review and bibliometric analysis of global microplastics using two database from Scopus, and PubMed to determine the research areas with the greatest research output analysis of analysis of annual scientific publication, country scientific production and the most cited countries, most relevant authors, most relevant journals and journals growth, most frequent words and co-occurrence network, and collaboration among countries. The contribution of this study is can help novice researchers in microplastics studies by displaying information on relevant publications and authors to consult when performing microplastics research. The motivation of this study is want to providing first research article that perform a literature review on the concepts of microplastics research, bibliometric analysis to evaluate existing knowledge of MPs, to establish hot issues and research trends using network analysis for a better understanding of MPs studies. The contribution of this study is can help researchers or academics who are new to microplastics research by providing information on which publications and authors to refer when performing microplastics research. Therefore, reseacher suggest that for future studies should evaluate and focus on the publications on other databases to determine if similar trends are present for microplastic, and the effects of MPs exposure on human health research.

Literature Review

Definition of Plastics

Since the 20th century, plastic has been a commonly used because plastic has benefits such as being lightweight, robust, pliable, corrosion resistant, chemical resistant, and inexpensive, and commonly used to replace glass, wood, and metal (Andrady & Neal, 2009; Van Cauwenberghe et al., 2015). Plastic's use is restricted, however, owing to its poor strength and lack of heat resistance. Plastic is a kind of polymer with extraordinary characteristics. Plastic polymers are also materials made up of monomers, which are molecular units. If the monomer is the same kind, the result is a homopolymer, however if the monomer is different, the result is a copolymer (Geyer et al., 2017). Heat may soften polymer polymers, allowing them to be readily moulded into different shapes and sizes for product manufacture (Andrady & Neal, 2009). As a result, plastics are extensively used in a variety of sectors, including packaging, construction, agriculture, healthcare, transportation, and others (PlasticsEurope, 2018). Plastics' lightweight, affordable, and durable qualities have resulted in a fast growth in supply. This is due to its properties, which make it suited for the production of a wide range of items (Derraik, 2002). Plastics that are has been used transferred to the ocean by a variety of reasons including wind, water currents, and humans activity (Pruter, 1987). Every year, up to 8 million metric tonnes of plastic enter the ocean. Plastics have become a menace to the environment that has accumulated on the surface of sea water. Some plastics will sink to the ocean's bottom and remain there for years or maybe for decades (Laist, 1987).

Definition of Marine Debris

Marine debris is defined as marine pollution contaminated by human activities that are purposefully or inadvertently thrown into the sea from land, water bodies, and beaches, or trash originating from operations at sea. Marine debris may be found in all marine ecosystems, whether deep or shallow. This is because human activities have an impact on marine debris. Other than human activity, various elements impact marine debris, including water or weather conditions, the structure of the earth's surface, and the physical features of the waste. Plastic debris, or garbage containing polymer components, is commonly carried by marine debris. This plastic waste has grown to be the most significant component of marine debris.

Plastic waste that decomposes in the sea eventually produces microplastic debris, which is what marine debris is. This plastic waste will contaminate the oceans and have an impact on the food chain and marine habitats. Plastic pollution including microplastics will also have a negative impact on marine biota since microplastics carry hazardous compounds. Examples of marine waste include m etals, glass, bottles, wooden boards, gloves, plastic, fishing nets, and many other types of marine debris have a negative impact on economic growth, fisheries, and tourism. This is so because when marine biota consumes microplastics because plastic waste is not handled properly it will cause fishery productivity to decline. Furthermore, if microplastics enter the food chain, such as fish, they will endanger human health. Marine debris, plastic waste, and microplastics have all emerged as national, regional, and global concerns. Plastic waste is a pollutant that endangers the variety of marine biota. If allowed untreated, it would most certainly face a higher hazard of pollution, disrupting ecosystems and the health of living things.

Types of Microplastics

The most common types of microplastics are fibre, film, and fragment microplastics, whereas pellet and foam microplastics are uncommon. This might be because the pellets in the waterways, beaches, and rivers have broken down into tiny particles before reaching the sediments. While the major feature of fibre type microplastics is similar to a fishing net and emits dazzling blue light when exposed to UV light. Fiber type microplastics are common because they are used in the production of garments, boats, fishing nets, and other items. Microplastics with plastic fragments are commonly utilised in plastic packaging. The figure 1 below shows the form and surface properties of microplastics classified as fragments, fibres, films, pellets, and foams (GESAMP, 2019).

Morphology	Description	Example
Fragment	• Rigid. • Jagged and irregular shape.	
Fiber	• Long or short pieces of line, in various color. • Mainly from the breakdown of fishing lines.	
Film	• Thin, flat and some is transparent. • May be derived from the breakdown of woven plastic bags.	
Pellet	• Hard, regular, disc-ovoid or cylindrical-shaped. • May be original manufactured primary microplastics.	 (Taken from Li et al., 2015)
Foam	• Soft, lightweight and porous. • Normally white in color with some yellow stain.	

Figure 1: The form and surface properties of microplastics
Source: (Tham Huey Yee, 2019)

Existence of Microplastics

Plastics are polymeric materials that develop under specified conditions of temperature and pressure (Lusher & Peter, 2017). Plastics are further classified into three types: thermoplastics, thermoses, and elastomers. Polyethylene (PE), polypropylene (PP), polyethyloro-ethylene, polyamide (PA), polyvinyl chloride (PVC), and polystyrene are examples of thermoplastic polymers that soften or melt when heated and harden when cooled (PS). Epoxy resin, polyurettane (PU), polyester resin, and bakalite are thermoset polymers that do not become liquid or soft after being formed. Elastomer is a type of elastic plastic that, like rubber and neoprene, can return to its original shape after being tugged. Plastic manufacturing also uses additives aimed at improving the quality of plastics such as plasticizers, antioxidants, UV stabilizers, lubricants, dyes.

Microplastics were first discovered in the environment about 1970. (Dehaut et al., 2016). Microplastics may be found in a variety of spatial environments, including the air, land,

water, and sea (Lusher & Peter, 2017). Many microplastics are disseminated and accumulated in the sea, whether on beaches or in shallow or deep water. Because of consumer demands, the usage of microplastics has increased throughout the 20th century. As a result of abrasion, deterioration, and physical breakdown, when these plastics are dumped into the environment, the emergence of growing microplastics that have the potential to be harmful to humans in the environment. Microplastics are more typically discovered at different depths, with quantities ranging from 0 to 14 particles/100 cm^3 of sediment. Microplastics originate and are heavily influenced by human activities around the coast. When human activities are close to the sampling area then the distribution of microplastics is also higher as in areas close to port, fisheries, and tourism areas.

Bioacumulation of Microplastics

Bioaccumulation is the accumulation of chemical compounds such as insecticides, methyl mercury, and several other organic chemicals in the body of an organism. Therefore, microplastics are detected in marine biota such as fish, shrimp, and shellfish. Microplastic particles, films, styrofoam, and monofilaments are regularly detected in the digestive tract of fish.

The bioaccumulation of xenobiotics in the body of living organisms is contingent on a number of variables, including their mechanism of absorption. Bioaccumulation of xenobiotics that enter living organisms by different methods, including skin contact, inhalation, and ingestion, and impact the energy activity of living cells. Additionally, xenobiotic distribution variables that enter the body impact bioaccumulation. The accumulation of xenobiotics in the body of a live organism has an effect on its health.

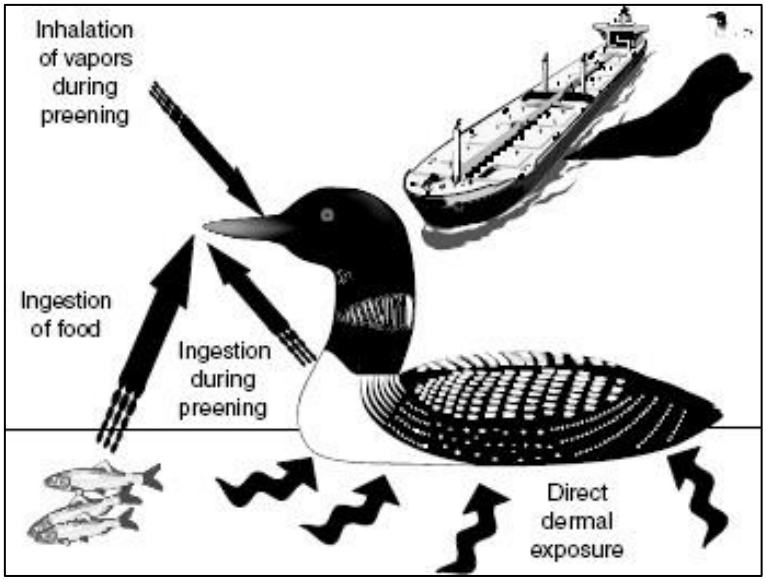

Figure 2: How to integrate xenobiotics into living organisms
Source: (Newman, 2009)

The impacts of microplastic bioaccumulation in the bodies of living organisms, whether human or animal, negatively impact the health system of living organisms and the stability of the environment, as it affects the food chain. Due to the presence of carcinogenic substances such as xenobiotics in microplastics, the development of health will be affected. The accumulation of xenobiotics in the bodies of living organisms will have negative health effects, including the development of chronic illnesses such as cancer, hormone problems,

and nervous system disorders. Additionally, bioaccumulation disrupts the stability of the environment. The accumulation or bioaccumulation of microplastics in the bodies of marine biota such as fish, shrimp, and shellfish has led to the eventual extinction of these organisms. And when a species vanishes or goes extinct, the food chain is indirectly disturbed, leading to an imbalance in the ecosystem.

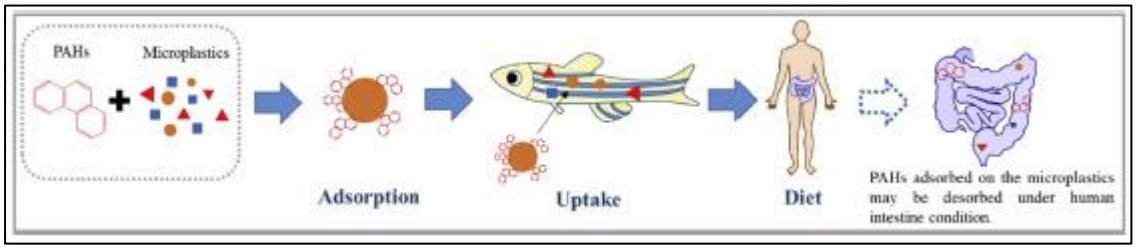

Figure 3: One possible entry of contaminants (e.g., PAHs) and microplastics in the human body through the food chain.
Source: (Yu et al., 2020)

Methods

Data source and Search strategy

A comprehensive search was performed online using databases Scopus (www.scopus.com), and PubMed (https://pubmed.ncbi.nlm.nih.gov/) on 12 May 2022. The search was conducted on a single day to avoid bias induced by daily database updates. In this retrospective analysis, researcher selected articles on microplastic articles that were published between 2010 to 2022 and were indexed in Scopus and PubMed. The search strategy used in the two databases was as follows:

Topic: “microplastics” OR “plastic particle” AND “impact of microplastics” OR “potential risk of microplastics”

Refined by: Document types in Scopus (THERE WAS NO RESTRICTION ON THE TYPE).
: Document types in PubMed (THERE WAS NO RESTRICTION ON THE TYPE)

Criteria : “titles, abstract and keywords *(topic area)*”

Year Published: 2010-2022.

Languages: English (Scopus and PubMed)

On 12 May 2022, research articles were downloaded in *CSV format (Scopus) and Text Document format (PubMed) to include all essential article information, including article title, author name and affiliation, abstract, keywords, and references to process using Rstudio software version 4.1.1. Scopus data publication downloaded after refinement is 268 out of 279 articles, whereas PubMed data publication is 1913 out of 1928 articles. In addition, biblioshiny for bibliometrix is used to view and evaluate trends as bibliometric maps. Biblioshiny can generate and provides dataset such as main information, annual scientific production, average citation per year, and three-field plot, most relevant sources, most local cited and so on.

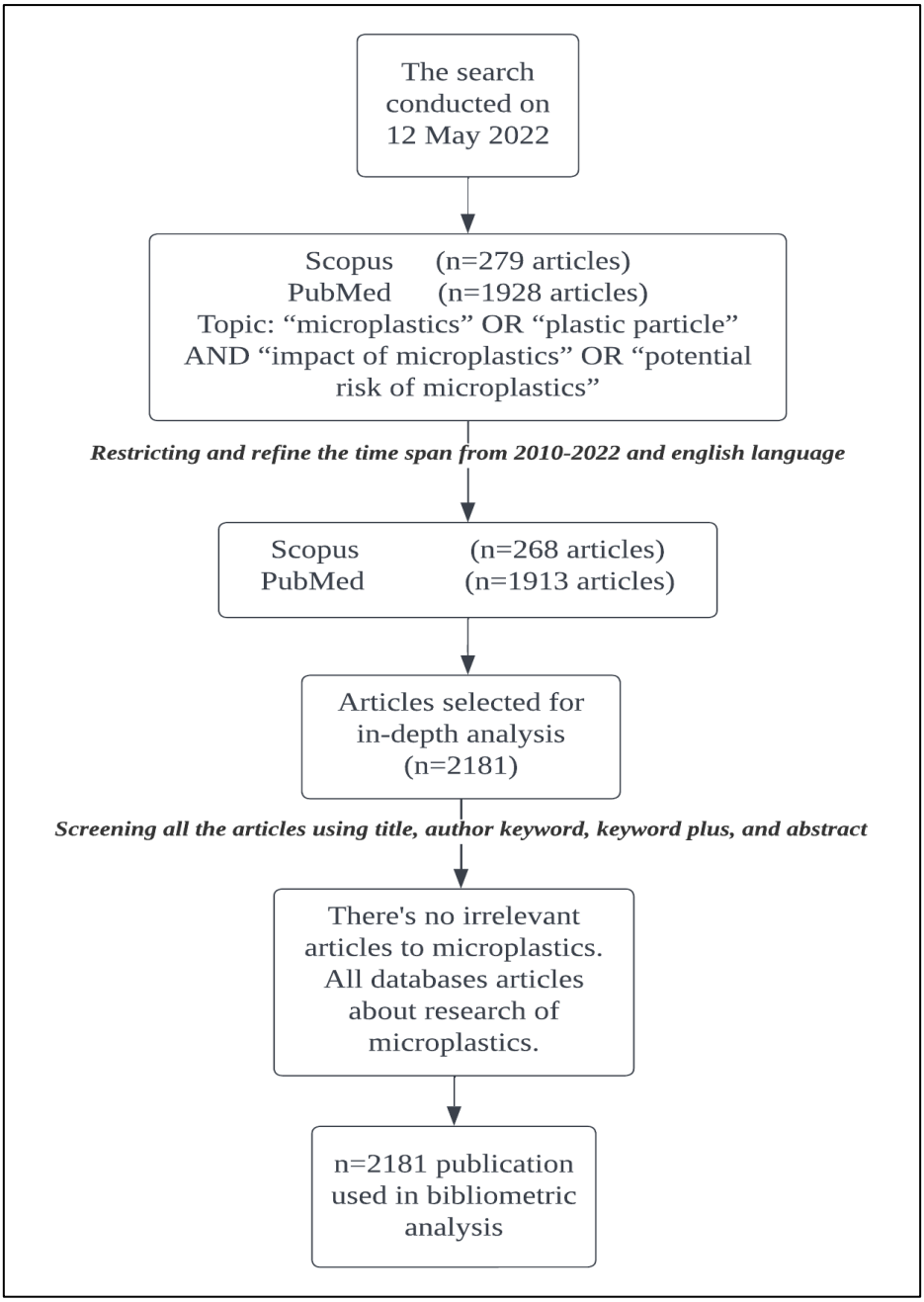

Figure 4: Flowchart for study selection

Eligibility Criteria and Study Selection

Only articles published between 2010 to 2022 with a focus on microplastics. Moreover, there was no restriction on the type of articles that were included, but only articles that using english language were included and been analyze.

Data Analysis

The researchers installed the most recent version 4.1.1 of Rstudio on Windows 8.1. Researchers open Rstudio and then type >install.packages("bibliometrix") in the command prompt to install the bibliometrix. The researcher then enters > library(bibliometrix) and biblioshiny(bibliometrix) at the Rstudio command prompt to launch the biblioshiny web-interface (Fakruhayat et al., 2022). The researcher will next access the biblioshiny web-interface and import the files downloaded from the Scopus and PubMed databases into the

biblioshiny app. A bibliometric analysis of microplastics trend using two database from Scopus, and PubMed has be done to get research output analysis of annual scientific production, country scientific production and the most cited countries, most relevant authors, most relevant journals and journals growth, most frequent words and co-occurrence network, and collaboration among countries. Figure 3 below shows the features of biblioshiny web-interface that can be used to analyze the data.

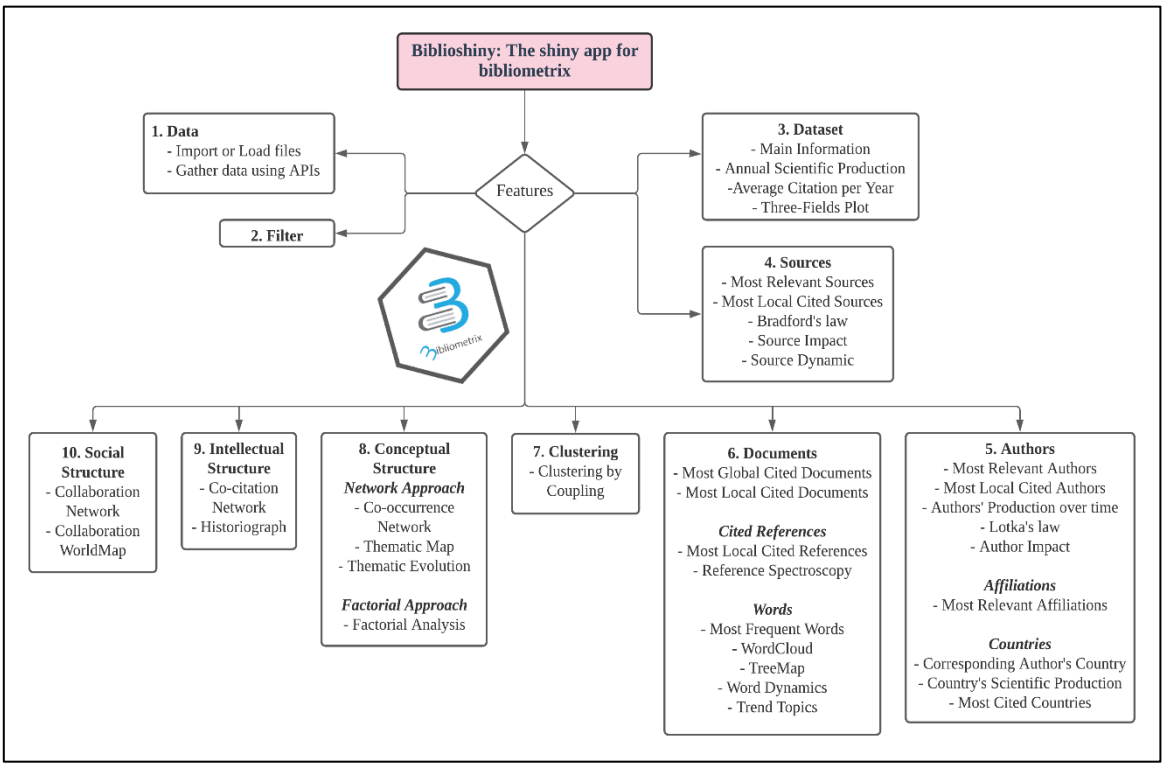

Figure 5: Features of Biblioshiny app for bibliometrix
Source: (Fakruhayat et al., 2022)

Results and Analysis

Using the search strategy has been mention above, researhcers retrieved 2181 databases of publication from two different indexed by Scopus, and PubMed in relevant topic to "microplastics" OR "plastic particle" AND "impact of microplastics" OR "potential risk of microplastics" over the year 2010 until 2022 around the world.

Annual Scientific Production

From 2010 to 2022, 2181 articles were published related to microplastics, plastic particle, impact of microplastics, and potential risk of microplastics articles indexing in Scopus (268 articles), and PubMed (1913 articles). Between 2010 and 2022, the highest number of articles published in Scopus indexed journals was in 2021 (79 of 268), while the lowest number was in 2012 (1 of 268). In addition, from 2010 to 2021, there are significant increase in global trends in annual scientific production in Scopus database for the topic of microplastics. Annual scientific production in PubMed showed the maximum of articles was published is 2021 (602 of 1913), and the minimum of articles was published is in 2010 which is only 1 publication recorded in that year. Moreover, the global trends of annual scientific production showed an obvious increase with the number of publications increasing steeply since 2010 until 2021.

Moreover, for the annual growth rate has been recorded 36.23% (Scopus), and 68.23% (PubMed),

Table 1
Figure: Annual scientific publications from 2010 to 2022.

Year	Scopus	PubMed
2010	0	1
2011	2	2
2012	1	4
2013	2	6
2014	2	9
2015	2	19
2016	6	37
2017	12	62
2018	17	107
2019	33	181
2020	52	369
2021	79	602
2022	60	514

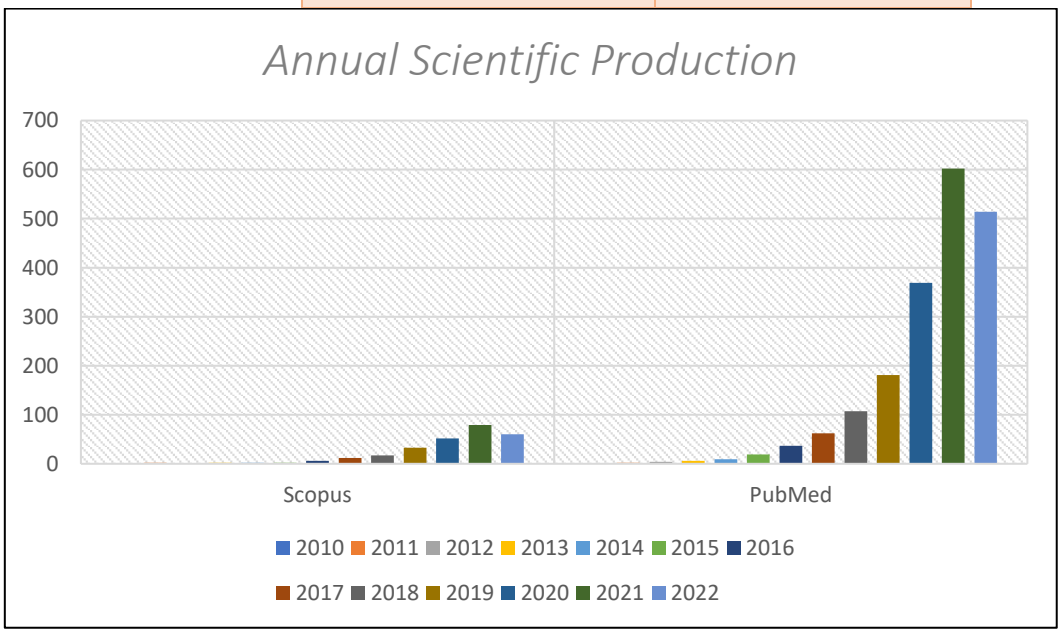

Figure 6: Annual scientific publications from 2010 to 2022 in Scopus and PubMed databases.

Country Scientific Production

Table 2 displays the findings of a global analysis of country scientific production. The analysis results demonstrate the most top 10 a global country scientific production on the topics of microplastics, plastic particle, impact of microplastics, and potential risk of microplastics.

Scopus' and PubMed publishing database shows top 10 most country scientific production aroundthe world between 2010 until 2022. According to the findings of the analysis, there were 54 countries aroundthe world that contributed to the Scopus index with articles focused on microplastics, while 82 countries contributed to the PubMed index with

articles on microplastics. When compared to other countries, China had the largest number of publications recorded of 603 articles. This was followed by Italy with 124 articles, the United Kingdom with 93 articles, and Canada in 10th place with 38 articles. According to the findings of the analysis, China also recorded the largest number of publications in the PubMed database with 4586 articles, followed by Italy with 675 articles, the United States of America with 638 articles, and South Korea in 10th place with 254 articles.

Table 2
Country Scientific Production

	Scopus		***PubMed***	
No	**Country**	**Freqency**	**Country**	**Freqency**
1	China	603	China	4586
2	Italy	124	Italy	675
3	Uk	93	Usa	638
4	Usa	90	Germany	565
5	Brazil	51	Spain	448
6	India	51	India	344
7	Germany	46	France	335
8	Portugal	42	Brazil	290
9	France	39	Australia	258
10	Canada	38	South Korea	254

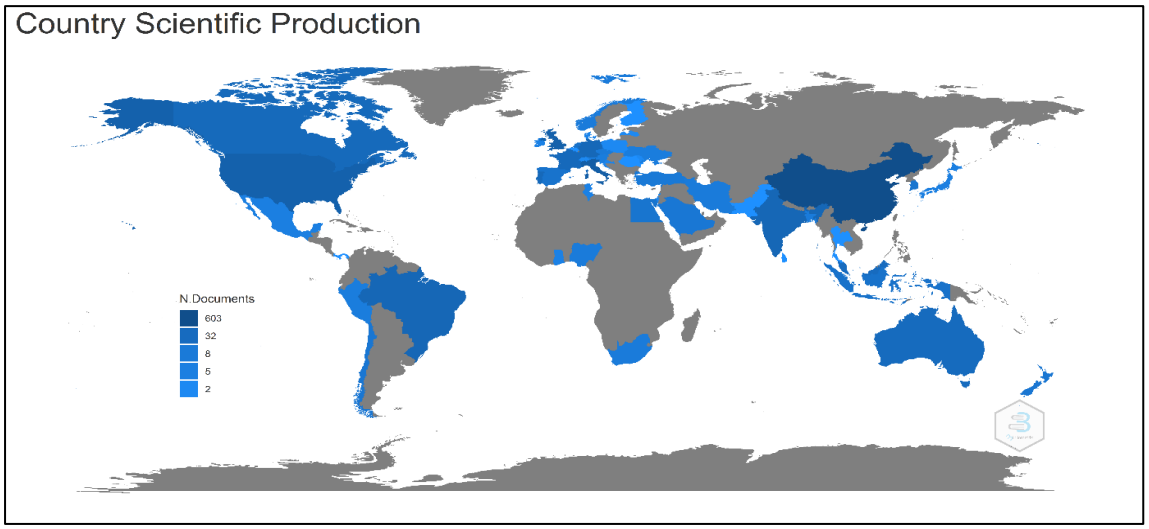

Figure 7: Country scientific Production indexed by Scopus

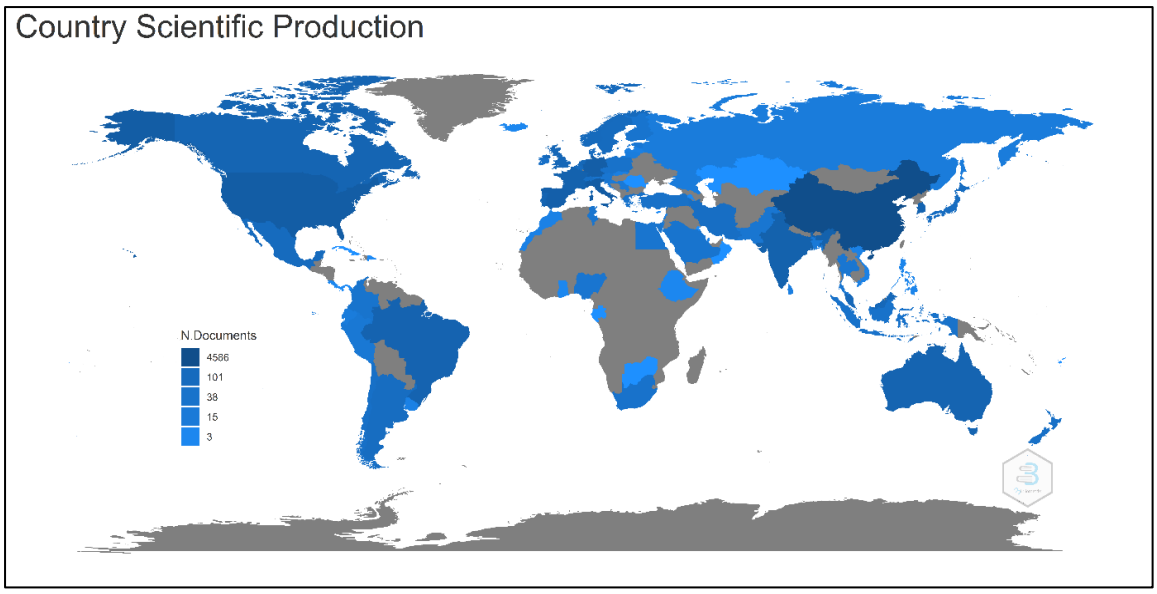

Figure 8: Country scientific Production indexed by PubMed

Most Relevant Authors

A total of 1184 authors have been identified in the 268 articles published in Scopus journals in the field of microplastics research. The top 10 authors are listed in (**Table 3**). According to the results of the analysis was discovered that an author by the name of Wang J recorded the largest number of article publications in the area of microplastics research in total was 14 articles. Followed by researcher by the name of Zhang Y, who has published as many as 12 papers; Liu Y, who has published 9 articles; and Ding J, who has published 5 articles which is are among the top 10 most significant authors in microplastics research publications.

Table 3
Top 10 most relevant author in microplastics (Scopus)

Top 10 most relevant author in microplastics research articles			
Authors	**Articles**	**Articles Fractionalized**	**Percentage (%)**
Wang J	14	3.58	5.2
Zhang Y	12	1.69	4.5
Liu Y	9	1.25	3.4
Li Y	6	1.02	2.2
Shi H	6	1.05	2.2
Yang Y	6	0.62	2.2
Zeng G	6	0.67	2.2
Zhang X	6	0.78	2.2
Chen Y	5	0.80	1.9
Ding J	5	0.70	1.9

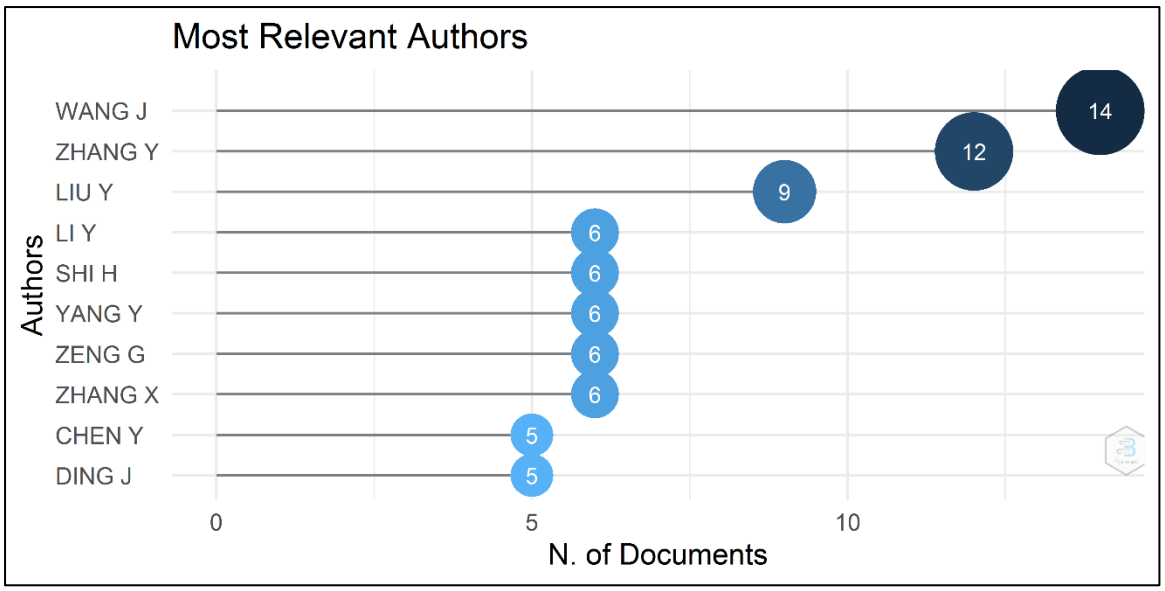

Figure 9: Top 10 most relevant authors in microplastics research articles indexed by Scopus

There are a total of 6489 authors identified in the 1,913 microplastics research publications published in PubMed journals (**Table 4**). The top 10 authors are listed. According to the results of the analysis, it was found that the author with the most article publications in the field of microplastics research was Zhang Y, who published a total of 68 papers. Followed by Wang J, who has published 60 articles, Li Y, who has published 52 articles, and Li D, who has published 29 articles as the ranking 10 most influential authors in microplastics research publications

Table 4
Top 10 most relevant author in microplastics (PubMed)

Top 10 most relevant author in microplastics research articles			
Authors	**Articles**	**Articles Fractionalized**	**Percentage %**
Zhang Y	68	10.55	3.6
Wang J	60	10.85	3.1
Li Y	52	7.36	2.7
Wang Y	49	6.79	2.6
Li J	41	5.94	2.1
Wang X	38	5.44	2
Liu Y	37	5.55	1.9
Zhang X	33	4.73	1.7
Li X	31	4.21	1.6
Li D	29	4.55	1.5

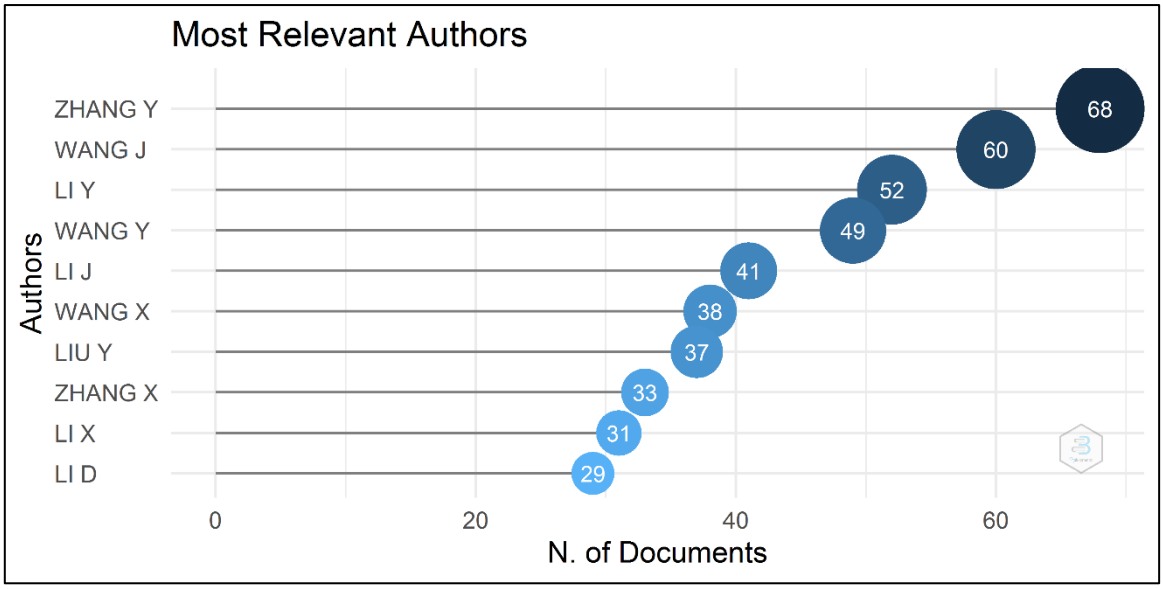

Figure 10: Top 10 most relevant authors in microplastics research articles indexed by PubMed

Most Relevant Journals (Sources)

The analysis of the most relevant journal articles in microplastics research revealed that overall 108 journals in 268 publications in the Scopus database. Table 5 displays the top 10 most relevant journal articles in microplastics research from a total of 108 journals. According to the findings of the analysis, the most popular journals are Science Of The Total Environment, which has 30 articles published. Environmental Pollution journals came in second place with 29 total papers published, followed by Marine Pollution Bulletin journals (20 articles), Chemosphere journals (14 articles), and so on. Environmental Research journals ranked 10th, with 4 published publications.

Table 5
Top 10 most relevant journals articles in microplastics research (Scopus)

Most relevant journals articles in microplastics research	
Sources	**Articles**
Science Of The Total Environment	30
Environmental Pollution	29
Marine Pollution Bulletin	20
Chemosphere	14
Ecotoxicology And Environmental Safety	10
Environmental Science And Pollution Research	10
Journal Of Hazardous Materials	10
Environmental Science And Technology	9
Environment International	5
Environmental Research	4

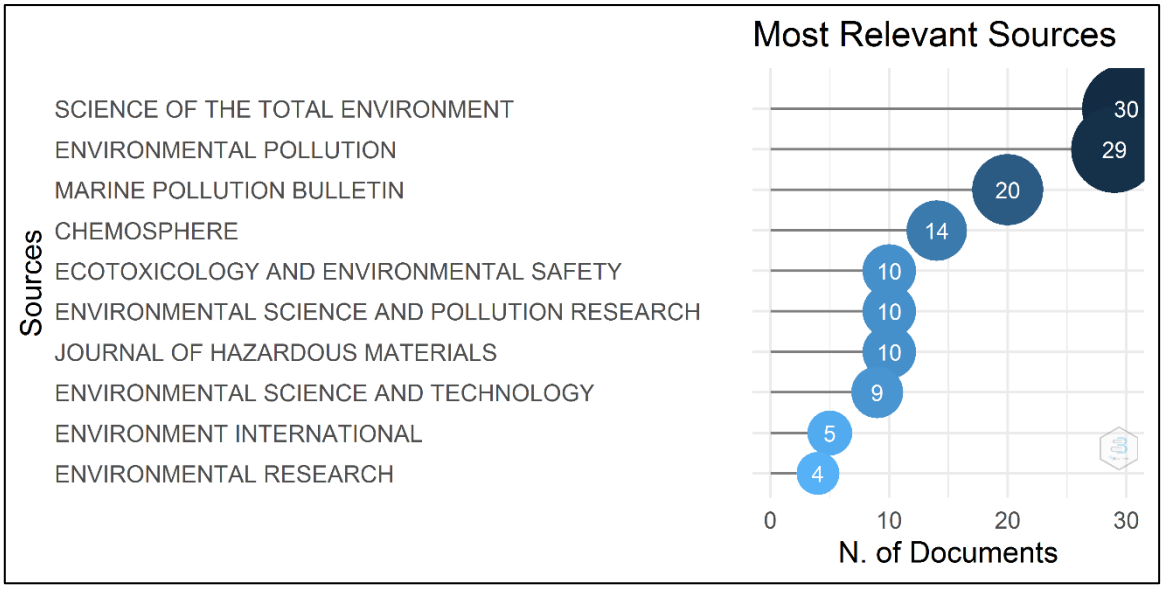

Figure 11: Top 10 most relevant journals articles in microplastics research (Scopus)

The analysis that conducted at the most relevant journal articles in the discipline of microplastics research has found that 197 different journals in 1913 publications in PubMed database. Out of a total of 197 publications, Table 6 presents the top 10 journal articles in the research of microplastics that are considered to be the most significant. The results of the analysis indicate that one of the most widely read journals is Science Of The Total Environment, which currently has 355 articles in PubMed database. Environmental Pollution journals came in second place with a total of 241 papers published, followed by journals of Journal of Hazardous Materials with 182 articles, journals of Marine Pollution Bulletin with 174 articles, journals of Chemosphere with 134 articles, and so on. The Environmental Research journals came in at ranked ten with 41 published articles.

Table 6
Top 10 most relevant journals articles in microplastics research (PubMed)

Most relevant journals articles in microplastics research	
Sources	**Articles**
The Science Of The Total Environment	355
Environmental Pollution (Barking Essex : 1987)	241
Journal Of Hazardous Materials	182
Marine Pollution Bulletin	174
Chemosphere	134
Environmental Science & Technology	85
Environmental Science And Pollution Research International	72
Water Research	51
Ecotoxicology And Environmental Safety	44
Environmental Research	41

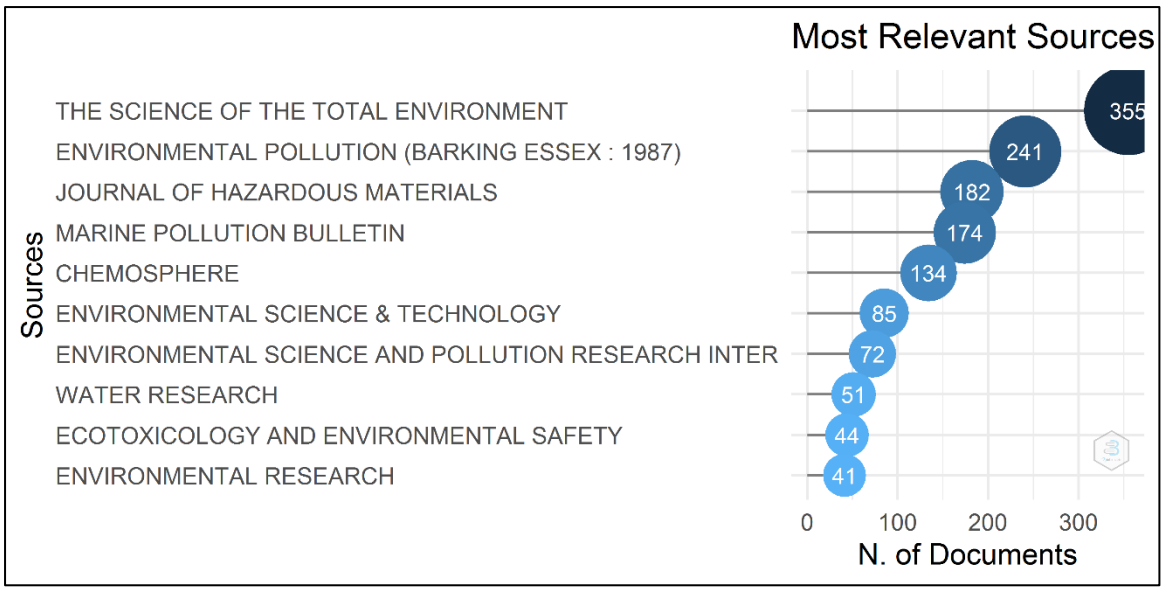

Figure 12: Top 10 most relevant journals articles in microplastics research (PubMed)

3.5 Most Frequent Words And Co-Occurrence Network On Microplastics Research

Keywords in research are one of the most essential factors in defining a topic of the study and may show scientific trends. The analysis of keyword co-occurrence networks will provide a clear overview of the relationships between a variety of terms through nodes. In the 268 articles related to microplastics research published in the Scopus database, 778 keywords were found to be utilised in microplastics research by researchers all over the globe. Table 9 displays the top 20 most commonly used keywords in microplastics research studies, as filtered by the author's keyword in Scopus database publications. The most frequently used keywords in the microplastics research discipline are "microplastic" (36 occurrences), "nanoplastics" (12 occurrences), "polyethylene" (9 occurrences), "toxicity" (9 occurrences), "ingestion" (8 occurrences), "oxidative stress" (8 occurrences), "plastic pollution" (8 occurrences), and so on (**Table 7**).

Table 7
The most top 20 frequently utilized keywords in microplastics research (Scopus)

The most top 20 frequently utilized keywords in microplastics research	
Words	**Occurrences**
microplastics	125
microplastic	36
nanoplastics	12
polyethylene	9
toxicity	9
ingestion	8
oxidative stress	8
plastic pollution	8
pollution	8
risk assessment	8
fish	7
human health	7
bioaccumulation	6
biofilm	6
freshwater	6
plastic debris	6
plastics	6
accumulation	5
apoptosis	5
marine environment	5

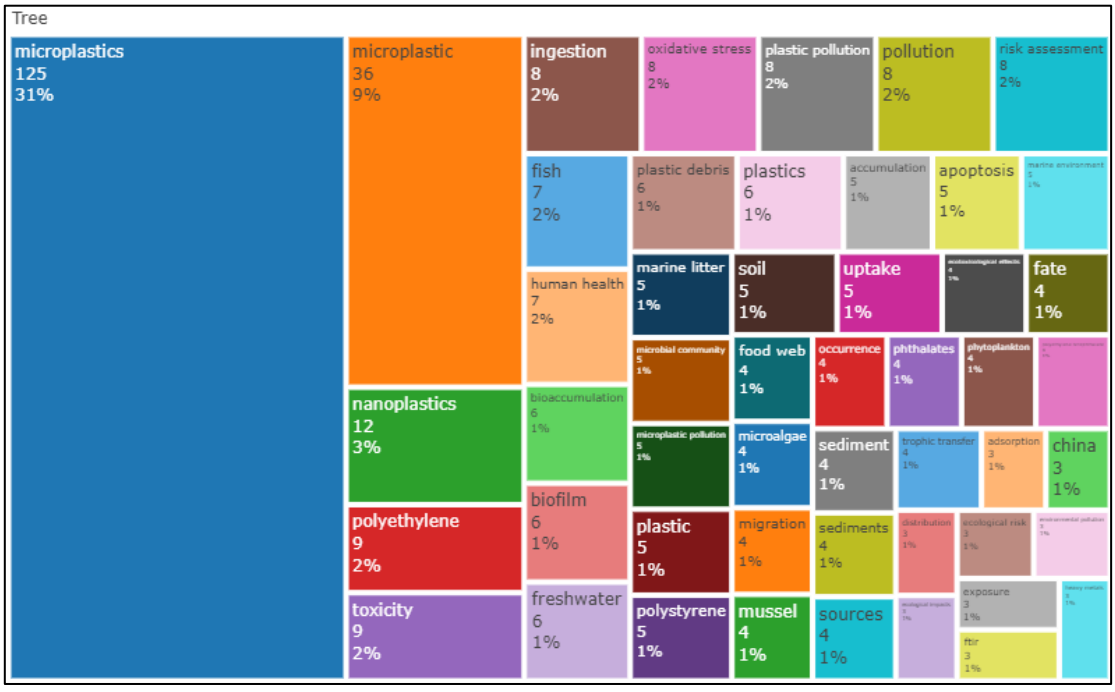

Figure 13: Tree map of top 50 frequently utilized keywords in microplastics research (Scopus)

2129 keywords were discovered to be used in microplastics research by researchers all over the world in the 1913 articles relevant to microplastics research published in the

PubMed database. Table 8 shows the top 20 most often used keywords in microplastics research studies as filtered by the author's keyword in PubMed database articles. According to result of analysis, "microplastic" (854 occurrences), "plastics" (800 occurrences), "animals" (691 occurrences), "environmental monitoring" (557 occurrences), "water pollutants chemical/analysis" (511 occurrences), "ecosystem" (405 occurrences), "humans" (359 occurrences), and so on are the most frequently used keywords in the microplastics research discipline (**Table 8**).

Table 8
The most top 20 frequently utilized keywords in microplastics research (PubMed)

The most top 20 frequently utilized keywords in microplastics research	
Words	**Occurrences**
microplastics	854
plastics	800
animals	691
environmental monitoring	557
water pollutants chemical/analysis	511
ecosystem	405
humans	359
plastics/toxicity	206
water pollutants chemical/analysis/toxicity	188
water pollutants chemical/toxicity	124
plastics/analysis	122
soil	114
microplastics/toxicity	108
water pollutants chemical	95
china	86
environmental monitoring/methods	85
polystyrenes	78
polystyrenes/toxicity	76
adsorption	75
environmental pollution	70

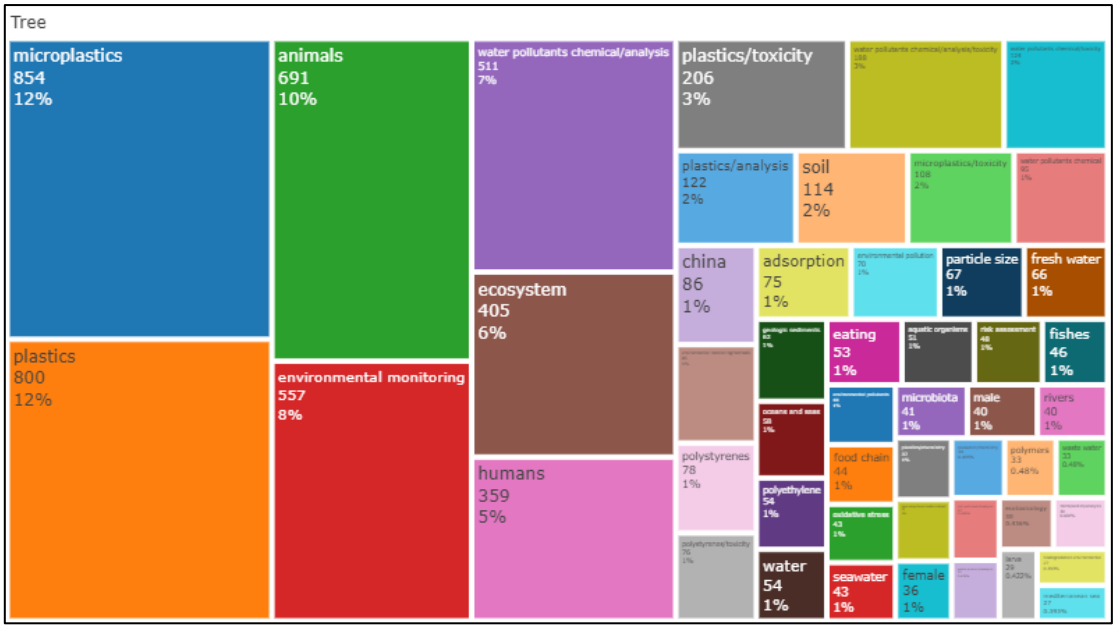

Figure 14: Tree map of top 50 frequently utilized keywords in microplastics research (PubMed)

Collaboration among Countries in Microplastics Research

In this part, researcher examine at collaboration trends and major patterns at the country levels around the world. According to the findings of the researcher's analysis, there are 139 collaborations among countries in microplastics research throughout the world in Scopus database. Table 9 lists the top 20 countries that collaborate the most on microplastics research. The highest frequency of collaboration countries is between the China and United States (USA) was 10 times, China and Hong Kong (9 frequency), China and Malaysia (4 frequency). Furthermore, collaboration between United Kingdom and USA has recorded 4 times. A 3 frequency collaboration among countries was recorded by United Kingdom with three country (Australia, Netherlands, and Norway). Moreover, collaboration between Germany and Norway has also been recorded 2 frequency, placing at ranked 20th globally in terms of collaboration in microplastics research.

Table 9

The top 20 most collaboration among countries in microplastics research (Scopus)

Collaboration among countries in microplastics research		
From	**To**	**Frequency**
China	USA	10
China	Hong Kong	9
China	Malaysia	4
United Kingdom	USA	4
China	United Kingdom	3
United Kingdom	Australia	3
United Kingdom	Netherlands	3
United Kingdom	Norway	3
USA	Canada	3
Brazil	Australia	2
Brazil	Norway	2
Brazil	Portugal	2
Canada	Australia	2
China	Australia	2
China	Canada	2
China	Czech Republic	2
France	Australia	2
France	Spain	2
Germany	Australia	2
Germany	Norway	2

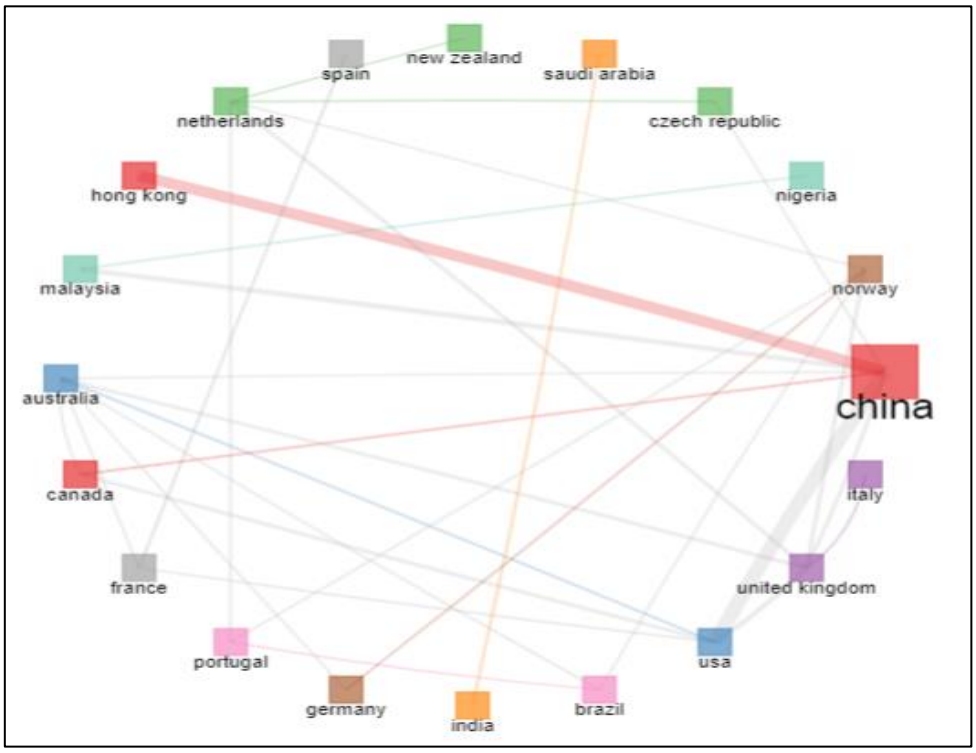

Figure 15: Collaboration network among countries around the world in the microplastics research (Scopus)

According to the results of the researcher's analysis, there are a total of 497 collaborations between countries in the field of microplastics research in the PubMed database throughout the whole world. The top 20 countries that work together the most on research related to microplastics are shown in table 10. The highest frequency of collaboration countries is between the country of China which is has 4 collaboration with other countries (China-USA; 74 frequency), (China-Australia; 27), (China-Canada; 18 frequency), and (China-Korea; 16 frequency). In addition, there have been 15 frequency recognised of collaboration between Italy and Spain. Spain and Portugal have been collaborating together on a research project about microplastics which is has recorded 14 frequency. In addition, 8 frequency of collaboration between China and Saudi Arabia in microplastics research putting them at ranked number 20 on the list of countries that collaborate the most around the world.

Table 10
The top 20 most collaboration among countries in microplastics research (PubMed)

Collaboration among countries in microplastics research		
From	**To**	**Frequency**
China	USA	74
China	Australia	27
China	Canada	18
China	Korea	16
Italy	Spain	15
Spain	Portugal	14
USA	Canada	13
China	Denmark	12
China	Germany	11
China	India	10
China	Spain	10
Norway	Sweden	10
France	Belgium	9
Germany	Norway	9
Italy	Germany	9
Netherlands	Norway	9
USA	Australia	9
Brazil	Portugal	8
China	Japan	8
China	Saudi Arabia	8

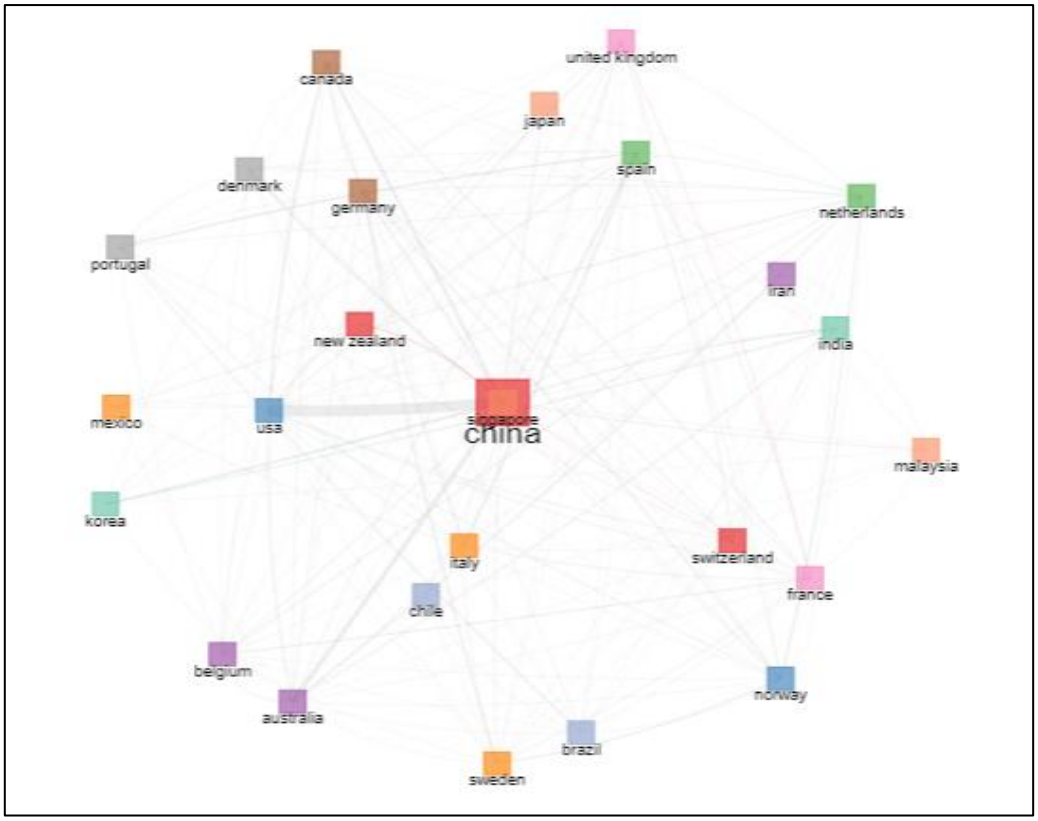

Figure 16: Collaboration network among countries around the world in the microplastics research (PubMed)

Discussion

Bibliometric analysis is a part of research that involves statistically analysing scientific papers in order to identify citation links between publications and research trends in a particular field. This type of research is helpful for comparing the contributions made by researchers from different countries (Şenel & Demir, 2018). A bibliometric analysis was carried out to evaluate global trends in microplastics research, with an emphasis on particular themes within the field, during a period of time spanning from 2010 to 2022. To the best of our knowledge, this study was carried out to fillthe gaps from previous study of bibliometric analysis on the global research on microplastics using the Scopus, and PubMed databases.

Researcher used “microplastics” OR “plastic particle” AND “impact of microplastics” OR “potential risk of microplastics” over the year 2010 until 2022 around the world as topics to find out the articles in Scopus, and PubMed databases. The purpose of the reseacher is want to focus on microplastics research and the impact of microplastics research around the world from 2010 to 2022, without no restriction on the type of articles and only articles using english languages been concluded. After screening, only 2181 articles remained for in-depth analysis. All 2181 articles retrieved from Scopus, and PubMed databases are related to microplastics research.

The number of scientific publications is an attractive bibliometric indicator that may indicate the growth of a discipline research area (Sun et al., 2018). For example, a conspicuous change in the number of articles published annually could indicate that there is an important turning point in the area of research. In the current analysis, the researcher discovered that the number of annual scientific publications in Scopus and PubMed databases increases steadily from 2010 to 2021. There are a number of factors that foster the growth of the

microplastics research such as the improvement of laboratory conditions and technology, the increase in the number of researchers, and the expansion of governmental policies in support of microplastics research. (Sharma etal., 2018).

The results of the analysis also show that the country of China is the country with the highest number of scientific production and the most cited in two databases Scopus, and PubMed. This is not surprising when China become a country that leads in microplastics research because China has a lot of researcher in microplastics rsearch area. In microplastics research, for the most relevant author is Wang J (Scopus), and Zhang Y (PubMed). For the result analysis of most relevant journal is by Science Of The Total Environment with 30 articles in Scopus and 355 articles in PubMed database. Futhermore, the most frequent word in microplastics research is “microplastic” (36 occurrences), “nanoplastics” (12 occurrences), “polyethylene” (9 occurrences), “plastics” (800 occurrences), “animals” (691 occurrences), “environmental monitoring” (557 occurrences), “water pollutants chemical/analysis” (511 occurrences), and so on in two different database. Currently, there are 139 collaborations among countries in microplastics research around the world in Scopus database and 497 collaborations among countries in PubMed databases have written publications about microplastics. In Scopus and PubMed database, the top most publishing countries were the collaboration countries between the China and United States (USA).

Conclusion

This article presents a literature review and bibliometric analysis of research on microplastics to determine the areas within which the annual scientific publication growth, the most productive authors, the most cited countries in microplastics research, most frequent word has been using, most popular journal name, and which countries has highest collaboration with other country in microplastics research. The bibliometric analysis of 2181 microplastics and impact of microplastics research documents gathered from the Scopus, and PubMed databases in over the year from 2010 until 2022. In this present article, bibliometric analysis was applied to the disciplines of microplastic and and the impact or potential risk of microplastics research with the aim to identify the current trends in these disciplines as occasionally used interchangeably in the literature. The main outcomes in this study is according to the bibliometric analysis, MPs studies have remarkably increases steadily from 2010 to 2021 in Scopus and PubMed databases, the country of China is the country with the highest number of scientific production, the most relevant author is Wang J in Scopus database, and Zhang Y in PubMed database, the most relevant journal is by Science Of The Total Environment in Scopus and PubMed database, the most frequent word in microplastics research is microplastic and plastics, and the top most collaborations among country publishing of microplastics research were the collaboration countries between the China and United States (USA) in Scopus and PubMed databases. Although there are a few studies of bibliometics analysis on microplastics, this study has been conducted because to fill the gaps studies from previous study with combining Scopus and PubMed databases and doing a new result analysis on microplastics research on the topic microplastics and impact or potential risk in microplastics over the year 2010 to 2022. Therefore, reseacher suggest that for future studies should evaluate and focus on the publications on other databases to determine if similar trends are present for microplastic, microfibers/microfibres, nanoplastic, and the effects of MPs exposure on human health research.

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Appendix A

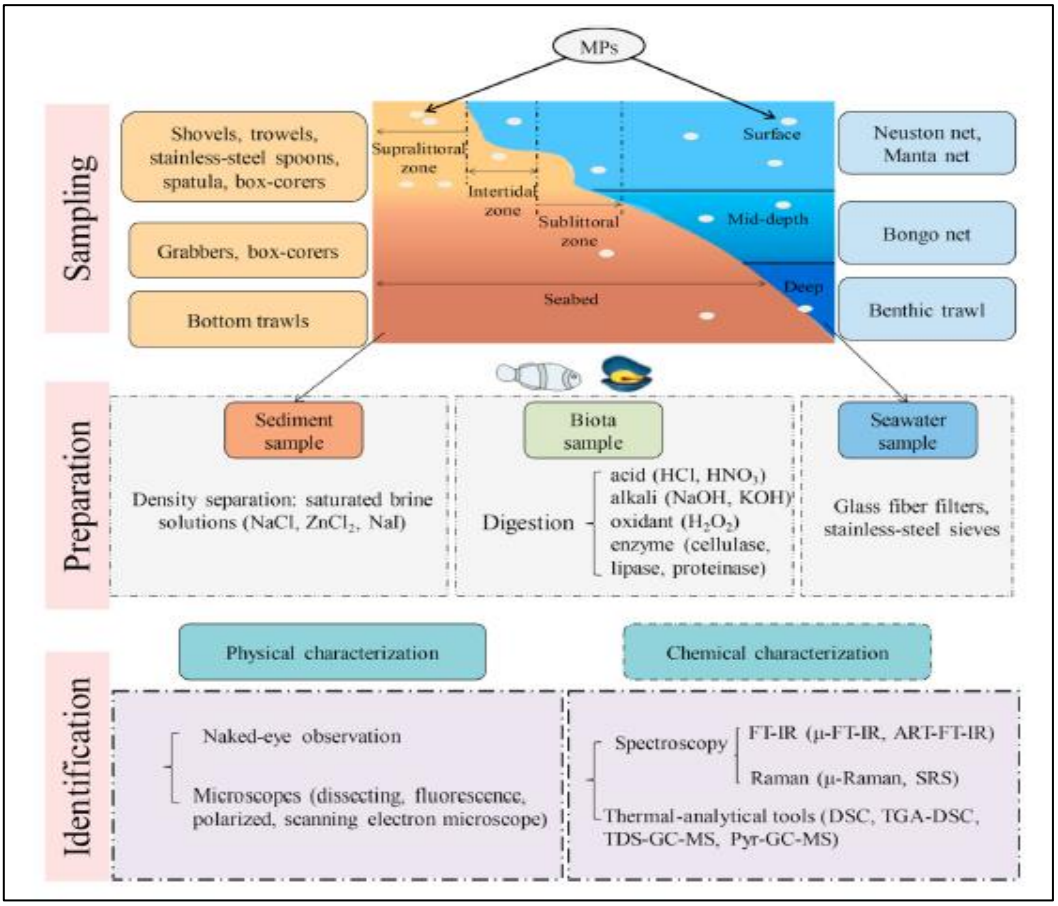

Figure 1: General procedure for the analyses of MPs
Source: (Wu et al., 2021)

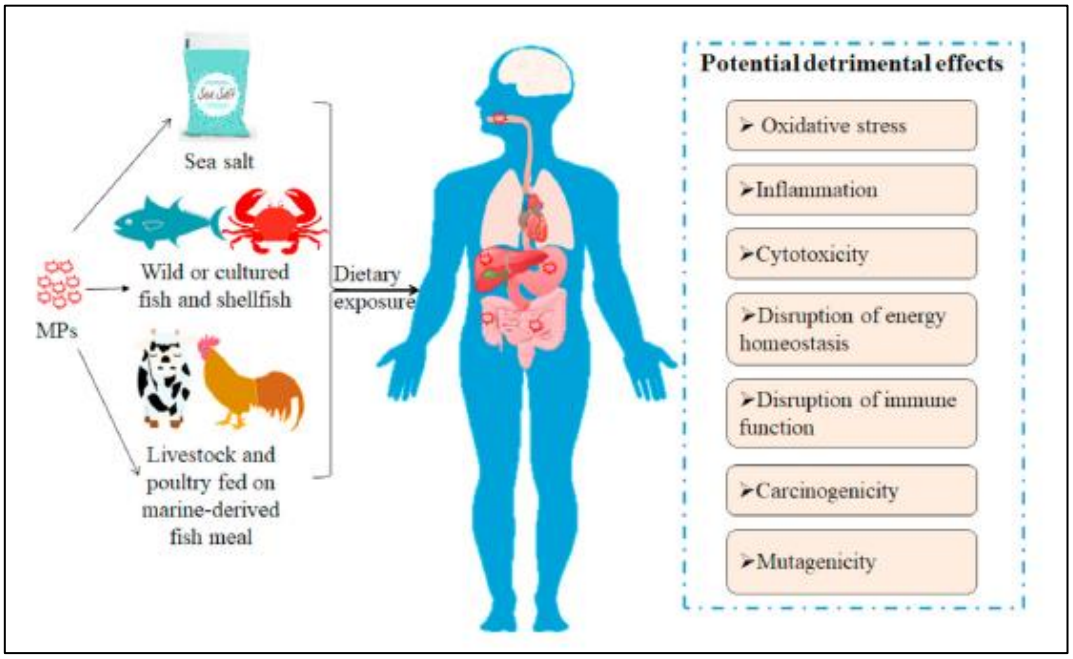

Figure 2: Dietary exposure of MPs and potential human health effects
Source: (Wu et al., 2021)