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A Comprehensive Review of Microplastic Pollution in South Asian Freshwater Environments

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ABSTRACT:
While the global discourse on microplastic pollution has garnered significant attention, the plight of South Asian freshwater ecosystems remains shrouded in relative obscurity. This oversight, particularly pronounced in developing nations, including those within South Asia, necessitates urgent redressal. Our meticulous review, drawing from an extensive analysis of 179 pertinent documents sourced from the esteemed Scopus database, endeavors to illuminate this crucial issue. Delving into the depths of South Asian freshwater landscapes, our study unveils the stark reality of microplastic contamination, dissecting its geographical spread, abundance, and the intricate tapestry of its physical and chemical attributes. In this exploration, we accentuate the burgeoning collaborative efforts amongst South Asian nations, with India spearheading pivotal research initiatives. Beyond the scientific realm, our review casts a discerning eye on the profound implications of microplastic infiltration on human health, compelling the formulation of proactive mitigation strategies. Through a synthesis of findings, we underscore the imperative for heightened vigilance and concerted action, advocating for a multifaceted approach encompassing further research endeavors, policy interventions, and international cooperation. In essence, our review serves as a clarion call, illuminating the urgent imperative to safeguard South Asian freshwater ecosystems and fortify human well-being against the insidious encroachment of microplastics.

1. Introduction

Plastics, a diverse group of high molecular-weight polymers, have become indispensable materials due to their mouldable nature and versatility [1]. The first synthetic plastic, celluloid, was introduced by Alexander Parkes in 1862, marking the onset of the plastic era [2]. Subsequent developments like Bakelite in 1927 revolutionized manufacturing but inadvertently initiated the onset of plastic pollution [3]. What was once considered a blessing soon became a curse as plastics began accumulating on Earth's surface. Plastic pollution was caused by the unsustainable usage and disposal of plastic products, posing threats to human health, ecosystems, and economies worldwide [4] [5] [6].

Rivers, vital conduits for plastic movement between ecosystems, have become hotspots for plastic pollution in terrestrial and freshwater environments [7]. Land-based sources contribute to the accumulation of plastic pollutants, particularly endangering fresh water as well as marine ecosystems [8]. Post-consumer plastic waste accumulation exacerbates environmental pollution [9], leading to the generation of microplastics [10,11].

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Plastic wastes break down in the environment through Biological, Physical and chemical processes, producing microplastics which are further degraded to form Nanoplastics. Microplastics (MPs) are characterized as plastic particles with size less than 5mm. Microplastics in freshwater pose threats through entanglement, ingestion, and their capacity to carry toxins [12]. Microplastics pose a significant risk as they can enter the food chain, Freshwater ecosystems in Southern Asia are particularly disrupted by microplastics, which accumulate hazardous pollutants and leach chemicals [13]. These plastics act as conduits for heavy metals in freshwater wetland systems and It makes it even more hazardous. [14]. Additionally, the abundance of microplastics in sediment poses serious threats to the lake's food web [15]. Reports indicate that microplastic contamination in freshwater environments leads to ingestion by aquatic animals, posing risks through trophic transfer, toxicity, and physical harm [16]. Furthermore, potentially harming organisms by triggering immune responses [17,18].

Nanoplastics are plastic particles smaller than 1 μm (i.e., 1000nm) [19]. Furthermore, the emergence of nanoplastics, presents an even more potent threat due to their enhanced ability to bind toxic chemicals, pathogens, and other pollutants because of their small size and large surface area compared to microplastic [20], [21]. The impacts of microplastic pollution on terrestrial and aquatic ecosystems are heightened by global change [22]. Despite their heightened risk, research on nanoplastics remains limited [23].

Similar to marine systems, freshwater systems also include microplastics; however, due to differences in characteristics such as closer distance to sources than marine environment and small system size, they show unique patterns in microplastic accumulation [24].

In the context of South Asia, where three of the world's most populous countries are located, research on microplastic pollution is relatively scarce, with notable exceptions in India [25]. Research on microplastics in freshwater environments is critical to accurately assess environmental risks and develop effective mitigation strategies, particularly in Southern Asian developing nations where the impacts of microplastic pollution are most acutely felt [26]; [27]. This region, despite its significance, faces a dearth of microplastic research, highlighting the urgent need for comprehensive studies to address this growing environmental concern.

2. Methods

Microplastics have been the subject of extensive study in recent years, primarily conducted by developed countries such as the United States, China, and European nations. Unfortunately, many third-world countries, despite being disproportionately affected, have not engaged in prominent research on microplastic pollution. However, it is noteworthy that India, as a developing nation, has made significant studies in analysing microplastic pollution, comparable to efforts in developed countries like China, United States, and other countries. To conduct our review, we utilized Scopus, an Elsevier database, employing keywords such as “Microplastic,” “Fresh Water,” “Lake,” “River,” and specific country names as shown in Fig. 1. Our search retrieved 179 relevant documents. The evolution of studies on the effects of microplastic pollution in South Asian freshwater environments has seen a notable increase in citations and publications since 2016, with a significant rise in total citation volume after 2020 (Table 1 and Fig. 2). On average, there were 539.67 citations per year during this period, indicating a growing focus on this field.

VOS viewer, a tool for visualizing bibliographic networks, has facilitated the analysis of cross-national cooperation in microplastic pollution research [28]. Fig. 3 depicts cooperation between nations based on productivity and citation metrics, revealing distinct clusters and highlighting the global interest in understanding and addressing microplastic pollution in South Asian freshwater environments. Collaborative efforts involving countries such as China, the United States, the United Kingdom, and Australia demonstrate international engagement in this critical South Asian environmental research area. Notably, smaller nations like Brunei Darussalam in Southeast Asia also contributed to research collaboration in South Asian freshwater ecosystems. India emerges as a prominent collaborator in this research area, while Nepal shows minimal collaboration and Bhutan and Maldives have no articles in the database.

In conducting our review, we aimed to gather a substantial body of studies focusing on various types of freshwater ecosystems, primarily from India where a considerable number of research articles are available. However, for countries such as Pakistan, Sri Lanka, Bangladesh, and Nepal, the number of publications are limited. Despite this challenge, we made an effort to include all relevant studies. Regrettably, we were unable to retrieve any research articles for Bhutan, Maldives, and Afghanistan, indicating a significant gap in scientific literature pertaining to microplastic pollution in freshwater ecosystems within these nations. This underscores the need for further research efforts and attention to address the knowledge gap and environmental concerns across South Asian countries.

3. Discussion

Microplastics and Microplastics have emerged as significant environmental issues in the 21st century, particularly impacting developing countries in Southern Asia due to high plastic production and challenges in waste management and law enforcement [29]. The presence of microplastics in lake systems varies globally depending on factors such as efficiency in plastic management, local economic structures and levels of development [30]. Table 2 shows the abundance and distribution of microplastic across South Asian fresh waters.

ABUNDANCE AND DISTRIBUTION OF MICROPLASTICS IN FRESHWATER ENVIRONMENTS

The distribution of microplastics in urban surface waters is significantly influenced by anthropogenic factors [31]. Groundwater and drinking water samples contain low concentrations of microplastics, likely due to abrasion from plastic equipment during transportation or water purification processes [32].

Microplastic pollution in South Asian freshwater ecosystems exhibits significant variability in abundance and composition, influenced by geographical factors. Urban areas show higher concentrations of microplastics compared to rural or remote regions, likely due to urbanization and anthropogenic activities [33]. Despite potential indirect effects of economic conditions on microplastic pollution, many South Asian countries lack substantial data on microplastic accumulation. This lack of data can be attributed to socioeconomic constraints and insufficient research funding, especially in countries like Bhutan, Maldives and Afghanistan [34].

Rivers generally exhibit higher microplastic abundances compared to lakes, likely due to transport and accumulation mechanisms influenced by anthropogenic discharges, tidal exchanges, flow dynamics, and microplastic density [35]. The relationship between the trophic condition of the lake and the quantity of microplastics in the sediments and surface water may also be responsible for the accumulation of MPs in river [36]. Hydrological conditions and morphometric features of lakes affect microplastic presence and distribution, with both direct and diffuse sources contributing significantly to microplastic loads [37]. Specific areas within larger lakes and rivers, termed "hot spots," exhibit high microplastic concentrations possibly due to the weathering and decomposition of plastics, with wind or waves carrying microplastics into water bodies where they concentrate in high number [38].

As rivers flow downstream from mountainous regions, microplastic quantities increase, accumulating in estuaries and lentic stretches before reaching coastal areas and contributing to microplastic pollution in urban coastal regions [39]. The complex relationship between socioeconomic factors and microplastic accumulation remains a less explored topic within the context of South Asian freshwater environments. Understanding these dynamics is crucial for developing effective strategies to mitigate microplastic pollution in South Asian freshwaters.

COMPOSITION OF MICROPLASTICS

Microplastics exhibit a diverse range of characteristics, influenced by various pollution sources and environmental factors. The composition of microplastics is predominantly polymeric, with materials like polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), and polyester (PET) which originating from industries, domestic waste, and anthropogenic activities. Polyethylene microplastics are particularly pervasive in freshwater systems

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globally, demonstrating high abundance rates compared to other polymers [40]. Studies have also suggested a correlation between microplastic colour and pollution levels, although conclusive data is lacking according to our analysis [41]. The likelihood of aquatic organisms ingesting microplastics may increase if the microplastics mimic the colour of their natural prey, as observed with blue microplastics and amber stripe scads in Rapa Nui, South Pacific [42]. The composition of the microplastic communities in various habitats shows strong relationships, indicating that sample sites in closed geographic locations had identical sources of pollution [43]. Also, microplastics exhibit varying sizes, influenced by pollution sources rather than geographic locations for instance, Vembanad Lake in India shows microplastics predominantly less than 4 mm, whereas Mahodand Lake in Pakistan exhibits a size range between 300 µm and 500 µm. The abundance and characteristics of microplastics, including colour, size, and polymer type, are heavily influenced by urbanization in developing countries like those in South Asia [44]. This indicates a strong correlation between high urbanization rates and microplastic pollution levels in South Asia.

FACTORS INFLUENCING ABUNDANCE, DISTRIBUTION, AND COMPOSITION

Freshwater environments exhibit varying levels of microplastic pollution, ranging from over a million particles per cubic meter to fewer than one particle per 100 cubic meters, depending on the location [45]. Research shows that microplastics in freshwater systems disperse vertically. The distribution of particles on different freshwater levels is dependent on a number of variables, including depth, the water source's flow rate, the size and density of the microplastics, and others. [46]. Analysing microplastics in both surface water and sediments is crucial for understanding their distribution and impacts. It is evident from our review that freshwater systems are often contaminated by fibres and filaments, likely originating from sewage effluents, particularly tainted by fibres from laundry [47]. Tourism emerges as a significant contributor to microplastic pollution, with globalization and tourism having asymmetric effects on pollution emissions in South Asia [48]. Regions with intense human activities or poor waste management practices tend to exhibit higher concentrations of microplastics.

In freshwater environments, microplastic pollution from fishery activities is a significant concern, with studies indicating a notable increase in microplastic concentrations associated with the use of 100 m mesh size nets [49,50]. The predominance of polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyethylene terephthalate (PET) microplastics underscores the impact of these materials on freshwater ecosystems, comprising up to 70% of total microplastic content [51,52]. Notably, microplastic beads constitute a small proportion of detected types in freshwater environments, potentially due to their efficient removal by primary and secondary wastewater treatment plants [49]. This complex array of microplastic sources—including microbeads from cosmetics and cleaning agents, fibres and fragments from laundered clothes, and degraded plastic litter—highlights the diverse origins and pervasive nature of microplastic pollution in freshwater ecosystems [52].

Waste management is a critical issue in South Asian countries like Bangladesh, India, Pakistan, and Sri Lanka, where inadequate disposal practices contribute to the breakdown of plastics into microplastics [53,54]. Despite population growth in South Asia since the 1950s, economic conditions in these countries have remained challenging, with globalization impacting the region significantly [55,56]. Proper regulations are essential to mitigate the accumulation of microplastics and their potential impacts on freshwater ecosystems and human livelihoods [51]. Addressing these complex issues requires integrated efforts to improve waste management practices and mitigate the sources of microplastic pollution in the region.

IMPLICATIONS FOR ENVIRONMENTAL AND HUMAN HEALTH

Microplastic pollution poses a significant threat to aquatic ecosystems due to its pervasive nature, environmental persistence, and diverse interactions with biota [57]. Microplastics have the ability to absorb and concentrate environmental pollutants, which can be transported through food chains and disrupt ecological processes, presenting an increasing hazard to marine biota [58]. Due to wind, microplastics from aquatic environment may

transfer to the terrestrial environments, where it may adversely affect microbial activity and soil structure, contributing to global changes in ecosystems [59].

Microplastics in freshwater sources are exposed to humans through a variety of means, including drinking and swimming, as well as through aquatic organisms' position within the food chain. Exposure to microplastics through ingestion, inhalation, or skin contact can lead to oxidative stress, inflammation, and an increased risk of neoplasia in humans [60]. Animal trials have demonstrated that exposure to polystyrene microplastics during pregnancy and lactation increases the risk of metabolic disorders in both mothers and offspring [61]. Additionally, microplastic exposure may result in neurotoxicity and immune system disruption [62].

The leaching of monomers, additives, and adsorbed pollutants from microplastics can lead to toxicity and can induce immune responses [63]. Respiratory system lesions and inflammatory reactions in airways and interstitial spaces have also been observed due to microplastic exposure [64]. Although microplastics are present in surface waters and sediments, their low quantities and minimal impact on species suggest they may not be currently negatively affecting the ecosystem [65].

However, the long-term accumulation of microplastics in human populations remains concerning, although the lowest threshold for human exposure to microplastic contamination is unknown, it can irreversibly build up to 8.32×10^3 particles/capita in children up to the age of 18 and up to 5.01×10^4 particles/capita in adults up to the age of 70. Mohamed Nor *et al.*, highlighting the need for continued research and mitigation efforts [66]. Understanding the full extent of microplastic pollution and its consequences on ecosystems and human health is essential for developing effective strategies to mitigate this growing environmental and public health issue.

MITIGATION STRATEGIES

The political, legal, economic, and sociocultural systems of South Asian nations are distinct and play a significant role in their approach to environmental challenges [67]. South Asian countries are striving to make an impact on global commerce and achieve self-sustainability in markets dominated by first-world nations, leveraging their unique advantages despite challenges like high population and distinct political climates. However, they face specific challenges related to microplastic pollution in their water bodies and require alternative and unique approaches in addition to traditional mitigation methods.

Microplastics primarily enter the environment through dumping sites and daily-use plastic products in South Asian nations, contributing significantly to freshwater pollution [68]. Mitigation options for microplastic pollution in these countries include pyrolysis, replacing plastics with biodegradable polymers, plastic filtration, and chemical or biological degradation [69]. Regulation of plastic use in tourism and fishing activities is crucial as these sectors are reported to be significant sources of microplastics in rivers and lakes.

Inadequate water treatment in water treatment plants is also a contributing factor to microplastic pollution in South Asian water systems. Establishing effective on-board ballast water treatment techniques and setting acceptable microplastic concentration limits are essential steps to reduce microplastic contamination in these nations [70].

Despite the growing concern, research on microplastic pollution in freshwater systems is still in its early stages in countries like India, Pakistan, and Bangladesh, while countries like Maldives, Bhutan, and Afghanistan have yet to report any research on freshwater microplastics [71]. Government investment in research is crucial to understanding the abundance and fate of microplastics in South Asian freshwater ecosystems and developing effective management and mitigation strategies. Comprehensive research on the dynamics, distribution, and degradation processes of microplastics is essential for designing targeted interventions to combat this emerging water pollutant [72].

Circular Economy

The circular economy, characterized by closed production systems and efficient resource use, aims to reduce resource intake, waste, emissions, and energy leakage to promote sustainable development [73]. This transition from a linear "take-make-use-dispose" model to a more sustainable resource allocation strategy addresses global sustainability challenges by improving the economy and lessening environmental stress [74,75]. Circular economy initiatives prioritize efficient energy use and material flow to mitigate the negative impacts of human activities on the environment [76].

Implementing circular economy principles, including the Reduce-Reuse-Recycle approach, can significantly reduce microplastic pollution and its environmental impacts [77]. For instance, circular economy practices like reusing and recycling textile waste can help control microfiber pollution in freshwater systems [78]. Circular economy strategies also aim to increase recycling rates, which can contribute to reducing plastic waste and associated pollution [79].

To effectively address microplastic contamination in South Asian countries, circular economy strategies should be applied, including eco-designing plastic products and strengthening regulatory frameworks [80]. However, it's important to acknowledge the limitations of the circular economy, such as unforeseen consequences and a lack of social considerations, which may constrain its ethical applications [81]. Despite challenges such as limited knowledge, resources, and costs, the circular economy remains a viable solution for addressing high levels of microplastic pollution in developing countries like those in South Asia [82].

5. Conclusion

In the omnipresence of plastic in our daily lives, the onus lies on us to safeguard our planet for the generations to come. To confront the pressing challenge of microplastic contamination in South Asia's freshwater ecosystems, our strategies must echo sustainability at every turn. Central to this endeavor is a concerted focus on reducing plastic consumption, revolutionizing waste disposal practices, exploring the promise of bioplastic alternatives, and pushing the boundaries of wastewater treatment technologies [83].

Furthermore, our battle against microplastic contamination demands relentless efforts in the regular removal of plastic debris from freshwater reservoirs, complemented by legislative actions aimed at curbing the proliferation of single-use plastic and fostering public consciousness regarding responsible waste management practices. The heightened prevalence of plastic pollution in urban and industrial enclaves within South Asia underscores the exigency for stringent waste management protocols and heightened industrial oversight.

Governments, recognizing the gravity of the situation, must earmark resources for extensive research endeavors aimed at unraveling the intricate web of microplastic pollution across diverse water bodies. These efforts should encompass a broad spectrum of research domains, ranging from major freshwater sources to subterranean aquifers, and delve into the nuanced interplay between microplastic contamination and geographical peculiarities such as riverine hotspots and seasonal fluctuations like the monsoon [83].

In acknowledging the looming specter of nanoplastics, characterized by their minuscule dimensions and expansive surface area, it becomes imperative for South Asian nations to lead the charge in researching both microplastic and nanoplastic pollution. Collaboration with international counterparts will be pivotal in forging effective mitigation strategies.

Crucially, Governments agencies must galvanize communities into action through education and inclusive participation, instilling a collective ethos of environmental stewardship and nurturing a vision of a sustainable tomorrow. In this collective endeavor lies the promise of a cleaner, healthier, and more resilient future for South Asia and beyond.

6. Future Prospectives

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Inspiring Solutions for Microplastic Pollution in South Asian Freshwater Ecosystems:

In the face of ubiquitous plastic intrusion into our lives, the imperative to safeguard South Asian freshwater ecosystems from the pernicious grip of microplastic pollution beckons innovative solutions. Anchored in sustainability, our approach hinges on concerted efforts to slash plastic consumption, revolutionize waste disposal practices, explore bioplastic alternatives, and propel advancements in wastewater treatment technologies. Priority must be accorded to reducing plastic disposal rates, especially in developing South Asian nations, through the deployment of cost-effective cleanup technologies and fortified source reduction initiatives. Legislative measures must curtail single-use plastic proliferation, while heightened public awareness campaigns foster responsible waste management practices. Urban and industrial zones, focal points of plastic pollution, necessitate stringent waste management regulations and heightened industrial oversight. Governments must allocate resources for comprehensive research spanning major freshwater sources and groundwater reservoirs, unraveling the intricate nexus between microplastic contamination and geographical features like river hotspots and seasonal variations. Acknowledging the looming threat of nanoplastics, South Asian nations must spearhead research efforts in tandem with international collaboration, bolstered by community engagement initiatives promoting collective responsibility for environmental stewardship and a sustainable future.

Authors' Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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Figures:

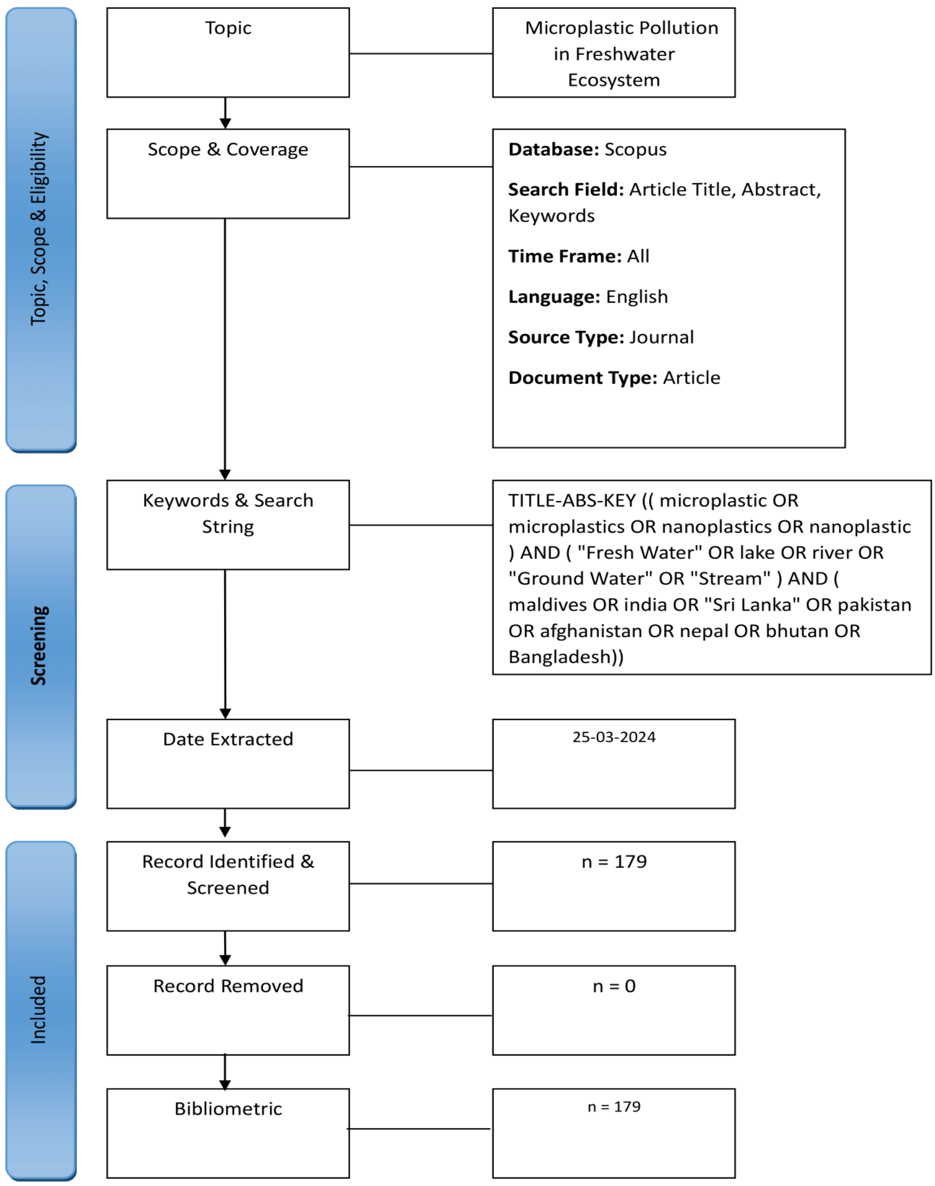

Fig. 1 Flow diagram of the search strategy (Zakaria et al., 2021)

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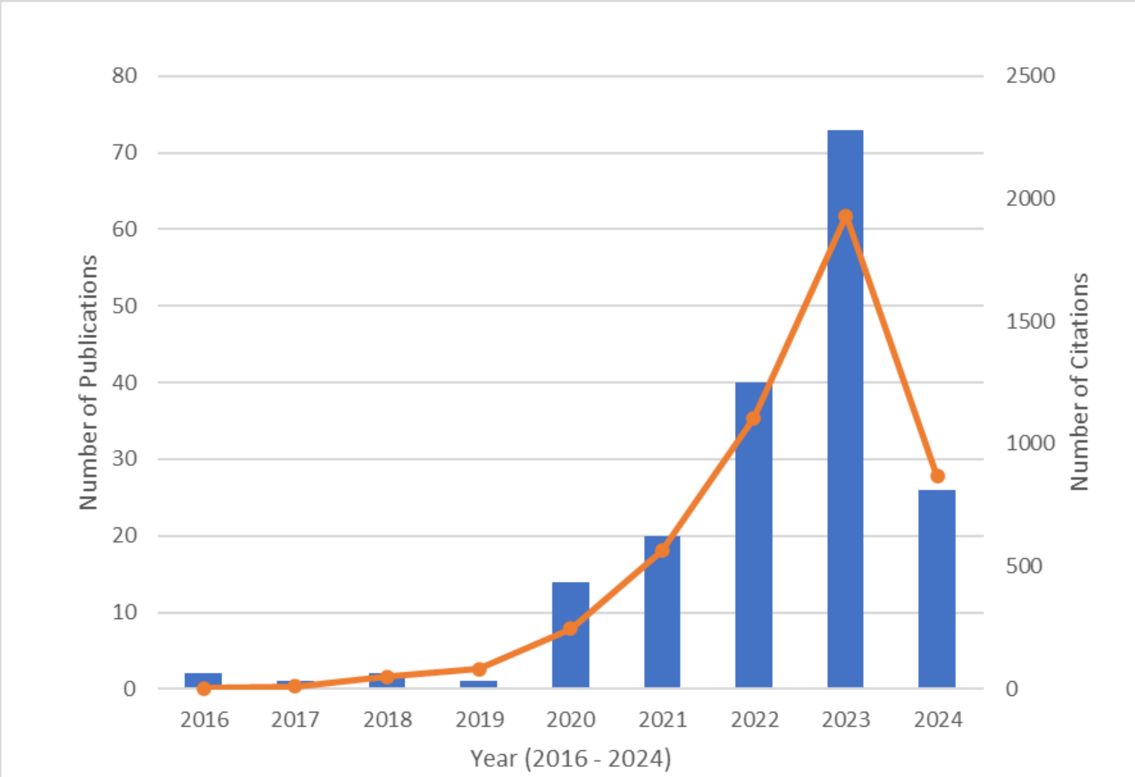

Fig. 2 Graph depicting publications on microplastic pollution in freshwater environments and their corresponding citations by year.

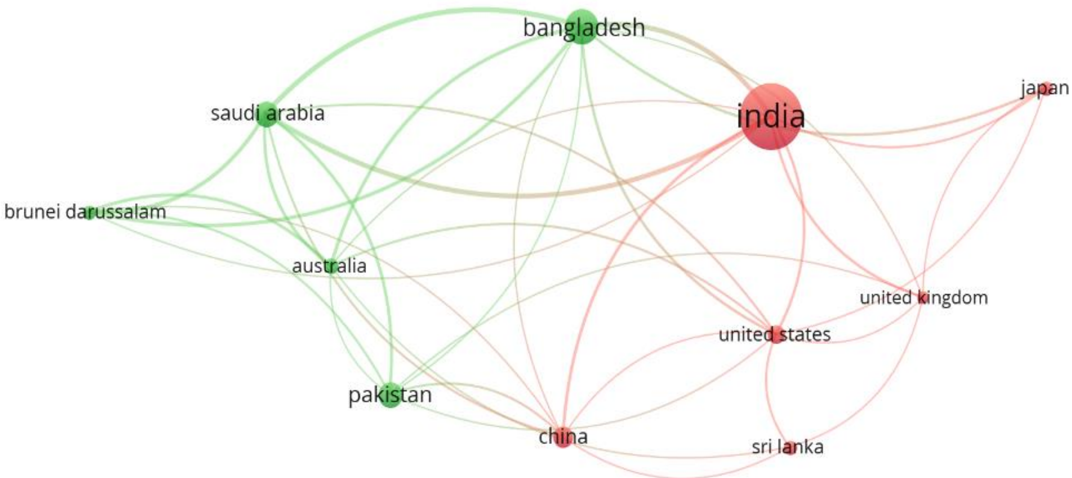

Fig. 3 Network visualization map of the co-authorship by countries.
Unit of analysis = Countries
Counting method: Full counting
Minimum number of documents of an author = 5
Minimum number of citations of an author = 5

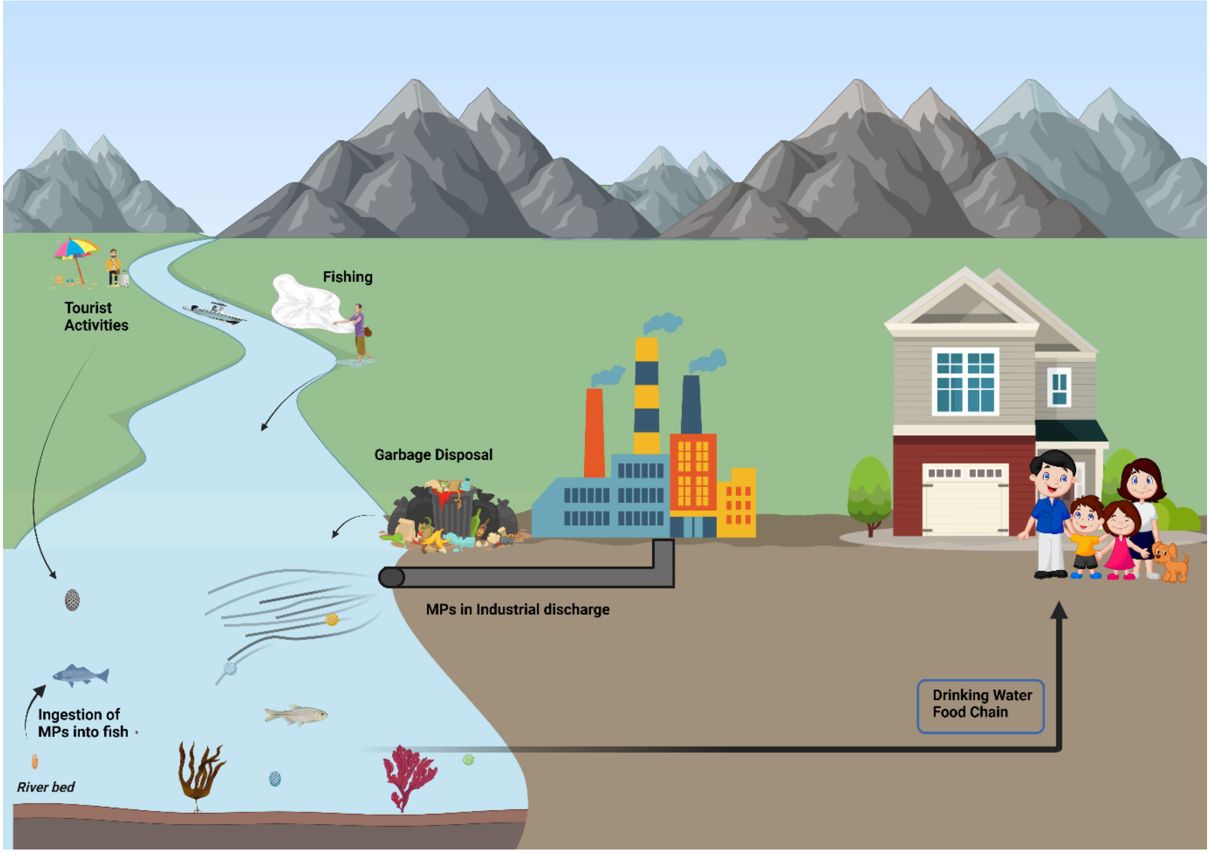

Fig. 4 Microplastics in Freshwater, Primarily Originating from Industrial Discharge, Fishing, Tourism, and Uncontrolled Garbage Disposal Activities, Potentially Entering Human Body via Food Chain and Drinking Water

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Tables:

Table 1 Total Number of Publications on Microplastics in Freshwater Ecosystems Retrieved from Scopus, Year-wise, with Respective Percentages and Cumulative Percentages

Year	Total Publications	Percentage	Cumulative Percent
2024	26	14.53	**100**
2023	73	40.78	**85.47**
2022	40	22.35	**44.69**
2021	20	11.17	**22.35**
2020	14	7.82	**11.17**
2019	1	0.56	**3.35**
2018	2	1.12	**2.79**
2017	1	0.56	**1.68**
2016	2	1.12	**1.12**
Total	**179**	**100**	

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Table 2 Presence of Microplastics in Various Freshwater Sources Across South Asia

Country	Water Source	Name of Water Source	Microplastics Identified	Abundance	Size Range	Composition	Major Source of MP/NPs	Sampling Year	References
India	Lake	Vembanad Lake	Fibres	0.872 ± 573 MPs/L of Water*	40 to 4730 µm (4 ± 3 mm)	NA	NA	Feb-19	**[84]**
	Lake	Urban-Dal Lake	Fibres	416 ± 38 MP/kg of dry sediment	NA	Polyamides, Polyethylene, Polyvinylchloride, and Polypropylene	Fishing activities, Tourism, and Untreated wastewater	NA	**[85]**
	Lake	Anchar Lake	Fibres – 91%, Fragments – 8%, Pellets – 1%	606 ± 360 MP/Kg of dry Sediment	NA	Polyamide (PA) - 96%, Polyethylene terephthalate (PET) - 1.4%, Polyvinyl chloride (PVC) - 0.9%, Polypropylene (PP) - 0.7%	Automobile, Textile, and packaging industries	NA	**[86]**
	Lake	Red Hills Lake	Fibres (37.9%), Fragments (27%), Films (24%), and Pellets (11.1%)	5.9 MPs/L of water and 27 particles/kg of dry sediment	NA	High-density polyethylene (HDPE), Low-density polyethylene (LDPE), Polypropylene (PP), and Polystyrene (PS)	Weathering of Fishing Nets, Automobile exhaust	August 2018	**[87]**
	Lake	Nainital lake	NA	8.6–56.0 MPs /L of Water and 400–10600 MPs/kg in surface sediments*	NA	High-density polyethylene	Tourist activities and Domestic run-off catchments	NA	**[88]**
	Lake	Lake Manipal (Mannapalla Lake)	Majorly Fibres (95.59% during Monsoon and 96.59% during post monsoon) and Fragments	0.423 MPs/L of water during Monsoon and 0.117 MPs/L of water during post monsoon	300–1000 µm	Polyethylene terephthalate (PET; 95.71%) Cellulose (CL; 1.38%)	Stormwater sewers and Tourist activities	September 2019 and January 2020	**[89]**
	Lake	Kolavai Lake	Fibres And Fragments	6.1 ± 2.5 MPs /L of Water	0.1 µm to 300 µm	Polyethylene (PE), High-density polyethylene (HDPE) and Polypropylene (PP)	Solid Waste disposal, Road Pollution	May 2022	**[90]**
	River	Ulhas River	NA	40 to 600 MPs /kg of sediment	NA	LDPE, HDPE, polypropylene, polystyrene, polyethylene, polyester, and nylon	NA	NA	**[91]**
	River	Noyyal River	Fragments, Films, Fibres and Sheets	500 to 6500 n/m^3 of dry sediments	0.05-5 mm	Majority polypropylene (PP), low-density polyethylene (LDPE), PET	Direct littering, Uncontrolled Waste	Winter (November-January) 2021	**[92]**

* *Marked have been converted to common units for consistency across the table, facilitating ease of understanding.*

							disposal, Washing Clothes		
	River	Mahanadi River	Fibres, Fragments and Films are majorly present irrespective of monsoon in both water and Sediments	5–25 MPs/L of Water and 62–354 items/ Kg of Sediments	Minimum size <0.125mm and maximum size 5mm	Polyesters (PEs), Polyethylene (PE), Polypropylene (PP), polyvinyl chloride (PVC), Polyamide (PA), Polystyrene (PS), and Polycarbonates (PC)	Plastic Waste Disposal, Fishingnets, Poorly treated Waste-water treatment plants	Monsoon Season (July-September) and pre monsoon season (May- June)	**[93]**
	River	Yamuna River	Fragment (60.7%), pellet (19.6%), Fiber (16.8%), Foam (1.9%), and Film (0.9%)	1.78 MPs/L of Water*	Between 0.25 mm and 5 mm	High-density polyethylene (HDPE), Low-density polyethylene (LDPE), polypropylene (PP), Polystyrene (PS), and Polyethylene terephthalate (PET)	Wastewater discharges, Bank run-off Activities, Religious practices, Wear and tear on the road etc.,	March 2020	**[94]**
	River	Ganges River	Fibres (91%), Fragments (9%)	0.038 MP/L of Water	Average 2459 µm	Rayon (54%), Acrylic (24%), PET (8%), PVC (6%), Polyester (5%) and Nylon (3%)	Washing Clothes, Waste disposal	May 2019	**[95]**
	Ground Water	Wells and Bore Wells	Foam, Fiber, Film, and Pellet	4.2 MPs/L of Water	In the range of 0.11–12.5 mm	Polyamide (nylon), Polyethylene (PP) and Polyester (P)	Industrial discharges, Tourism activities, Dumping wastes, Leakage of drainage systems	January 2019	**[96]**
	Ground water	Well	Fibres (48%), Flakes (22%)	12 MPs/L of Water	NA	NA	NA	NA	**[96]**
Pakistan	Lake	Rawal Lake	Films, Fibres, Granules and Foam	0.0064 ± 0.0005 to 0.0088 ± 0.0005 MPs/L of Water*	In the range of 0.045 to 5 mm	Polyethylene, Polypropylene and Polystyrene	Sewage waste and Household dumping	February 2020	**[97]**
	Lake	Mahodand Lake	Fibres (50%), Sheets (28%), and Fragments (22%)	0–5 MPs/L of water	In the range of 300–500 µm Particles (57%), 150–300 µm Particles (28%) and 50–150 µm Particles (15%)	Low-density Polyethylene (LDPE) - (44.4%), Polypropylene homopolymer (PPH) - (19.4%), Polyvinyl chloride (PVC) - (30.5%), and High-density polyethylene (HDPE) - (5.5%)	Tourism activities	June and July of 2019	**[98]**
	River	River Ravi	Fibres, Fragments, foam and beads	In Water: 0.768 ± 0.869 MPs/L of Water during Monsoon 1.324 ± 1.925 MPs/L of	Majority 300 µm to 5mm MP	Polyester (PES), Polypropylene (PP), Polystyrene (PS), and Polyethylene	Household washing, textile effluent, Building Construction Pollution and Cosmetics	Post-monsoon 2019 and monsoon 2020	**[99]**

				water post Monsoon* In Sediments: 5323 ± 3792 MPs/kg during Monsoon 2637 ± 2701 MPs/kg during Post Monsoon					
Bangladesh	Lake	Dhanmondi Lake	Film, Pellets, Fibres, Fragments and Foam	19 MPs/L of Water, 29 MPs/kg of Sediments	In the range of 100 µm to 5 mm	HDPE (40%), LDPE (30%), PVC (10%), PP (10%), and PC (10%)	NA	September 2021	**[100]**
	Lake	Gulshan Lake	Film, Pellets, Fibres, Fragments	36 MPs/L of Water, 67 MPs/kg of Sediments			Domestic sewage, Industrial waste, and Stormwater runoff		
	Lake	Hatir Jheel Lake	Film, Pellets, Fibres, Fragments	33 MPs/L of Water, 48 MPs/kg of Sediments			Domestic sewage, Industrial waste, and Stormwater runoff		
	River	Jamuna River	Foam (52%) in Surface Water and Foam (31%) in Sediments	0.16±0.02 MPs/L of Water and 10.33±1.45 MPs/kg of Sediment	Majority 0.5 – 2mm	NA	Fishing Nets, Agricultural mulching	July 2019	**[101]**
	River	Turag River	In surface water: Film (31%) and in sediment: Film (45%)	0.2±0.1 MPs/L of Water and 86.00±12.17 MPs/kg of Sediments	Majority 0.5 – 2 mm	NA	Dumping from industries and nearby urban run-offs		
	River	Karnafully River	In surface Water: Fibres (83%) and Fragments (17%) In Sediments: Fibres (56%), Fragments (34%), Films (6%), and Pellets (3%)	2.11 ± 1.15 MPs/L of Surface water and 477.04 ± 112.02 MPS/kg of Sediments	Average 0.86 ±0.10 mm in Surface water and 1.40 ± 0.08 mm in Sediments	PET (24.1 %), PP (17.2 %), PA (Nylon) (13.8 %), and Rayon (7 %)	Solid waste spills and Poor Waste Management	March 2020	**[102]**
Sri Lanka	Lake	Beira Lake	Fibre (>80%)	NA	NA	NA	Synthetic Textiles.	2021 and 2022	**[103]**

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		Talangama Canal	Fibre and Fragments	NA	NA	NA	Fishing nets, Ropes, and Plastic straws	2019 to 2022	
Nepal	Lake	Phewa Lake	NA	Mean Abundance in rainy season 1.51 MPs/L and 2.96 MPs/L in winter season	NA	NA	NA	February, 2021 and July, 2021	**[104]**

***NA = Data Not Available**