Nature Environment and Pollution Technology
An International Quarterly Scientific Journal
p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454
Vol. 22 No. 3 pp. 1635-1641 2023
Review Research Paper
https://doi.org/10.46488/NEPT.2023.v22i03.050
Open Access Journal

Microplastic Pollution in Seawater: A Review Study

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 17-02-2023
Revised: 06-04-2023
Accepted: 08-04-2023

Key Words:
Microplastics
Pollution
Seawater
Plastics

ABSTRACT

Due to its detrimental effects, notably on the well-being and biota of the ocean, microplastic contamination is becoming a bigger concern. Because of this, the issue of microplastics in the marine ecosystem is currently a major concern. The purpose of the study is to objectively evaluate the most recent data supporting the impact of microplastic contamination in seawater. When creating the standards for assessing the literature, P.I.C.O. was taken into account. For this inquiry, databases were selected and used throughout the data-collecting process. We checked PubMed, CINAHL, Google, Hinari, and the Cochrane Library. Boolean operators (AND, OR) and keywords were employed in the search to avoid oversaturating the data. Keywords used as per MeSH: Microplastic, plastics, seawater, ocean, pollution, microplastic exposure. The last five years (Since 2017) worth of studies were incorporated. Boolean search for relevant terms used. This limited my query to 188 records through various database searches. Several things were removed because they were unrelated to the study's subject. Due to its detrimental impact on marine biota, the issue of microplastic contamination in the marine ecosystem is a current concern. Microplastics, which serve as a vector, become stuck with harmful pollutants. It is necessary to implement conservation management strategies and assistance for different educational programs to protect the environment from these hazardous microplastics. Humans are exposed to plastic waste when eating fish tainted with plastic. As a result, there are various outbreaks of chronic diseases, and people suffer the effects. The public's education on the harmful effects of microplastics is a crucial need in this field. As a result, many inventions would be promoted to decrease the use and consumption of plastic and its products.

INTRODUCTION

One of the most significant contaminants in the marine environment is microplastics, which accumulate in sediments worldwide. (Zhao et al. 2018). Marine ecosystems all around the world are contaminated by microplastic litter. Due to the durability of these materials, the impact of microplastic contamination in the marine ecosystem may endure for years to come. Microplastics are a new category of pollutants that might be problematic, and there are currently few established methods for detecting them (Uyarra et al. 2016)

In the marine environment, plastic waste is common and disintegrates into tiny particles known as microplastics. The size of microplastics is limited to those with a diameter of less than 5 mm, and there are two subgroups: big MPs (1–5 mm) and tiny MPs. However, this categorization has no official name (0.1-1 mm). Microplastics comprise 92.4% of the estimated 5 trillion plastic objects, or 268 940 tonnes, in the world's seas. Bottles, containers, buoys, textile fibers, cosmetic microbeads, and even nanoparticles from industrial discharge are some of the main sources. Based on size, they are separated into macroplastics (2.5 cm to 1 m), mesoplastics (5 mm to 2.5 cm), microplastics, and nanoplastics. Under the effects of environmental weathering, primary plastic debris breaks down and biochemically degrades into secondary Microplastics (Thi Kim Khuyen et al. 2021)

The ocean is currently filled with plastic waste, which almost certainly affects every marine species. A conservative estimate of a recent study indicates that 2,141 different species have been discovered to face plastic pollution in their natural settings (Tekman et al. 2022)

Plastic microparticle buildup in lower trophic levels may have a cascading impact on marine food webs, ultimately harming humans. This emphasizes the significance of plastics

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as a growing source of toxins that are dangerous to both the environment and human health (Campanale et al. 2020).

Justification

For the management of pellets and to prevent heavy objects from entering the ocean, specific efforts directed at the primary and secondary sources of microplastic are needed (where they decay). Sadly, if current patterns continue, both humans and animals will continue to be in danger, and mishaps will happen before these objectives are met. Different issues arise when environmental passives are addressed. Microplastic cannot be removed from saltwater or separated from the sand by sieving. It would be ineffective even if one could collect these tiny particles. Microplastic will continue to travel in sluggish, complicated patterns to the ocean's floor, where they will eventually be buried for millennia in sand and muck (Ivar Do Sul & Costa 2014)

According to reports, microplastic can operate as a vector for pollutants by absorbing them and aiding in their bioaccumulation, particularly in marine environments, organisms & consequently, food webs (Amelia et al. 2021)

Experts have long voiced concern about the growing amount of plastic in the environment. The alarm about macroplastics has been raised by iconic images of sea creatures wrapped in soda can rings or straws sticking out of their nostrils. However, microplastics, smaller than 5 mm in diameter and shed from synthetic fabrics or resulting from the breakdown of larger chunks, are even more widespread, and their effects on human health are still unknown.

Corals, planktons, fish, whales, and other marine invertebrates are just a few examples of marine biota that may consume microscopic plastics passed down to the food chain. Due to their large surface-to-volume ratio, microplastics easily absorb hydrophobic contaminants from the aquatic system. Microplastic pollution is a growing problem because of its negative impacts, particularly on the health and biota of the ocean. Because of this, the issue of microplastics in the marine ecosystem is currently a major concern.

However, there has not yet been a comprehensive look at seawater microplastic contamination. This review study focuses on the abundance and features of microplastics in various environmental and biological components to better understand the condition of microplastic contamination in seawater. The background information on microplastics provided by this study might aid in developing successful plastic pollution management policies by the government.

Microplastics can unintentionally introduce various hazardous hydrophobic pollutants into the food chain by absorbing these contaminants from the environment. Further methods must be devised to solve the major problem of marine environment microplastic contamination. It is crucial to cease further production of plastic and swap it out for more environmentally friendly materials to prevent a problem in the future.

The problem of microplastics has been ignored for a long time, and the necessity to study the possible consequences, exposure routes, and toxicity of microplastic towards living organisms of the marine ecosystem and on human health is highlighted by the unavoidable exposure of people to microplastic.

Aim

The study aims to critically review current evidence contributing to the effect of microplastic pollution in seawater.

Objectives

1. To critically analyze current literature on microplastic pollution in seawater
2. To draw findings based on the results of the qualified investigations to facilitate review studies
3. Interpret, contextualize, and provide a summary and conclusion of the selected research results.

Research Question

The research question of this study was how microplastics pollute seawater and what is the impact of these microplastics.

MATERIALS AND METHODS

A comprehensive review of all relevant studies related to Microplastic pollution is included. The research design included published and unpublished studies and summarizing the findings.

Data collection is crucial to systematic reviews since it provides the basis for conclusions. If it turns out that there are better methods to define the populations, treatments, outcomes, or study designs, changes to the protocol should only be approved after the review questions have been developed. We looked at several printed and digital sources. Search engines were also employed to hunt for websites that may be used as references. The preset selection criteria for the research were directly derived from the review questions.

A more detailed examination of the quality of a few studies was carried out using wide critical evaluation principles. A comprehensive technique was used to choose the best research sample for this evaluation (Table 1). When creating the standards for assessing the literature, P.I.C.O.

was taken into account. This demonstrated that the suggested study had received enough responses.

A question must address the topic at hand specifically and be phrased in a way that makes it simpler to locate an answer. PICO makes this procedure simpler. It provides an example of the essential elements of a suitable query.

Criteria for PICO

Table 1: Criteria for PICO.

Participants	Studies related to microplastic pollution in seawater
Intervention	Microplastic pollution in seawater
Comparison/Control	Role of microplastic in seawater
Outcome	Impact of microplastic pollution

Data Collection Strategies

Databases were chosen and utilized throughout the data collection method for this investigation. PubMed, CINAHL, Google Scholar, Hinari, and the Cochrane Library were consulted. Boolean operators (AND, OR) and keywords were employed in the search to avoid oversaturating the data. This shows that intentional or unintentional bias may be found depending on how a search is done. Therefore, it is crucial to demonstrate that a comprehensive, extended, and wide search was carried out.

The scientific literature search was first carried out in Pubmed using the keywords: Microplastic AND Pollution OR Seawater OR Ocean OR Plastics within the article title, abstract, and keywords. Subsequently, a second, advanced search was carried out in CINAHL, Google Scholar, and Hinari using the keyword combinations (“microplastic,” “pollution”), (“seawater,” “microplastics”), (“seawater,” “pollution,”) and (“microplastic,” “ocean,”) within article titles. Further, the scientific literature was carried out in The Cochrane Database of Systematic Reviews (Cochrane Reviews)

Keywords Used as Per MeSH

Microplastic, plastics, seawater, ocean, pollution, microplastic exposure. The principal investigator and abstracts did initial searches, screening of tiles, and study reviews were conducted by co-authors. Any differences of opinion were discussed, and a consensus was reached; Coauthors extracted the data independently and compared the results. The following data was extracted from each study, published year of study, Author name, location, additional factors, and key findings

Inclusion/Exclusion Criteria

The last five years (Since 2017) of studies were incorporated. Articles not originally published in English were disqualified due to the possibility of language bias due to the writers’ limited experience and the possibility of an inaccurate translation. After doing a boolean search for them, the study utilized several filters to choose appropriate phrases based on my inclusion criteria (Table 2). This restricted the search using different databases to 188 records.

A PRISMA flow diagram was framed (Fig. 1). Many articles were removed because they were unrelated to the study’s subjects. After removing the duplicates, the abstracts of each publication were reviewed. Once further studies that did not meet the requirements were excluded, eight papers that satisfied the inclusion criteria were included.

17 relevant studies that fulfilled the inclusion criteria were identified as potentially useful but eventually disregarded, along with the justifications for each.

Table 2: Inclusion and Exclusion Criteria.

Inclusion Criteria	Exclusion Criteria
Studies related to microplastic pollution in seawater	Studies related to rivers/ ponds/streams
Studies related to articles written in English	Articles in pre-printed literature
Articles Free to access	Case Reports
Peer-reviewed articles	
Studies Published in the year 2017 and afterward	
Non-experimental quantitative studies	

RESULTS

Eight studies were analyzed (Table 3).

The discovery that marine life and all ocean ecosystems include tiny particles made from plastic garbage is no longer news. Microplastic contamination seems to be one of the largest environmental challenges facing the planet right now. 240 samples of sixteen species of fish, squid, and shrimp that are all suitable for human consumption were collected. In water samples and marine life, microplastic debris was found. The most common size range for microplastic particles was 150 to 500 m. One of the first studies to concurrently measure the amount of microplastic particles and how they affect marine life in this area (Alfaro-Núñez et al. 2021).

The quantity of marine plastics in seawater is a useful indicator of marine plastic pollution since it shows the current level of pollution and the levels of waterborne exposure that marine organisms are exposed to. Two microplastic monitoring techniques are suggested for use in regional and global assessments of pollution status through time and space, assessments of ecological risk, and a description of their key characteristics. Despite the strong connection

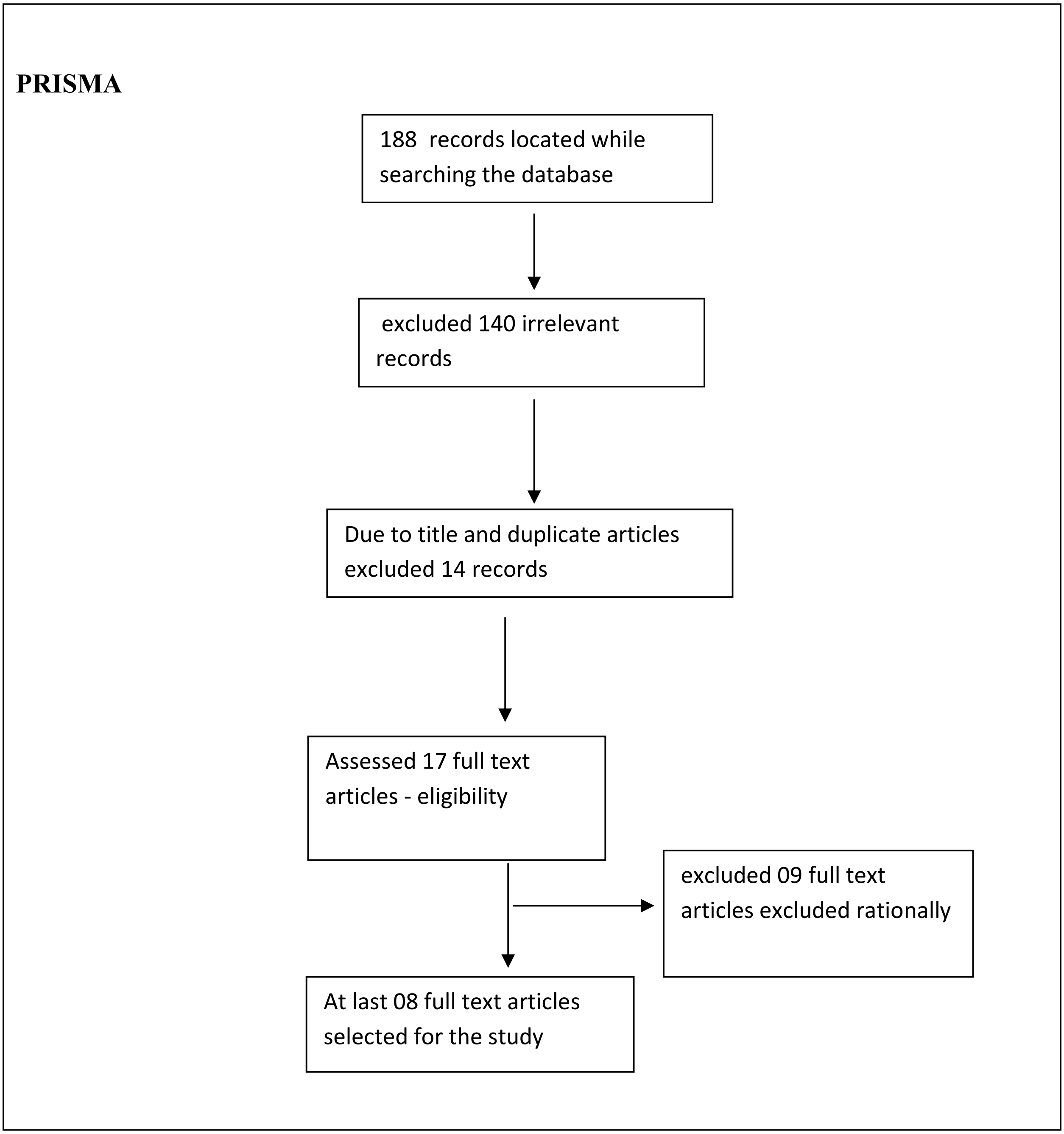

Fig. 1: PRISMA Flow chart.

between macroplastic and microplastic pollution (Shim et al. 2022).

Over time, unreacted monomers, oligomers, and additives from plastics released into the water may leach. Additionally, metals and polychlorinated biphenyls, as well as other organic and inorganic pollutants, are absorbed by plastics from the surrounding saltwater. The research determined the amount of additives found in seven categories of common plastic debris in the waters in 2015. (Bottles, bottle caps, EPP containers, silverware, supermarket bags, meal wrappers, straws, or stirrers) (De Frond et al. 2019).

The polymeric kinds found were high-density polyethylene, polystyrene, polypropylene, and polyethylene terephthalate. This investigation discovered microplastic

Table 3: Characteristics of Included Study.

Author and Year	study design	Location	Additional Factor	Key findings
(Alfaro-Núñez et al. 2021)	Exploratory study design	4000 km-trajectory encompassing 453,000 square kilometers- Tropical Eastern Pacific & the Galápagos archipelago	specimens of the sixteen distinct species- fish, crabs, and mollusks.	The bulk of the particles ranged in size from 150 to 500 m and were microscopic microplastics. Microplastic fragments - sedimentary habitats, shores, pelagic zones 7, 36, deep sea 37, and in living organisms
(Shim et al. 2022)	Review study	Between- North Pacific and the world's other ocean basins.	Two microplastic monitoring techniques: evaluation of ecological risk and pollution status throughout time and space	The North Pacific has seen more extensive microplastic monitoring efforts than other ocean regions. However, these studies were geographically skewed towards marginal waters in the Northwest Pacific region.
(De Frond et al. 2019)	Comparative case studies	Locations - Two coastal (Hong Kong & Hawaii), Two open ocean (North Pacific & South Atlantic gyres)	the volume of certain chemical additives entering the global seas with everyday plastic waste, & the volume of chemicals that have been sorbed	With more PCBs present closer to the source, where plastic is more prevalent /square foot than in the ocean, the mass of chemicals and plastics in a site are connected.
(Mohan et al. 2022)	Microplastic prevalence study	Beaches of Port Blair, ANI: Cove Beach, Quarry Beach, and Wandoor Beach are three coastal stations.	The analyzed locations contained lines, bits, pellets, foams, and microplastic fibers.	Waste from a nearby municipal landfill that contains microplastics. Fourier Transform Infrared Spectroscopy (FTIR) discovered that the beach silt included plasta zinc, a novel sort of polymer that may or may not be a nano plastic. Its presence indicates that the marine environment biologically and enzymatically degraded microplastic.
(Dutta et al. 2022)	Exploratory study	03 beaches viz Aksa, Versova, and Girgaon Chowpatty of Mumbai city	Spatial variation was also observed	Beads were the most common MPs in both the sediments and the saltwater column, whereas fibers contributed the least. Most of the seen particles were in the 0.45 to 500 m range. The number of smaller size fractions has been shown to increase, which raises the likelihood of harm to aquatic life.
(Keerthika et al. 2022)	Exploratory study	Beach sediment - Thoothukudi region, south-east coast of India, Gulf of Mannar region	The presence of inorganic materials on the surface Microplastics may result from environmental factors or plastic additions.	Along the Thoothukudi coast, microplastics (5 mm) are pervasive and pose a major danger to the marine ecosystem and life.
(Jeyasanta et al. 2020)	Exploratory study	08 sandy beaches- shoreline of Tuticorin, TN	fishing activity intensity and macro- and microplastic concentrations	These polymers are frequently found: PET, PS, PE, PP, NY, and PVC. The concentrations of micro- and mesoplastics are highly correlated.
(Sun et al. 2018)	comprehensive study	Yellow Sea, bounded by China and the Korean Peninsula	composition of the polymer type	In 80% (40 of 50) of the sample stations in the Yellow Sea, there were microplastics found in the seawater.

contamination from municipal garbage dumps close to the shore. Transforming Fourier, the beach silt was found to include plasta zinc, a novel sort of polymer that may or may not be a nano plastic, according to infrared spectroscopy. Its presence indicates that the marine environment biologically and enzymatically degraded microplastic. Further research is necessary to identify the variables affecting microplastic prevalence, its hazardous effects on the marine environment, and the mechanisms of microplastic degradation in the marine ecosystem (Mohan et al. 2022).

Microplastic concentrations averaged 204 by 110 particles per kilogram and 103 by 60 particles per liter in marine sediments, respectively. The most common kinds of microplastic were beads, whereas fibers contributed the least to the sediments and saltwater column. Most of the seen particles were in the 0.45 to 500 m range. The number of smaller size fractions has been shown to increase, which raises the likelihood of harm to aquatic life (Dutta et al. 2022).

A recent investigation demonstrated that microplastics (<5 mm) are widespread, providing a major hazard to the marine ecosystem and marine species. Energy dispersive X-ray (EDX) spectroscopy spectra revealed that the inorganic elements present at the surface of the microplastic may have come from the environment or as plastic additives (Keerthika et al. 2022).

Plastic trash prevalence differs among the research locations depending on the level of fishing and other activities of human nature. Using the polymers PP, NY, PET, PE, PS, and PVC as their constituents, mean concentrations of microplastics have been determined. PE is the most predominant polymer (Jeyasanta et al. 2020).

Plastic contamination in the ocean is a global issue. Most marine plastic pollution comes from microplastic, which is tiny enough to be consumed and possibly harmful to marine life. Polypropylene and polyethylene account for 88.13% of all main polymer types. Seawater contains a patchy distribution of MPs, with large MP concentrations seen in coastal cities. The polymer type has a varied composition, with 46% of the MPs in zooplankton being fiber-shaped. The taxa and their abundance in the Yellow Sea are factors in the retention of MPs in zooplankton (Sun et al. 2018).

Fish exposed to microplastics experience neurotoxicity, growth slowdown, and aberrant behavior. Microplastic effects on human health are not well understood. Owing to the high concentration of MPs in the environment, exposure might happen by eating, breathing, or skin contact. After exposure to MPs, humans may undergo oxidative stress, cytotoxicity, neurotoxicity, immune system disturbance, and MP translocation to other tissues. There is still much to learn about MPs' harmful effects on fish and humans (Bhuyan 2022).

DISCUSSION

The current study found that bioaccumulation is quite likely to happen with microplastics due to their tiny size. After being eaten by a range of marine species, such as corals, plankton, fish, seabirds, and marine mammals, they migrate up the food chain. Several chemical stabilizers and additives are also included in plastic polymers, which lead them to absorb toxic substances from their environment. Since the amount of pollution in the ocean has risen, there is an apparent and growing threat to human health.

Ocean pollution poses a clear and present danger to human health and well-being, as supported by Landrigan et al. (2020), who mentioned that Methylmercury and PCBs are the ocean pollutants whose human health effects are best understood. Exposing infants *in utero* to these pollutants through maternal consumption of contaminated seafood can damage developing brains, reduce IQ and increase children›s risks for autism, ADHD, and learning disorders (Landrigan et al. 2020).

The quantities of floating plastic in the Mediterranean Sea were investigated to see if this basin might be considered a major plastic waste accumulation location. The Mediterranean exhibited more big plastic items than oceanic gyres, indicating the region was close to pollution sources even if most of the plastic debris was in millimeter-sized bits (Cózar et al. 2015).

It is anticipated that interactions between micro- and nanoplastics and the immune system might result in immunotoxicity and, as a result, detrimental outcomes (such as immunosuppression, immunological activation, and aberrant inflammatory response). The ability of micro- (10 m) and nano-plastics (40-250 nm) to generate lethal effects at the cell level in terms of oxidative stress was recently demonstrated by in vitro investigations using cerebral and epithelial human cells, supporting the scientific hypotheses about the potential impacts on human health (Barboza et al. 2018).

When ingested by humans, the fate and consequences of microplastics are still debatable and poorly understood. If the distribution of particles in secondary tissues, such as the liver, muscles, and brain, is possible, then only microplastics smaller than 20 m can penetrate organs. Those with a size of about 10 m should be able to access all organs, cross cell membranes, cross the blood-brain barrier, and enter the placenta. The effects of microplastics on human health are not entirely understood. However, they might be caused by their physical characteristics (size, shape, and length), chemical characteristics (additives and polymer type), concentration, or microbial biofilm development (Campanale et al. 2020).

CONCLUSION

Microplastic pollution of the marine ecosystem is a contemporary issue due to its negative effects on marine biota. The toxic contaminants attach themselves to the microplastics, which act as vectors. To better comprehend the various variables that affect the occurrence of microplastic in marine ecosystems and its biological effects on marine biota, further research is necessary. Fish may be exposed to toxic compounds and harmful microbes through MPs. People consume fish contaminated with plastic and are exposed to plastic debris. As a result, numerous outbreaks of chronic illnesses happen, and individuals experience the consequences. It is necessary to implement conservation management strategies and assistance for different educational programs to protect the environment from these hazardous microplastics. The public's education on the harmful effects of microplastics is a crucial need in this field. Many innovations to reduce the usage and consumption of plastic and its products would be encouraged. The collection and reuse of plastic waste is the most important strategy for lowering the quantity of plastic that enters the ecosystem. Find alternatives to plastic things to eliminate future dangers.

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