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(Review Article)

An overview on the production, management and impact of microplastic contamination on marine species and marine environments: A review

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Abstract

The purpose of this paper is to review and evaluate published literature on the production, management and impact of microplastic contamination on marine species and marine environments. A systematic method was utilized to access research works of literature on "production, management and impact of microplastic contamination on marine species and marine environments". A total of Sixty-two (62) research papers published between the years 1972 to 2022 was accumulated and used for this review. A subjective approach was used to select the topics: production, management and impact of microplastic contamination. In this paper, four (4) effects of microplastics on organisms and the environment was assessed. Additionally, the formation and classification of microplastics were evaluated. Subsequently, the paper delves into the production and the management of global plastic production as well as the sources of contamination. Further, this review assessed the quantity of microplastics in the gastrointestinal tract and edible muscles of various fish species. A mini checklist of sixty-one (61) fish species from thirty (30) families dwelling in nine (9) different marine habitats, all contaminated by microplastics was also presented in this review. Moreover, possible solutions to overcome the impact of microplastics on organisms and aquatic environments were also mentioned in this article. The published works of literature established that the global plastic production is constantly increasing with a growing world population thus leading to mismanagement of plastic resources and introducing them to the environment. Microplastics can cause serious complications in humans, marine organisms such as fishes, crustaceans, marine mammals and sea birds and even contribute to the degradation of mangrove forests and the coastal environment. This review highlights the fact that more extensive studies on the impact of microplastic contamination in organisms and the environment should be done in neotropical countries since there is a dearth and gaps of such information on research and published data in these biodiversity rich regions.

Keywords: Microplastics; Contamination; Waste Disposal; Fishes; Production; Management

1 Introduction

1.1 Microplastics

Fish may inadvertently or intentionally consume macroplastics, nanoplastics, mesoplastics, and microplastics. Additionally, research conducted in laboratories has shown that fish exposed to microplastics and nanoplastics may have a range of adverse effects, including cytotoxicity, behavioral changes, lipid metabolism changes, and physical harm

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[33] [73] [151]. However, microplastics pose a greater threat. Despite their tiny size, they also lead to more serious issues. Marine life is not the only species affected by this; humans are also affected [33] [73] [96]. Because of their tiny size and color, microplastics are more easily absorbed by fish and mistaken for food. As a result, there is a greater chance that these smaller particles will be consumed by these small marine species, which are typically the foundation of marine food webs [33] [73] [138] [150].

Finding out how many of these diverse polymer types and shapes are present in the natural environment is like attempting to find needles in a haystack. As these pollutants are not consistent in type, they appear in all different shapes, sizes, and forms [33] [77] [78]. Classification of these size, shape, and color are the primary morphological features used to classify microplastics [28] [31] [109]. Given that size affects the kinds of creatures that microplastics may harm, size might be considered one of the most significant elements when discussing microplastics [56] [95]. Due to their high surface area to volume ratio, small particles have a high leaching potential and facilitate chemical uptake [147].

1.2 Microplastic formation

A combination of 2 (two) environmental elements, such as solar ultraviolet radiation that promotes the oxidative decomposition of polymers, has a significant impact on the foundation of microplastics [131] [141]. The polymer may be further broken down into smaller fragments by mechanical abrasion caused by wind, waves, ocean currents, animal bites, human activity, or weathering; this process is particularly evident in the decreasing order of plastics that float in water, in the mid-water column, and in the sediment. In the marine environment, some plastics hardly ever fully degrade or mineralize (becoming carbon dioxide or methane) [40] [131].

When these broken-down plastics find their way into the ocean, they affect marine life in a variety of ways through ingestion and trophic energy transfer during bioaccumulation and biomagnification [25] [45] [106]. These impacts eventually have an impact on humans. Polychlorinated biphenyls, polyaromatic hydrocarbons, and polybrominated diphenyl ethers are persistent, bioaccumulative, and toxic organic contaminants that are linked to microplastics in the ocean. These contaminants have the ability to disrupt the hormone system [40] [131]. However, the necessity for this review study has been spurred by the growing understanding of the negative effects that improper waste management and disposal can have on marine populations and the ecosystem's overall health.

The sun's UV radiation causes plastic particles to break down into smaller sizes, from macroscopic to microscopic, and finally into nanoplastics (undetectable dimensions) [27]. The majority of microplastics originate from produced goods that undergo strong chemical degradation, which breaks down polymers, later on [130]. Because plastics' substantial molecular weight determines their integrity, significant degradation makes the substance weaker and permits the plastic to disintegrate, making them fragile enough to shatter into tiny fragments [3] [59] [130].

Although these pieces are invisible to the unaided eye, they may undergo additional degradation, changing the carbon polymer into CO_2, which may then be absorbed by marine organisms [3] [151]. Standard polymers such as nylons, polypropylene (PP), linear low-density polyethylene (LLDPE), and high-density polyethylene (HDPE) are degraded by photo-oxidative degradation, which is triggered by UV-B radiation from sunshine in a marine environment [59] [130] [138]. UV radiation acts as a thermooxidant to initiate this process. But one thing that makes the process possible is oxygen [28] [96] [130]. Other types of deterioration do exist, but they proceed far more slowly than light-induced oxidation. In maritime environments, all biomaterials, including plastics, will typically biodegrade, although at a rate that is orders of magnitude slower than light-induced oxidative breakdown [31] [130] [150].

1.3 Global trend of microplastic production, waste disposal and management

Since plastics are utilized in products, transportation, and other areas, an increase in production and use of plastics may result from the growing human population and industrialization [137]. From roughly 3.1 billion in 1961 to roughly 7.3 billion in 2015, this has grown significantly, and by 2050, it is predicted to reach 9 billion. The need for safe fisheries and aquaculture products, along with population growth, will propel plastic production to new heights. Approximately 275 million tons of plastic garbage are produced by coastal countries, and it is predicted that between 4.8 million and 12.7 million tons of this debris end up in the oceans [54].

The production of both plastics and microplastics increased dramatically starting in the early 1950s due to a significant rise in large-scale industrial manufacturing. Plastics are used in almost every facet of daily life. For instance, the primary uses of plastics in the European Union (EU) are: packaging (39.9%), a large portion of which is single-use; building and construction (19.7%); automotive industry (8.9%); electrical and electronic (5.8%); agriculture (3.3%); and other applications (22.4%), which include furniture, sports, health and safety, consumer and home appliances, and other applications [84] [85] [107].

In 1950, two million tons of plastic were manufactured worldwide. Plastic manufacturing has increased 200 times yearly since then, reaching 381 million tons in 2015 (Figure 1). According to Ritchie *et al*. (2018), this is the same as the mass of two-thirds of the world's population. The global financial crisis of 2008 was the main cause of the production decline that occurred in 2009 and 2010.

The intricate details of the plastic production, distribution, and waste management chain must be understood in order to fully comprehend the total amount of plastics that are introduced into the environment and the world's oceans [117]. Global plastic trash was expected to have reached 275 million tons in 2010, whereas the world's primary plastic production was estimated to have reached 270 million tons in 2010. Based on the data, it did exceed the yearly primary output from plastic garbage from previous years; plastic debris in coastal zones is certain to end up in the ocean.

The amount of plastic waste generated along the coast within 50 kilometers of the coastline was found to be 99.5 million tons in 2010. However, only poorly managed plastic waste poses a significant risk of spilling into the environment. In 2010, 31.9 million tons were generated; of this, 8 million tons, or 3% of the world's annual plastic waste, crossed the line and entered the ocean through multiple outlets, including rivers. The amount of plastic waste found on the ocean's surface is several orders of magnitude lower than the annual ocean plastic inputs [117]. The "missing plastic problem" is the name given to this discrepancy. There is, however, little data available regarding the quantity of plastic floating on the water's surface; estimates range from 10,000 to 100,000 tons [117].

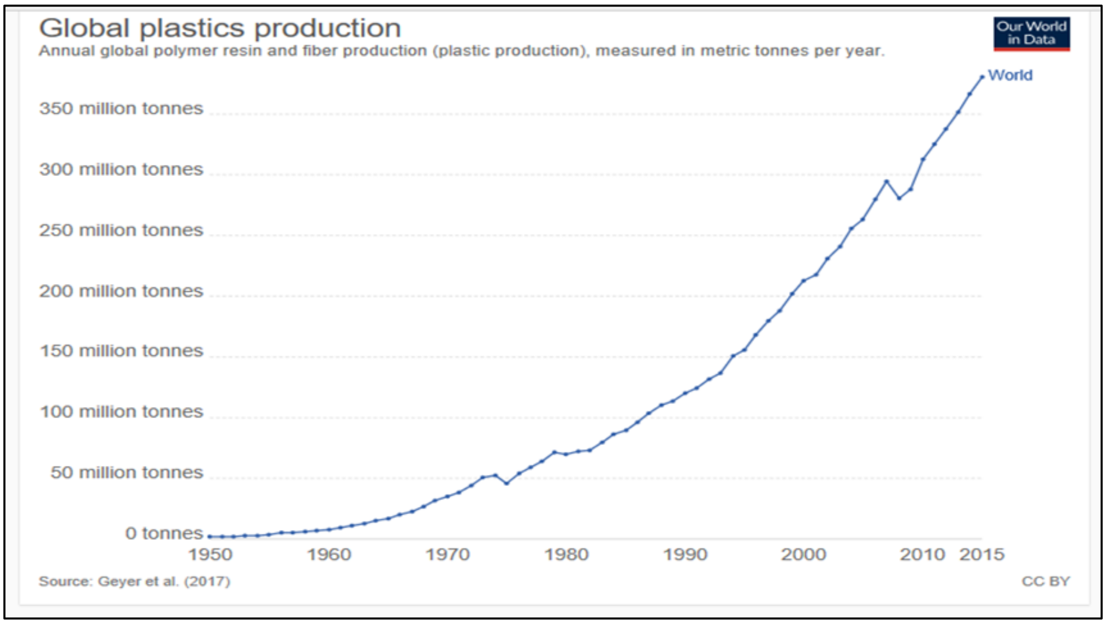


Figure 1 Trend in global plastic production 1950-2015 (Sources: Gyer *et al*., 2017 & Ritchie *et al*., 2018)

Over the years, the ways used to dispose of plastic garbage have changed globally. From 1980 to 2015, methods such as recycling, incinerating, or dumping were used [117]. Plastic recycling and incineration were negligible prior to 1980; all plastic garbage has been disposed of. Rates rose at a rate of about 0.7 percent annually for recycling and incineration starting in 1990 [117]. According to estimates from 2015, 55% of plastic garbage worldwide was disposed of, 25% was burned, and 20% was recycled [117].

Materials that are poorly managed trash are those that have a greater chance of being transferred to coastlines from interior waterways or into the ocean by wind or tidal transport. This is the amount of material that has been improperly or carelessly disposed of [117]. Waste that is meant to be managed through waste collection or storage facilities but is ultimately not managed lawfully or effectively is referred to as inadequately disposed of waste. In essence, this addresses the dumping of waste in open, uncontrolled landfills or dumps; it illustrates how materials are not entirely contained and might leak into the environment. Due to this, there is a greater chance of leaks and their transportation by rivers, winds, and tides to the environment and oceans [117] [146] [152].

The following variations can be observed in waste management efficacy worldwide: High-income nations have very efficient waste management infrastructure and procedures in place, such as the majority of Europe, North America, Australia, New Zealand, Japan, and South Korea. However, discarded plastic garbage that isn't recycled or burned is kept in safe, closed landfills. That being said, this does not imply that plastic is not a threat to the ecosystem [61] [101] [117]. Nonetheless, the rate of improperly disposed of garbage is significant in low-to-middle-income nations, including several in Sub-Saharan Africa and South Asia. This demonstrates the possibility of ocean and river pollution [44] [101] [117.

2 Material and Methods

The topic of "production, management and impact of microplastic contamination" was the subject of a systematic review using "Google Scholar," a web-based search engine which provides a quick and easy way to search and access published literature from articles, journals and books. Thematic search terms such as microplastics, contamination, waste disposal, fishes, production and management were used in the search.

The subjects that were evaluated in this research were chosen using an approach that involved assessing at the related works of literature. Publications between the years 1972 to 2022 were acquired for this review. However, not all of the articles that were reviewed, were used in this study because the major objective was to assemble data from recent research (past 10 to 20 years) on impact of climate change on fishes and fisheries. However, papers that contained relevant literature from as far back as the 1900's and the 2000's were also utilized for this review. Seventy-four (74) research articles were retrieved and included in this review and literature from sixty-two (62) papers published between the years 1973-2024 were presented in this paper.

The search yielded different results: Some articles had all the thematic keywords and some were obtained that were specific to solution and management of microplastics in the environment, while others were specific on a certain species of fish used in the study and some were specific to methods used in the detection and identification of microplastics in fish species. Some papers were also specific to plastic production and plastic management to achieve environmental sustainability.

3 Results

When searching "Google Scholar" for information on production, management and impact of microplastic contamination, a total of 34,200 was retrieved. Among the results obtained from the search, a total of 16,500 were published within the years 2000-2023, 29,800 were published between the years 2010-2023 and 19,700 were published within the years 2015-2023. 17,000 publications between the years 2010-2023 reviewed the impact of microplastics contamination on marine organisms and 17,100 publications between the years 2010-2023 reviewed the impact of microplastics contamination on marine environments.

However, not all the results retrieved for this research focused on production, management and impact of microplastic contamination. While some focused solely on production of microplastics, others examined management of microplastics to avoid contamination as a separate topic. Some research papers were specific to solution and management of microplastics in the environment. Additionally, other papers were specific on a certain species of fish used in the study and some were specific to methods used in the detection and identification of microplastics in fish species and few papers were specific to plastic production and plastic management to achieve environmental sustainability.

4 Discussion

4.1 Classification of microplastics

Primary and secondary microplastics are the two categories of microplastics that exist technically (Figures 2, 3, 4 & 5 respectively). Primary microplastics are micro-sized synthetic polymers that are employed as exfoliates in a variety of processes, including the production of synthetic clothing, sandblasting media, chemical formulations, and product maintenance. Another kind of primary plastic (< 2 mm in size) is called a microbead, and it is composed of polyethylene (PE): According to its density and branching, polyethylene is categorized into the most prevalent kinds [133].

One strong thermoplastic with a changeable crystalline structure that is also incredibly light is polyethylene. Tens of millions of tons are produced globally annually, making it one among the most widely produced plastics in the world. It is created by polymerizing ethylene (or ethene) monomer. Products like films, shopping bags, tubes, plastic components, clear food wrappers, detergent bottles, and so on are made of polyethylene [120].

4.1.1 Branched Versions

- Low-density polyethylene (LDPE): This material is used to make squeeze bottles, toys, housewares, mulch for farms, packaging film, garbage and shopping bags, and wire and cable insulation [120].
- Linear low-density polyethylene (LLDPE): This material produces goods that are comparable to LDPE because of its similar qualities [120].

4.1.2 Linear Versions

- High-density polyethylene (HDPE): utilized in toys, injection-molded pails, caps, supermarket bags, construction film, and appliance housings [120].
- Ultra-high-molecular-weight polyethylene (UHMWPE): These polymers have a tensile strength that is several times greater than that of steel because they can be pulled, or stretched, into a highly crystalline condition after being spun into fibers. Bulletproof vests are knitted using yarns derived from these fibers [120].

4.1.3 Polypropylene (PP)

Made from a mixture of propylene monomers, polypropylene is a thermoplastic and one of the most widely produced plastics worldwide. It is utilized in many different applications, including as textiles, specific devices like live hinges, plastic parts for numerous industries, including the automobile industry, and packaging for consumer goods [120].

Some sources state that the material's present worldwide demand creates an annual market of roughly 45 million metric tons, and by 2020, it's predicted that demand will have increased to roughly 62 million metric tons. About 30% of the total is used by the packaging industry, with the manufacturing of electrical and equipment accounting for the remaining 13% of the total. The automobile and home appliance sectors each account for 10% of the market, with building materials coming in second with 5%. The remaining portion of the world's polypropylene usage is made up of other uses [120].

4.1.4 Polystyrene (PS)

Beads are extensively utilized in medical equipment. Conversely, secondary microplastics are broken-down byproducts of macro or mesoplastics that are primarily produced by a variety of environmental processes, including hydrolysis, photodegradation, thermo-oxidative degradation, biodegradation, and thermal degradation. Additionally, nanoplastics are plastic particles smaller than 1 µm in size. Because of their huge surface ratio, nanoplastics may have ramifications for the bio-amplification and bioaccumulation of several chemicals and contaminants [27].

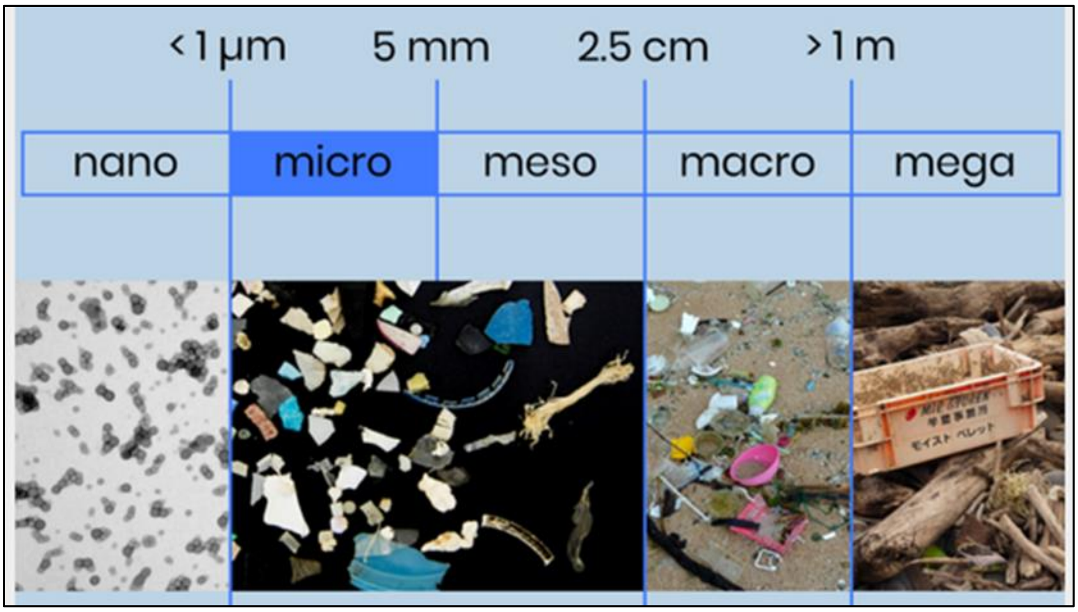
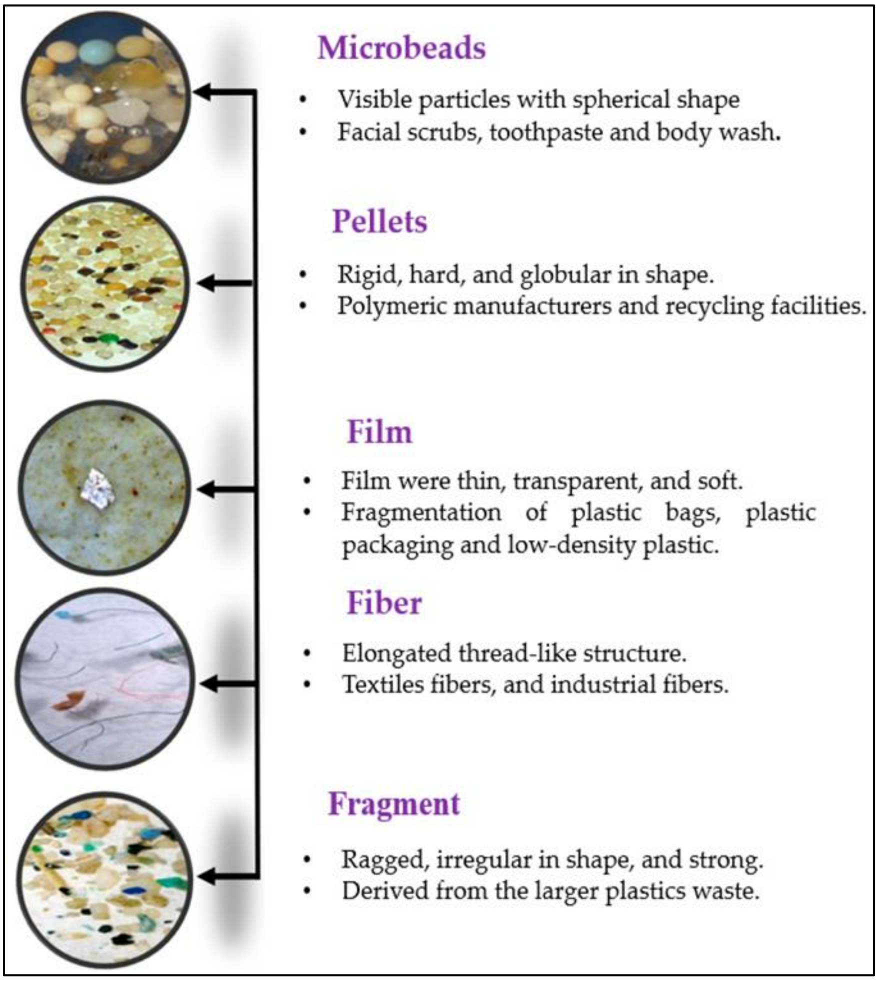


Figure 2 Classification of microplastics (Source: Kunz, 2022)



Microbeads

- Visible particles with spherical shape
- Facial scrubs, toothpaste and body wash.

Pellets

- Rigid, hard, and globular in shape.
- Polymeric manufacturers and recycling facilities.

Film

- Film were thin, transparent, and soft.
- Fragmentation of plastic bags, plastic packaging and low-density plastic.

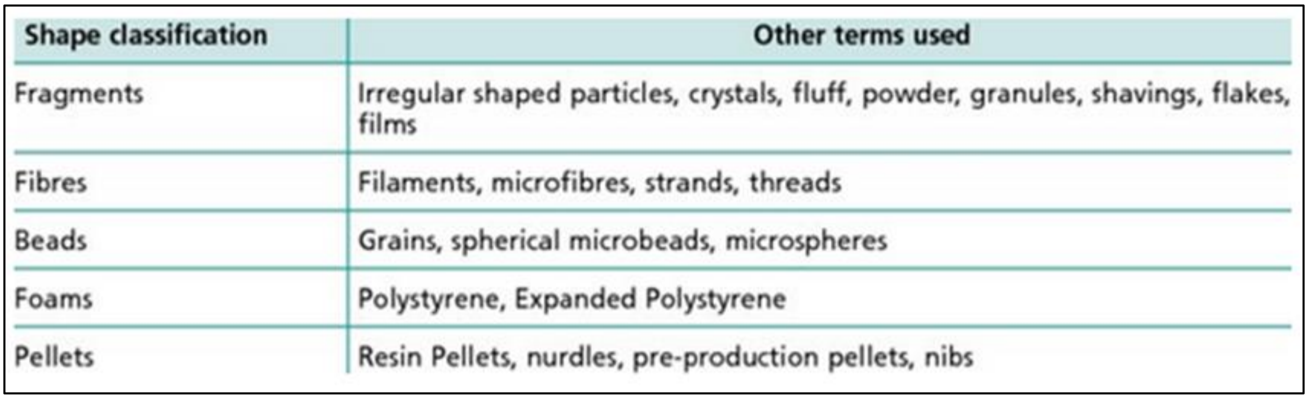
Fiber

- Elongated thread-like structure.
- Textiles fibers, and industrial fibers.

Fragment

- Ragged, irregular in shape, and strong.
- Derived from the larger plastics waste.

Figure 3 Sources and types of microplastic particles (Source: Prapanchan *et al.*, 2013)



Shape classification	Other terms used
Fragments	Irregular shaped particles, crystals, fluff, powder, granules, shavings, flakes, films
Fibres	Filaments, microfibres, strands, threads
Beads	Grains, spherical microbeads, microspheres
Foams	Polystyrene, Expanded Polystyrene
Pellets	Resin Pellets, nurdles, pre-production pellets, nibs

Figure 4 Classifying microplastics by shape (Sources: Lusher *et al.*, 2017 & Lusher *et al.*, 2017)

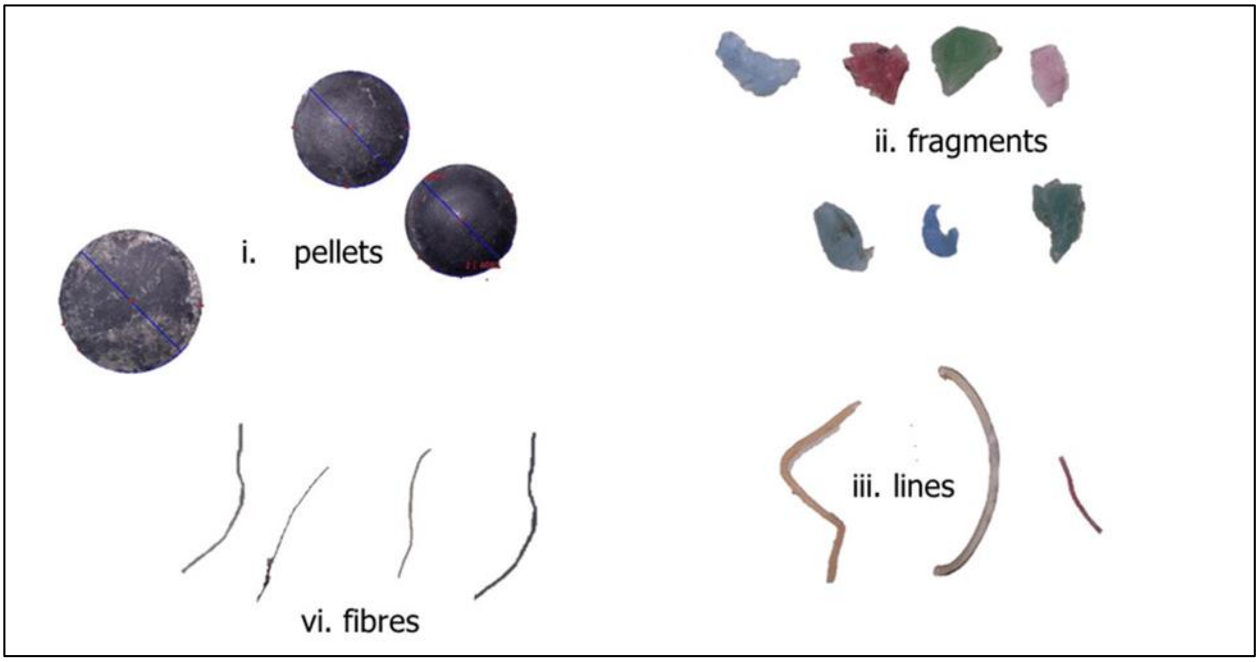


Figure 5 Types of microplastics morphology (Source: Massarelli *et al*., 2021)

4.2 Global impact of microplastics

Many marine species from a wide range of maritime settings have been shown to contain microplastics. The first reports of microplastic contamination date back to the early 1960s [22] [53]. Microplastic contamination is not a recent phenomenon [84] [85]. It is only now that the matter is concerning that the scientific community, international organizations, governments, and the media are paying attention to it. Human and environmental health concerns have been the main drivers of this surge in interest [84] [85] [143]. On the other hand, worries stem from possible effects on human health and food safety. The production of plastics, regardless of size, has increased environmental hazards and their prevalence.

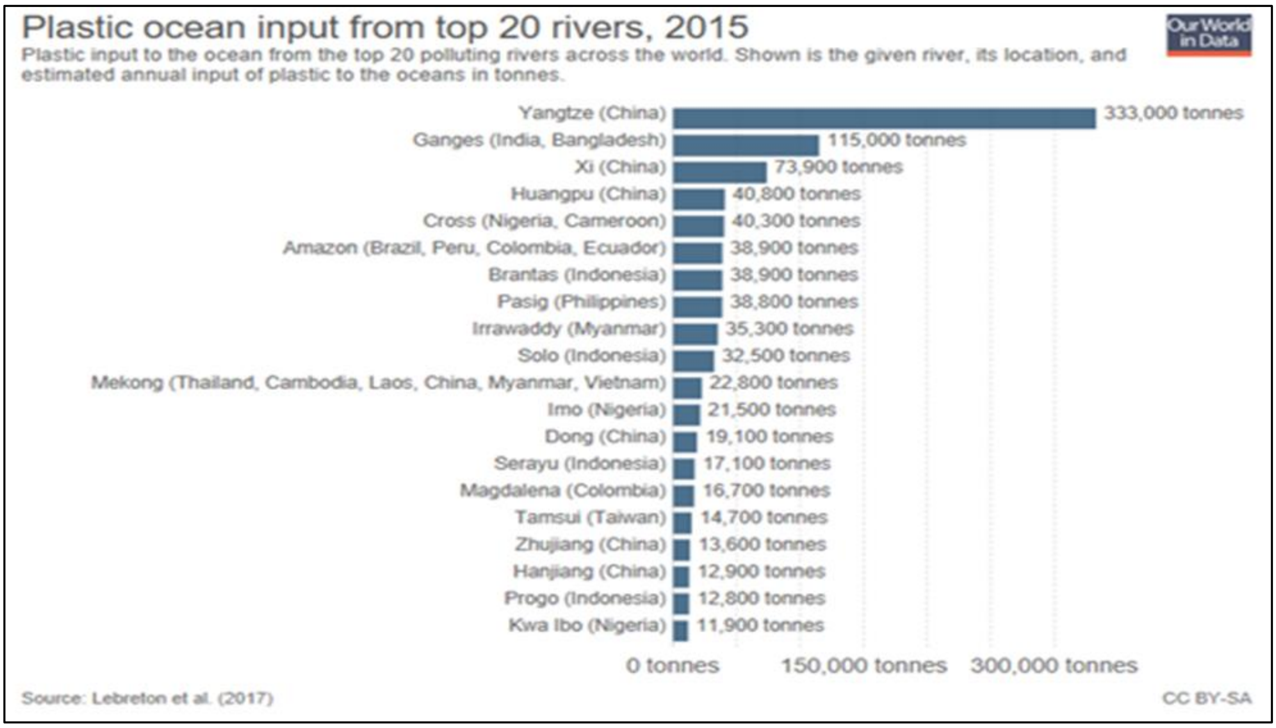


Figure 6 Location of rivers and their annual plastic input to the ocean (Source: MigSelv, 2019)

The consequences and implications of plastic and microplastic pollution on aquatic environments and humans must be reduced by using appropriate waste management techniques. Unfortunately, environmental deterioration, fragmentation of current stocks, and increased production of plastic products are anticipated to cause microplastic contamination to rise [117]. Based on modeling studies, it is estimated that 0.41-4 million tons of plastic trash are transferred annually from rivers to oceans worldwide. On the other hand, the world's worst contaminated rivers account for an estimated 20 percent of the plastic inflow into the oceans. A 2015 estimate was completed in 20 rivers along with the nations it flows through (Figure 6) [117].

Two-thirds of the 67 percent of the yearly river input worldwide were represented by the top 20 rivers. However, Asia is home to the majority of the polluting rivers. According to Xiong *et al*. (2019), the Yangtze River is the most polluted river. In 2015, it contributed over 333,000 tons, or more than 4% of the yearly contamination of the ocean with plastic. The Yangtze River drains 695,000 square miles of land and runs through nine provinces. After that, it runs east to west through the regions of Shanghai, Qinghai, Tibet, Yunnan, Sichuan, Chongqing, Hunan, Jiangxi, Anhui, and Jiangsu until emptying into the East China Sea. Plastic enters seas through rivers, tides, beaches, and marine sources. Plastics are buoyant, making it easier for them to be moved by wind and surface current routes. This has a significant impact on the distribution and accumulation of ocean plastics.

This is an increasing concerned since, plastic is a manufactured good; it does not exist naturally, and the reason it is prevalent in nature is primarily due to humans [116]. Regarding microplastics, it can be argued that in certain cases they were purposefully introduced into ecosystems; this represents the waste products of our current way of life, which is strongly dependent on plastic products [116]. Due to the widespread presence of microplastic pollution in freshwater aquaculture ecosystems and the high volume of commercial fish raised and consumed—including whole fish that are cooked and typically include the guts along with the flesh—microplastics may pose a health risk to humans through their diets [92].

It is crucial to identify the degree of microplastic pollution in fish. Fish that ingest plastic wind up on our plates. Therefore, people are also affected. And by bioaccumulation and biomagnification, this takes place. The possibility that exposure to microplastics would have adverse ecological repercussions is a clear definition of the ecological dangers associated with microplastic pollution. Potential pathways of exposure for marine creatures include breathing in microplastics, ingesting them directly, or ingesting them indirectly through prey items. Regardless of the route, marine species may experience adverse chemical and physical effects from consuming microplastics. The physical retention of microplastics in digestive tracts and the chemical leaching of plastic additives into tissues are two possible effects [92].

These have been studied using a range of outcomes, including growth rate, fecundity, and mortality, during well-regulated laboratory exposures. Our knowledge of the potential ecological effects of various MP exposure pathways in the marine environment can be improved by having a better grasp of endpoints like bioaccumulation and biomagnification [92].

Two important concepts used in ecological risk assessments to estimate the amount of pollution movement within food webs are bioaccumulation and biomagnification. Conventional understanding of bioaccumulation and biomagnification typically refers to chemical contamination that has dissolved. The net uptake of a contaminant, such as MPs and/or additives from the environment through potential pathways like touch, ingestion, respiration from any source (e.g., water, sediment, prey), is commonly referred to as bioaccumulation (or body burden) [92]. Additionally, when an organism's uptake of a pollutant is far greater than its capacity to ingest a contaminant, this phenomenon is known as bioaccumulation.

Contaminants may biomagnify at higher trophic levels as a result of bioaccumulation and the ensuing trophic transmission of the contaminant. An increase in an organism's concentration of a contaminant relative to its prey's concentration is referred to as biomagnification within a food chain. According to Miller *et al*. (2020), trophic transfer is taking place, meaning that all contamination is greater in trophic levels due to direct ingestion of prey in lower trophic levels. This means that the pollutants emitted by microplastics can be consumed and absorbed by humans. These have the potential to cause genetic changes and disrupt the human endocrine system [17]. The presence of plastic in the water has been linked to an increase in the quantity of compounds known as persistent organic pollutants (POPs), which include dichlorodiphenyltrichloroethane (DDT) and polychlorinated biphenyl (PCB) [17] [99] [144].

Our inappropriate garbage disposal practices are choking our ocean, which ultimately affects us humans [17] [123] [145] [153]. Research has demonstrated that microplastics pose a risk to the environment, particularly marine environments, and human health. Unfortunately, small plastic particles continue to float on the sea's surface, where they are eaten and accumulate in the bodies and tissues of many species (Table 4). Over time, the plastic on the top dissolves.

[17] [151] [153]. According to estimates, microplastic is present in 15–20% of marine species that end up on our tables [17] [153].

Furthermore, many of the chemicals that are often used to create plastics are harmful, according to Cingotti & Jensen, 2019. Key components of household goods and food packaging include phthalates, bisphenol A (BPA), and certain brominated flame retardants. It has been established that these chemicals are endocrine disruptors and can harm human health if consumed or inhaled. Endocrine-disrupting chemicals (EDCs) are defined as substances that are external to the human or animal organism and possess hormonal action that alters the endocrine system's homeostasis. As such, there is interest in these substances. These substances interfere with the endocrine system's growth and disrupt the organs' ability to respond to hormone signals. The potential of endocrine disruptors may: (a) mimic natural hormones, (b) stimulate their action, (c) alter their pattern of synthesis and metabolism, or (d) change the expression of particular receptors may result in their endocrine and reproductive consequences [100].

4.3 Effects of microplastics

Global markets are primarily impacted by six classes of plastics, which are polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET) as the most dominant, polyvinyl chloride (PVC), polystyrene (PS), and poly-urethane (PUR) as the least dominant [52] [131]. Microplastics are classified into various types. Fossil fuels are the source of plastic; however, biomass can also be utilized as feedback. The majority of synthetic and natural polymers are produced and sourced in Figures 7, 8 and 9 and their common applications are displayed in Table 1. Primary and secondary microplastics are the two categories of microplastics that can be discovered in marine environments.

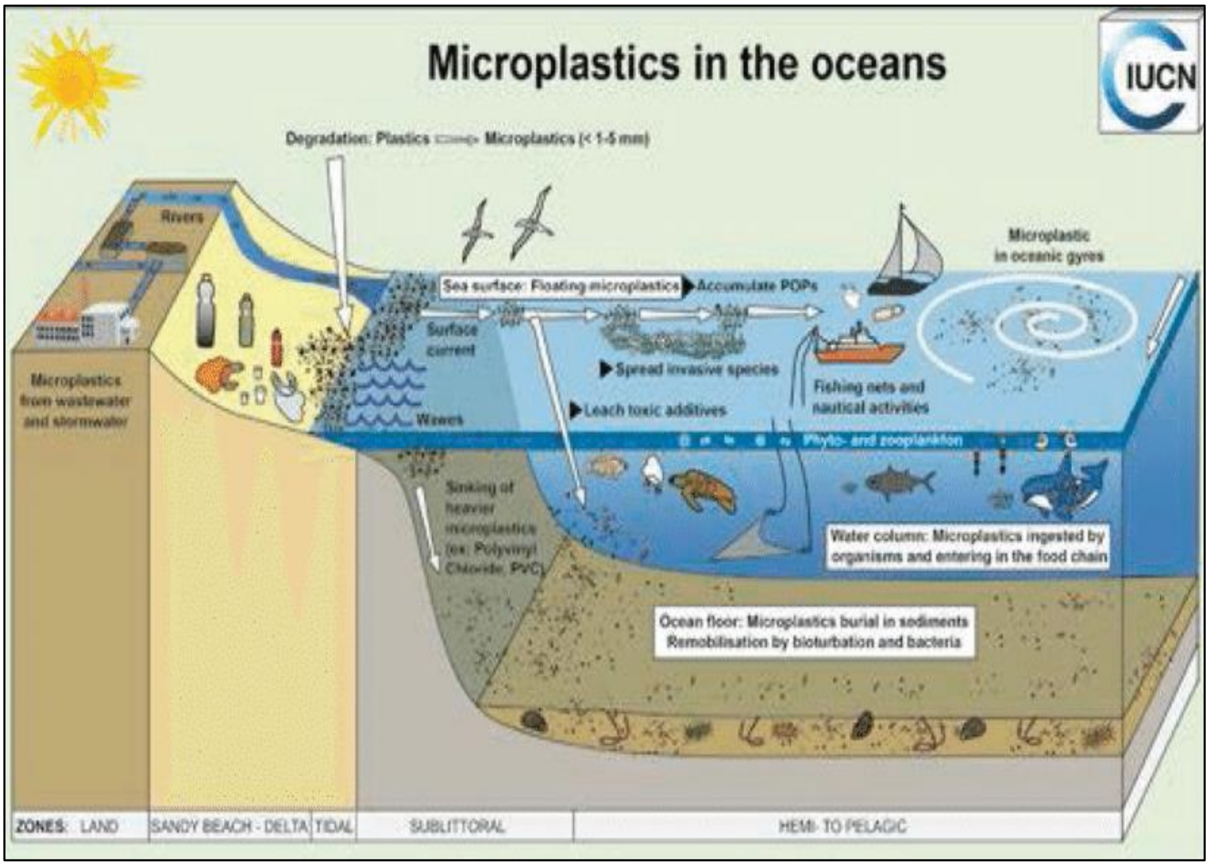


Figure 7 Schematic drawing showing the main sources and movement pathways for plastics debris in the oceans (Source: Ogunola & Palanisami, 2016)

Primary microplastics, which fall within the size range of 1 nm to 5 mm, are purposefully mass-produced and found in personal hygiene items such as air-blasting, toothpaste, shower gel, scrubs, and cosmetics [46] [131]. According to Astudillo *et al.* (2009), Bowmer & Kershaw (2010), Gesamp (2015), Solomon & Palanisami (2016) and other studies, the degradation of major plastic items such as fishing gear, ships, aquaculture, and recreational activities can promote secondary microplastics.

Microplastics are manufactured for particular applications, such as industrial scrubbers or in personal cleaning products such as toothpaste. All plastics can be subject to fragmentation on environmental exposure and degradation into (secondary) microplastics (Figure 9). The proportion of plastic reaching the ocean to become plastic litter depends on the effectiveness of the re-use, recycle and waste management chain [52] [131].

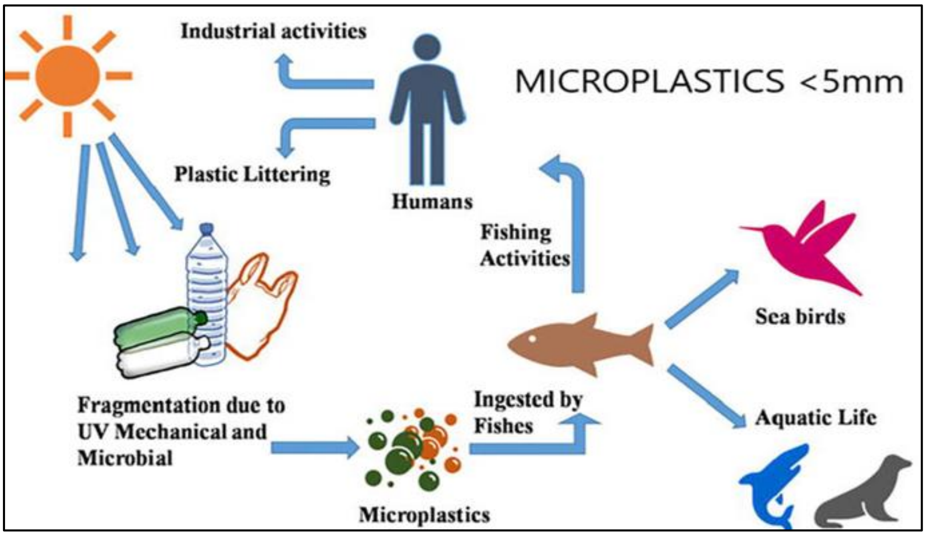
Table 1 Common applications of plastics and their densities found in the marine environment

Common Applications	Resin Types	Specific Gravity
Polyethylene	Storage containers, plastic bags	0.91-0.95
Polypropylene	Bottle caps, ropes, strapping, gears	0.90-0.92
Polystyrene	Cups, floats, cool boxes	0.01-1.05
Polystyrene (expanded)	Containers, utensils	1.04-1.09
Polyvinyl Chloride (PVC)	Containers, film pipes	1.16-1.30
Nylon or Polyamide	Rope, fishing nets	1.15-1.15
Poly (ethylene-terephthalate)	Strapping, bottles	1.34-1.39
Polyester Resin + glass-fibre	Boats, textiles	>1.35
Cellulose acetate	Cigarette-fibre	1.22-1.24

(Adapted from Andrandy, 2011 & Solomon & Palanisami, 2016)

A combination of 2 (two) environmental elements, such as solar ultraviolet radiation that promotes the oxidative decomposition of polymers, has a significant impact on the foundation of microplastics [131] [141]. Mechanical abrasion that can further break the polymer into smaller fragments, such as wind, waves, ocean currents, animal bites, human activities, or they go through the process of in particular, the process of weathering takes place in the sediment, mid-water column, and decreasing order of polymers that float in the water. In the marine environment, some plastics hardly ever fully degrade or mineralize (becoming carbon dioxide or methane).

When these broken-down plastics find their way into the ocean, they affect marine life in a variety of ways through ingestion and trophic energy transfer during bioaccumulation and biomagnification. These impacts eventually have an impact on humans (Figure 8). Polychlorinated biphenyls, polyaromatic hydrocarbons, and polybrominated diphenyl ethers are persistent, bio-accumulative, and toxic organic contaminants that are linked to microplastics in the ocean. These contaminants have the ability to disrupt the hormone system [40] [131].



(Source: Issac & Kandasubramanian, 2021)

Figure 8 Effect of microplastics in water and aquatic systems

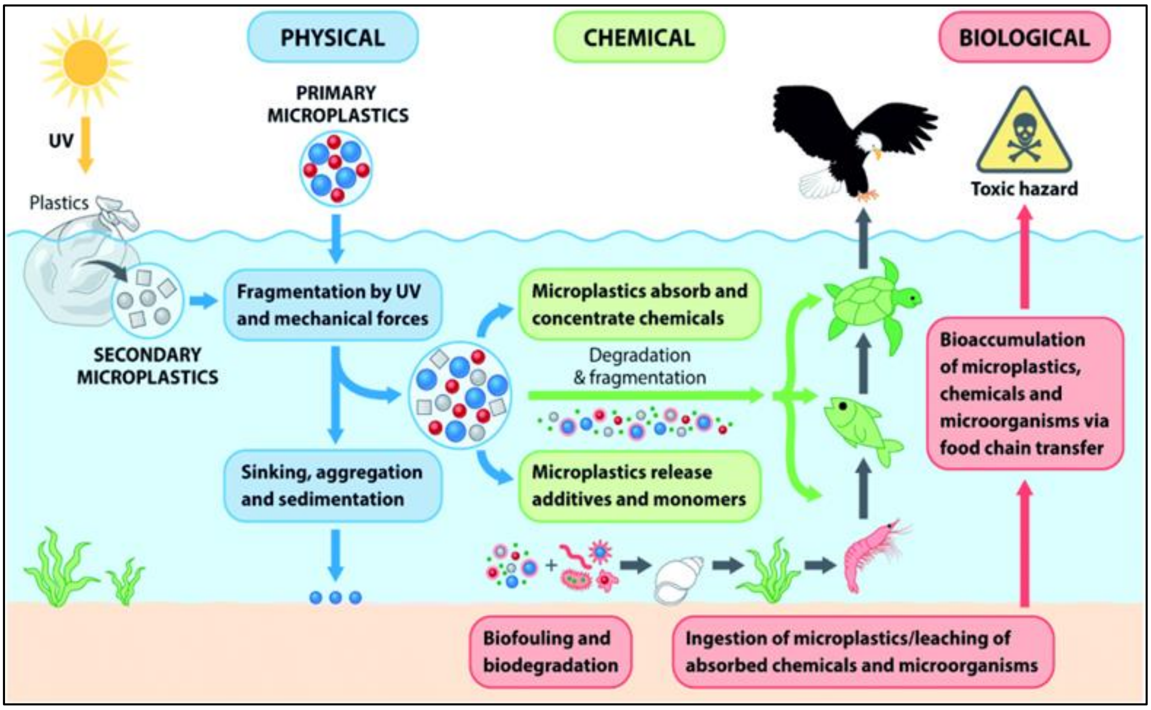


Figure 9 Summary of oceanic plastics accumulation and cycle with physical, chemical and biological degradation (Source: Watt *et al.*, 2021)

Table 2 discuss the effects of microplastics on both organisms and the environment. When a large portion of a population's fitness or physiological processes are disrupted, ecosystems are undoubtedly impacted [71]. However, the consequences were determined [131], and they are as follows: ingestion of microplastics and its physical impacts; spread of invasive species and social and economic consequences.

Table 2 Effects of microplastics on organisms and the environment

Effects	Taxa	Description of effects	Author(s)
The physical effects of microplastics ingestion	*Danio rerio* (zebra fish); *Oryzias melastigma* (Indian medaka/ brackish medaka); *Sparus aurata* (Gilt-head bream); *Engraulis encrasicolus* (European anchovy); *Merlangius merlangus* (Whiting); *Mullus barbatus* (Red mullet); *Scomber japonicus* (Chub mackerel); *Clupea harengus* (Herring); *Scomber scombrus* (Makerel); *Engraulis japonicus*	The majority of the scientific research published over the years shows that ingesting microplastics is harmful. According to Jovanovi (2016), consuming microplastics need not always be hazardous. Additionally, fish have evolved to cope with undesired gastrointestinal nonfood material since they frequently ingested various partially digestible or indigestible materials, such as fish scales, wood, macroinvertebrate shells, etc. (Table 3). On the other hand, the emergence of micro and nanoplastics in aquatic environments has some special properties that could have a variety of effects on fish. Most plastics produced are made up of a mixture of plastic polymers and various additives, such as phthalates, which are added to plastic to improve its performance and may be harmful substances that affect reproductive health. Consequently, the intestinal system or digestive organs become obstructed, blocked, or clogged, which prevents the organisms from consuming further food sources or may lessen their feeding stimulation, upsetting the trophic level (pseudo-satiation). Starvation is primarily caused by this kind of interruption. For example, according to a 2003 assessment, Eriksson & Burton noted that certain marine animals have a tendency to consume and bioaccumulate plastic waste by consuming	(Azzarello & Van Vleet, 1987); (Spear *et al.*, 1995); (Derraik, 2002); (Eriksson & Burton., 2003); (Thompson, 2006); (Talsness et al., 2009); (Foekema *et al.*, 2013); (Lusher *et al.*, 2013); (Rochman *et al.*, 2013); (Sulochanan *et al.*, 2014); (Thomas & Nas, 2014); (Caruso, 2015); (Collard *et al.*, 2015); (Rochman *et al.*, 2015); (Brate *et al.*, 2016); (Jovanovi, 2016); (Liboiron *et al.*, 2016); (Lu *et al.*, 2016); (Rummel *et al.*, 2016); (Solomon

	(Japanese anchovy); *Gadus morhua* (Northern cod); *Micromesistius poutassou* (Blue whiting); *Sprattus sprattus* (Sprat); *Scomberomorus cavalla* (King mackerel); *Decapterus macrosoma* (Shortfin scad); *Trachurus trachurus* (Horse mackerel); *Merluccius merluccius* (Hake); *Pagellus acarne* (Bream); *Solea solea* (Common sole)	pelagic fish species that have previously absorbed the plastic during feeding. Additional potential negative consequences are supported by scientific data demonstrating that exposure to microplastics can cause a wide range of toxic insults, including physical ingestion, disruptions in energy metabolism, alterations in liver physiology, feeding disruption to reproductive performance, and antagonistic or synergistic interactions with other hydrophobic organic contaminants at trophic levels. According to data presented by Spear *et al*. (1995), the physical state (body weight) is negatively impacted in proportion to the quantity of plastic particles consumed. Microplastics are transferred through the gastrointestinal tract's epithelium following inadvertent or deliberate intake (Table 3). They are then either maintained in the gastrointestinal system or may be ingested through faeces. Microplastic retention in the digestive tract can have a detrimental effect on the organism's health by resulting in physical abrasions and/or perforations, lowering nutritional absorption, and significantly reducing feeding behaviour due to the perception of false fullness. Additionally, it has been reported that fish exposed to microplastic particles may experience hepatic stress. The fish may be exposed to chemicals present in or attached to the MP, which could have a range of consequences on them (Figures 12 & 13), including changed blood biochemistry, immunological activity, or expression. At the organ/tissue level, gastrointestinal oxidative stress and histological damage are typical manifestations. MP processing and/or any associated chemicals set off an immune response that results in localized cell damage and physiological structure morphological features. The types and activity of symbiotic bacteria can change due to changes in gastrointestinal shape, which can result in dysbiosis of the gut and modifications in metabolism. The impacts that have been reported include: malfunction during the developmental and reproductive stages; fish experiencing hepatic stress; lower steroid levels and delayed ovulation; endocrine disruption; and mortality.	*et al*., 2016); (Güven *et al*., 2017); (Fossi *et al*., 2017); (Ory *et al*., 2017); (Anbumani & Kakkar, 2018); (Jabeen *et al*., 2018); (Qiao *et al*., 2019); (Xiong *et al*., 2019); (Ding *et al*., 2020); (Walkinshaw *et al*., 2020); (Yu *et al*., 2020); (Zhao *et al*., 2020); (Khalid *et al*., 2021)
Transport of invasive species by microplastics	*Valamugil speigleri* (Detritus feeder mullet); *Siganus canaliculatus* (Herbivorous rabbitfish); *Kuhlia rupestris* (Rock flagtail/ jungle perch/ mountain trout); *Neogobius melanostomus* (Round goby)	Microbial assemblages in marine sediments have the potential to speed up metabolic processes that support the decomposition of the debris itself as well as the absorption, desorption, and breakdown of compounds linked to microplastics. Additionally, after being ingested by larger organisms, microplastics may operate as a haven for microbes that could affect the ecology and resident microflora. When plastics are found in the marine environment, a group of organisms known as the plastisphere rapidly colonize the microplastics. Eriksen *et al*. (2013) were the first to note that dangerous microorganisms stuck to plastic waste. When microplastics are discovered on the water's surface, they often act as raft substrates for a variety of epifauna and microbes, including diatoms, bacteria, barnacles, hydroids, and tunicates, which then carry them to other environments. The world's rivers are particularly	(Carpenter, 1972); (Deines *et al*., 2007); (Graham & Thompson, 2009); (Eriksen, *et al*., 2013); (Zettler *et al*., 2013); (Solomon *et al*., 2016); (Beaumont *et al*., 2019); (Oh & Park, 2020); (Walkinshaw *et al*., 2020); (Bowley *et al*., 2021)

		susceptible to invasive species introduction, changed hydrology, and pollution. These plastispheres have the capacity to harbour harmful bacteria and make them more accessible to the species eating microplastics, they pose a risk to the marine environment, aquaculture, and food security. Eventually, some of these bacteria will be able to use their biofilms to alter the structure of microplastics.	
Social and economic effects of microplastics	*Alburnus alburnus* (Common bleak); *Cottus gobio* (European bullhead); *Leuciscus leuciscus* (Common dace); *Phoxinus phoxinus* (Common minnow); *Squalius cephalus* (European chub)	When plastic pollution degrades a natural resource-like the ocean-it affects socioeconomic systems by reducing the quality of the environment for coming generations. As a stressor, plastics can interact with other environmental stressors like those brought on by other pollutants, shifting ocean temperatures, ocean acidification, and overfishing. For instance, the North Pacific Ocean's marine species, such as fish, can have long-term effects on the fishing industry. Marine plastic may cause significantly more harm as a result of the combined effects of these stresses. Microplastics are collected through food changes as a result of their presence in the food chain. The loss of food security, livelihoods, income, and good health could have a substantial effect on human well-being worldwide if there is a threat to the ongoing provision of these ecosystem services. As an illustration, bisphenol in humans, exposure has been connected to alterations in hormone levels in the blood, diabetes, and heart disease.	(Beaumont *et al.*, 2015); (Naeem *et al.*, 2016); (Solomon *et al.*, 2016)
Effects of microplastics on human-beings and other organisms associated with them	*Dicentrachus labrax* (European seabass); *Platycephalus indicus* (Bartail flathead); *Epinephelus coioide* (Orange-spotted grouper); *Alepes djedaba* (Shrimp scad); *Sufflamen fraenatus* (Masked triggerfish); *Pseudotriacanthus strigilifer* (Long-spined tripodfish); *Sardinella longiceps* (Indian oil sardine); *Rastrelliger kanagurta* (Indian mackerel); *Anodontostoma chacunda* (Chacunda gizzard shad); *Dussumieria acuta* (Rainbow	Eating seafood can expose humans to plastic particles; however, there is currently insufficient information available to conduct a thorough assessment of the hazards to humans regarding the amount of human exposure, chronic toxic impact concentrations, and underlying processes by which microplastics cause effects. According to Adams, 2020, a senior lecturer in biomedical science at Cardiff Metropolitan University, ingesting microplastics may have a variety of potentially dangerous effects, such as: • Inflammation: The body produces chemicals and white blood cells that become inflamed to protect us from infection. Tissue damage can be caused by the immune system, which is normally protective. • An immune response to anything the body considers to be "foreign"; these kinds of reactions can be harmful to the body. • Acting as carriers for additional toxins that enter the body: Microplastics have the ability to repel water and bind to substances that would otherwise dissolve, such as organic pollutants like pesticides and chemicals known as dioxins, which have been connected to cancer. They can also bind to compounds containing hazardous metals like mercury. Because microplastics are so common in marine and aquatic habitats, they are contaminating seafood and transferring dangerous toxins to people. The study investigated the adsorption of carcinogenic polycyclic aromatic hydrocarbons (PAHs) onto microplastics and estimated the possible cancer risk associated with human consumption of	(Horstmann *et al.*, 2002); (Francescone *et al.*, 2014); (Zhang *et al.*, 2015); (Lu *et al.*, 2016); (Pan *et al.*, 2016); (Treyer, 2016); (Deng *et al.*, 2017); (Mattsson *et al.*, 2017); (Sharma & Chatterjee, 2017); (Wright & Kelly, 2017); (Deng *et al.*, 2018); (Jin *et al.*, 2018); (Cordani & Somoza, 2019); (Lim *et al.*, 2019); (Luo *et al.*, 2019); (Ma *et al.*, 2019); (Plata *et al.*, 2019); (Adam, 2020); (Miller *et.al*, 2020); (Oh & Park, 2020); (Randall, 2020); (Sharma *et al.*, 2021)

	sardine); *Megalaspis cordyla* (Torpedo scad); *Cynoglossus abbreviates* (three-lined tongue sole); *Stolephorus commersonnii* (Devis's anchovy/ long-jawed anchovy); *Buglossisium luteum* (Solenette/ Flatfish); *Labeo chrysophekadion* (Black shark minnow); *Pelteobagrus fulvidraco* (Yellowhead catfish); *Henicorhynchus siamensis* (Siamese mud carp); *Mullus barbatus* (Red mullet); *Clupea harengus* (Herring);	microplastics enriched with PAHs. The adsorption equilibrium fit the Freundlich isotherm model appropriately. Carcinogenic PAHs could adsorb 46–236 g g1 on microplastics; in water, 45 minutes was needed to reach maximum binding. The leachate produced by e-waste microplastics was extremely hazardous; for instance, it included 3.17 mg L1 of total PAHs, which is about 1000 times more than the standard for the PAH congener benzo[a]pyrene. Over the course of a lifetime, children's estimated cancer risk from microplastic consumption is 1.13 105, while adults' estimated cancer risk is 1.28 105. Both estimates are greater than the suggested threshold of 106. Microplastics have the potential to spread dangerous pollutants to seafood, such as fish and prawns, raising the risk of cancer in people. In addition to problems with development and reproduction. If these microplastics get into the body, toxins may accumulate in adipose tissues. When marine animals, such as fish, are consumed, they can have harmful effects on humans due to a process known as alternate ingestion of microplastics. This alteration in chromosomes can eventually result in illnesses. In marine organisms, the digestion of microplastics causes chronic biological effects due to the accumulation of microplastics in their cells and tissues (Table 4). Microplastics are referred to as cytotoxic when they are present in excessively high concentrations. A type of uncontrollable cell death or a rupture of the necrotic plasma membrane could cause the cell to die. However, the mode of death is very non-specific, as most MP preparations are typically associated with surfactant molecules. At high concentrations, these would disturb the lipid bilayer of the plasma membrane (PM). These substances have the capacity to interfere with essential cellular surface structures including proteoglycans and other elements of the extracellular matrix, as well as cellular signalling pathways that depend on interactions between extracellular ligands and cell surface receptors, even at low concentrations. Thus, surfactants linked with plastic might have varying effects on cellular physiology. Depending on the kind of cell, MP may be absorbed via endocytosis quite quickly. MPs that have been endocytosed are problematic for several reasons. Initially like the plasma membrane, they might permeabilize endosomal membranes if they are present in significant amounts. If this happens, MPs released into the cytosol may interact with and impact important organelles such as the nucleus and mitochondria, as well as cellular functions such as the production of mitotic spindles and the movement of chromosomes during cell division. Additionally, MPs/NPs would probably prevent transport carriers from moving through the cell via the exocytic pathway, which could prevent the cell surface expression of important signalling receptors or membrane transporters. Finally, they are probably going to interfere with endosomal membrane trafficking, which	

		is necessary for a number of vital cellular processes like reverse signalling from endosomal compartments and surface protein turnover and signalling inhibition. It is unlikely that MPs will ever experience effective endosomal-route inter-compartmental transfer. It seems unlikely that the MPs will be rapidly broken down in the lysosome, even if they do end up there. The degradative functions of late endosomes and lysosomes, as well as the essential macroautophagy process of cellular membrane turnover, would be interfered with by MP growth in these organelles. Issues in autophagic clearance may set off positive feedback loops that ultimately result in the death of autophagic cells. Conversely, internalized MPs/NPs might encourage autophagy. MPs and metallic nanoparticles may control autophagy in similar ways (Issues in autophagic clearance may set off positive feedback loops that ultimately result in the death of autophagic cells. Conversely, internalized MPs/NPs might encourage autophagy. MPs and metallic nanoparticles may both control autophagy. At the very least, one may classify these activities as a form of cellular stress. Stresses in endo-lysosomes and PM would cause cellular stress reactions. The NADP oxidases may produce reactive oxygen species (ROS) (NOXs) in response to stress. By decreasing the effectiveness of electron transport chain (ETC) activities, mitochondrial dysfunction—whether brought on by endosomal MPs/NPs or stress—may increase the formation of reactive oxygen species (ROS). MPs and NPs can enter the bloodstream through the gut-vascular barrier or may undergo transcytosis, which enables them to travel to other organs. It is believed that tainted food is the source of MPs and NPs in humans' stomachs. Small NPs could perhaps enter the bloodstream, but undigested MPs would primarily be eliminated in stool. If MPs or NPs were swallowed, their initial point of contact would be the intestinal epithelium. It is anticipated that only excessively high concentrations of plastics or those containing adsorbed toxicants may result in acute inflammation and harm to the viability of the gut lining. On the other hand, it is unclear what effect MPs and NPs that are constantly present but ineffectively eliminated have on the gut. It is well known that MPs/NPs promote intestinal disease in fish. The data obtained by using mice as an experimental component in the experiments has painted a clear picture of the ramifications of gastrointestinal toxicity. If this happens, there's a chance that the gut-vascular barrier may be breached, giving MPs and NPs access to the bloodstream and the portal vein, which leads to the liver. This can be achieved, as demonstrated by certain mouse models. Metabolic diseases and liver illness may arise from chronic inflammation and long-term MP/NP accumulation in the liver tissues. On the other hand, the accumulation of MPs/NPs in lung tissues may cause chronic pulmonary illnesses. Additionally, as was already indicated, a fish model has shown that NPs are present in brain tissues. It is important to note, nevertheless, that it is still unknown if MPs or NPs may	

		be found in human brain samples or the brains of experimental mice. As of yet, there is no concrete evidence linking MPs/NPs to disease, metabolic dysfunction, or cell or tissue accumulation in humans. In mouse research, dysbiosis of the gut microbiota is one of the most common findings. Changes in the gut microbiota may lead to gastrointestinal disorders by generally upsetting physiological homeostasis. More importantly, changes in the gut microbiota have been linked to a number of chronic diseases affecting other organs, such as cardiovascular disease, neurological issues, inflammation, and cancer. Regarding the latter, behavioural changes in larger animals receiving MPs may have their root cause in dysbiosis of the gut microbiota. Blood arteries may block if significant concentrations of these aggregated protein-plastic complexes are found. Moreover, while NP loading of red blood cells (RBCs) at a low ratio of 1:50 did not affect RBC activities, loading that was 10–50 times higher resulted in RBC damage from oxidative, osmotic, and mechanical stress. Nonetheless, it is hard to envision a significant acute accumulation of NPs in the human circulation in natural environments.	

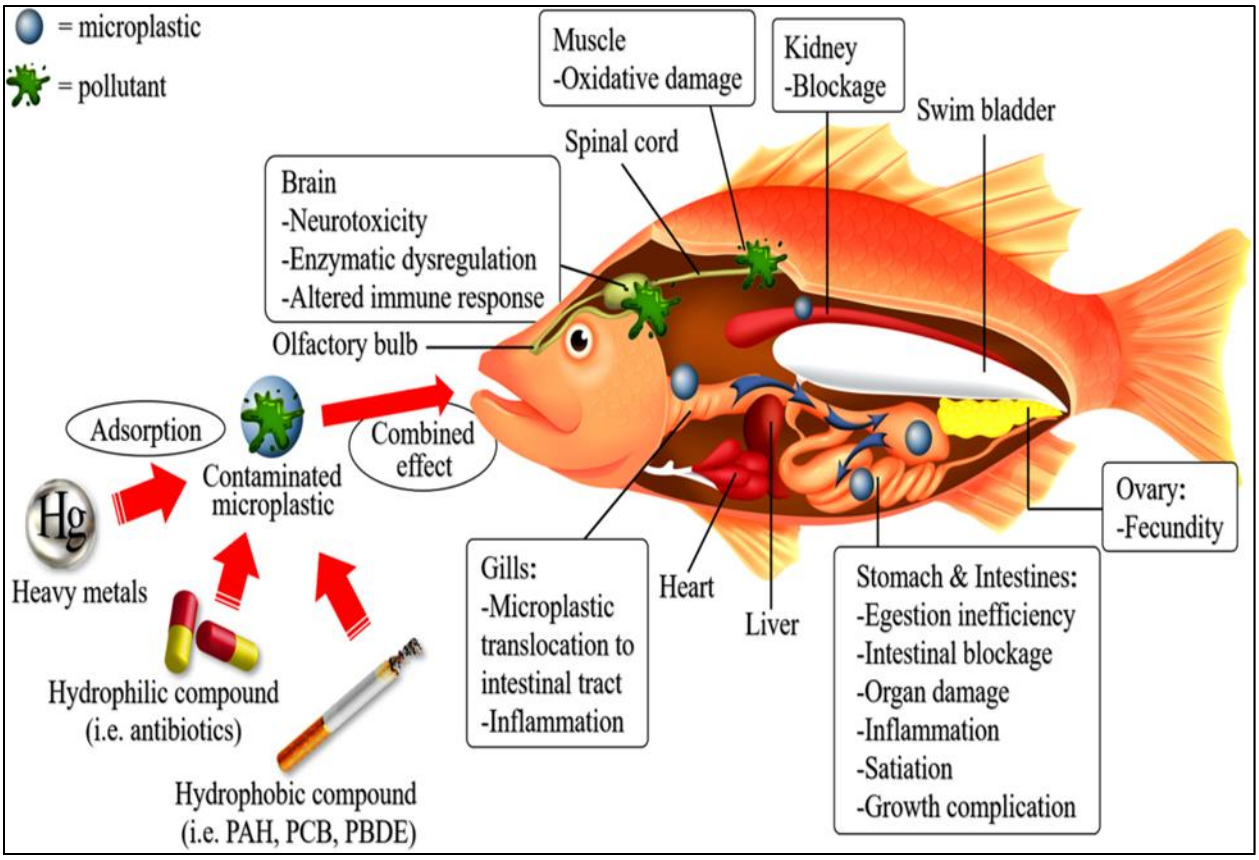


Figure 12 Negative effect on microplastics on fishes (Source: Amelia *et al.*, 2021)

Table 3 Microplastics in the gastrointestinal tract in some species of fishes

Species	**Family**	**F**	**GIT**	**SL (mm)**	**Author(s)**
Alburnus alburnus	Cyprinidae	BP	A	90.36 ± 18.54	(Froese & Pauly, 2021); (Parker *et al.*, 2022)
Barbatula barbatula	Nemacheilidae	D	G	39.63 ± 11.38	(Froese & Pauly, 2021); (Parker *et al.*, 2022)
Cottus gobio	Cottidae	D	G	30.21 ± 6.18	(Froese & Pauly, 2021); (Parker *et al.*, 2022)
Gasterosteus aculeatus	Gasterosteidae	BP	G	29.92 ± 4.16	(Froese & Pauly, 2021); (Parker *et al.*, 2022)
Leuciscus leuciscus	Cyprinidae	BP	A	130.72 ± 34.84	(Froese & Pauly, 2021); (Parker *et al.*, 2022)
Perca fluviatilis	Percidae	D	G	153.52 ± 28.59	(Froese & Pauly, 2021); (Parker *et al.*, 2022)
Phoxinus phoxinus	Cyprinidae	D	A	55.55 ± 11.66	(Froese & Pauly, 2021); (Parker *et al.*, 2022)
Rutilus rutilus	Cyprinidae	BP	A	114.82 ± 34.40	(Froese & Pauly, 2021); (Parker *et al.*, 2022)
Squalius cephalus	Cyprinidae	BP	A	130.67 ± 45.96	(Froese & Pauly, 2021); (Parker *et al.*, 2022)

For each species: F denotes the primary feeding type: D; demersal, BP; benthopelagic, GIT indicates the structure of the gastrointestinal tract: A; agastric (undifferentiated stomach), G; gastric (differentiated stomach), SL the mean standard length ± standard deviation; (Results taken from Parker *et al.*, 2022)

Table 4 Microplastics in the edible muscle tissues in some species of marine and freshwater fishes

Author(s)	**Family**	**Species**	**Ecosystem**	**MP in muscle (MP items/ g)**
(Barboza *et al.*, 2020); (Pandey *et al.*, 2022)	Moronidae	*Dicentrachus labrax*	Marine	0.4 ± 0.7
(Barboza *et al.*, 2020); (Pandey *et al.*, 2022)	Carangidae	*Trachurus trachurus*	Marine	0.7 ± 1.3
(Barboza *et al.*, 2020); (Pandey *et al.*, 2022)	Scombridae	*Scomber colias*	Marine	0.6 ± 0.8
(Abbasi *et al.*, 2018); (Akhbarizadeh *et al.*, 2019); (Pandey *et al.*, 2022)	Penaeidae	*Penaeus semisulcatus*	Marine Estuary	0.360 36
(Akhbarizadeh *et al.*, 2019); (Pandey *et al.*, 2022)	Portunidae	*Portunus armatus*	Marine	0.256
(Akhbarizadeh *et al.*, 2019); (Pandey *et al.*, 2022)	Mugilidae	*Liza klunzingeri*	Marine	0.275
(Abbasi *et al.*, 2018); (Akhbarizadeh *et al.*, 2018); (Akhbarizadeh *et al.*, 2019); (Pandey *et al.*, 2022)	Platycephalidae	*Platycephalus indicus*	Marine Estuary	0.178 18.50 ± 4.55 55
(Akhbarizadeh *et al.*, 2018); (Akhbarizadeh *et al.*, 2019); (Pandey *et al.*, 2022)	Serranidae	*Epinephelus coioide*	Marine	0.158 7.75 ± 2.16
(Akhbarizadeh *et al.*, 2018); (Pandey *et al.*, 2022)	Carangidae	*Alepes djedaba*	Marine	8.00 ± 1.22
(Akhbarizadeh *et al.*, 2018); (Pandey *et al.*, 2022)	Sphyraenidae	*Sphyraena jello*	Marine	5.66 ± 1.69
(Selvam *et al.*, 2021); (Pandey *et al.*, 2022)	Balistidae	*Sufflamen fraenatus*	Marine	4–18

(Selvam *et al*., 2021); (Pandey *et al*., 2022)	Chaetodontidae	*Heniochus acuminatus*	Marine	6
(Selvam *et al*., 2021); (Pandey *et al*., 2022)	Triacanthidae	*Pseudotriacanthus strigilifer*	Marine	10–36
(Selvam *et al*., 2021); (Pandey *et al*., 2022)	Leiognathidae	*Leiognathus brevirostris*	Marine	10
(Selvam *et al*., 2021); (Pandey *et al*., 2022)	Carangidae	*Atropus atropus*	Marine	33
(Daniel *et al*., 2020); (Pandey *et al*., 2022)	Clupeidae	*Sardinella longiceps*	Marine	0.07 ± 0.26
(Daniel *et al*., 2020); (Pandey *et al*., 2022)	Scombridae	*Rastrelliger kanagurta*	Marine	0.005 ± 0.02
(Daniel *et al*., 2020); (Pandey *et al*., 2022)	Engraulidae	*Thryssa dussumieri*	Marine	0.005 ± 0.02
(Daniel *et al*., 2020); (Pandey *et al*., 2022)	Clupeidae	*Anodontostoma chacunda*	Marine	0.005 ± 0.02
(Daniel *et al*., 2020); (Pandey *et al*., 2022)	Clupeidae	*Sardinella gibbosa*	Marine	0.005 ± 0.02
(Daniel *et al*., 2020); (Pandey *et al*., 2022)	Engraulidae	*Stolephorus indicus*	Marine	0.005 ± 0.02
(Daniel *et al*., 2020); (Pandey *et al*., 2022)	Dussumieriidae	*Dussumieria acuta*	Marine	0.005 ± 0.02
(Daniel *et al*., 2020); (Pandey *et al*., 2022)	Sphyraenidae	*Sphyraena obtusata*	Marine	0.005 ± 0.02
(Daniel *et al*., 2020); (Pandey *et al*., 2022)	Carangidae	*Megalaspis cordyla*	Marine	0.005 ± 0.02
(Abbasi *et al*., 2018); (Pandey *et al*., 2022)	Sillaginidae	*Sillago sihama*	Estuary	64
(Abbasi *et al*., 2018); (Pandey *et al*., 2022)	Cynoglossidae	*Cynoglossus abbreviatus*	Estuary	34
(Abbasi *et al*., 2018); (Pandey *et al*., 2022)	Synodontidae	*Saurida tumbil*	Estuary	12
(Praboda *et al*., 2020); (Pandey *et al*., 2022)	Engraulidae	*Stolephorus commersonnii*	Estuary	29.33 ± 1.19
(Pandey *et al*., 2022)	Channidae	*Channa punctatus*	Freshwater	0.65 ± 1.18
(Pandey *et al*., 2022)	Cyprinidae	*Labeo bata*	Freshwater	0.33 ± 0.39
(Pandey *et al*., 2022)	Cyprinidae	*Labeo rohita*	Freshwater	0.44 ± 0.67

(Results taken from *Pandey et al*., 2022)

Table 5 Mini checklist on the microplastic concentration in different body parts of fish species found in a variety of aquatic environment

Fish species	**Common name**	**Family**	**Water Resource**	**Body part**	**SD**	**Author(s)**
Buglossisium luteum	Solenette/ Flatfish	Soleidae	Channel	GIT	0.080	(Lusher *et al.*, 2013); (Azizi *et al.*, 2021)
Trachurus trachurus	Atlantic horse mackerel/ European horse mackerel/ Common scad	Carangidae	Channel	GIT	0.100	(Lusher *et al.*, 2013); (Azizi *et al.*, 2021)
Microchirus variegatus	Thick back sole/ Bastard sole/ Lucky sole	Soleidae	Channel	GIT	0.100	(Lusher *et al.*, 2013); (Azizi *et al.*, 2021)
Callionymus lyra	Dragonet	Callionymidae	Channel	GIT	0.130	(Lusher *et al.*, 2013); (Azizi *et al.*, 2021)
Merlangius merlangus	Whiting/ Merling	Gadidae	Channel	GIT	0.150	(Lusher *et al.*, 2013); (Azizi *et al.*, 2021)
Aspitrigla cuculus	Gurnard/ Sea robin	Triglidae	Channel	GIT	0.150	(Lusher *et al.*, 2013); (Azizi *et al.*, 2021)
Trisopterus minutus	Cod/ Poor cod/ Codfishes/ True cods	Gadidae	Channel	GIT	0.170	(Lusher *et al.*, 2013); (Azizi *et al.*, 2021)
Cepola macrophthalma	Redband fish	Cepolidae	Channel	GIT	0.180	(Lusher *et al.*, 2013); (Azizi *et al.*, 2021)
Micromesistius poutassou	Blue whiting	Gadidae	Channel	GIT	0.230	(Lusher *et al.*, 2013); (Azizi *et al.*, 2021)
Zeus faber	Dory	Zeidae	Channel	GIT	0.330	(Lusher *et al.*, 2013); (Azizi *et al.*, 2021)
Osmerus eperlanus	Smelt/ European smelt	Osmeridae	River	g	0.420	(McGoran et al., 2017); (Azizi *et al.*, 2021)
Platichthys flesus	Dabs/ Righteye flounder/ European flounder	Pleuronectidae	River Estuary	g GIT	1.170 0.550	(McGoran et al., 2017); (Bessa *et al.*, 2018); (Azizi *et al.*, 2021)
Rutilus rutilus	European sport fish/ Common roach	Cyprinidae	River	GIT	1.250	(Horton *et al.*, 2018); (Azizi *et al.*, 2021)
Gobio gobio	Wild gudgeons	Cyprinidae	River	GIT	1.240	(Slootmaekers *et al.*); (Azizi *et al.*, 2021)
Hemiculter Leucisculus	Carp/ Sharp belly/ Gamefish	Cyprinidae	River	g	0.010	(Li *et al.*, 2020); (Azizi *et al.*, 2021)
Konosirus punctatus	Dotted gizzard shad/ Konoshiro gizzard shad	Clupeidae	Bay	m	0.613	(Wu *et al.*, 2019); (Azizi *et al.*, 2021)
Larimichthys crocea	Drums/ Large yellow croaker/	Sciaenidae	Bay	m	0.678	(Wu *et al.*, 2019); (Azizi *et al.*, 2021)

	Yellow croaker/ Croceine croaker					
Bagrus bayad	Bagrid catfish	Bagridae	River	GIT	1.700	(Khan *et al.*, 2020); (Azizi *et al.*, 2021)
Dicentrarchus labrax	European bass/ Sea bass/ White salmon	Moronidae	Estuary	GIT	0.610	(Bessa *et al.*, 2018); (Azizi *et al.*, 2021)
Evynnis cardinalis	Threadfin porgy/ Cardinal seabream	Sparidae	River	S	1.000	(Chan *et al.*, 2019); (Azizi *et al.*, 2021)
Lutjanus stellatus	Star snapper	Lutjanidae	River	S	1.100	(Chan *et al.*, 2019); (Azizi *et al.*, 2021)
Repomucenus richardsonii	Dragonet	Callionymidae	River	S	1.200	(Chan *et al.*, 2019); (Azizi *et al.*, 2021)
Solea ovata	Lidah/ Sirih/ Malay/ Small flat fish	Soleidae	River	S	1.700	(Chan *et al.*, 2019); (Azizi *et al.*, 2021)
Pelteobagrus fulvidraco	Yellowhead catfish/ Korean bullhead/ Yellow bonefish	Bagridae	Bay	GIT	0.580	(Zhang et al., 2017); (Azizi *et al.*, 2021)
Culter dabryi	Humpback/ Lake sky gazer	Cyprinidae	Bay	GIT	0.710	(Zhang et al., 2017); (Azizi *et al.*, 2021)
Culter alburnus	Top mouth culter	Xenocyprididae	Bay	GIT	1.380	(Zhang et al., 2017); (Azizi *et al.*, 2021)
Pelteobaggrus vachelli	Bagrid catfish/ Trout	Bagridae	Bay	GIT	1.410	(Zhang *et al.*, 2017); (Azizi *et al.*, 2021)
Cyprinus carpio	Common carp/ Eurasian carp/ European carp	Cyprinidae	River Lake	GIT g	0.400 1.300	(Jabeen *et al.*, 2017); (Zheng *et al.*, 2017); (Azizi *et al.*, 2021)
Channa maculata	Blotched snakehead	Channidae	River	GIT	0.800	(Zheng *et al.*, 2017); (Azizi *et al.*, 2021)
Carassius gibelio	Prussian carp/ Silver Prussian carp/ Gibel carp	Cyprinidae	River	GIT	2.800	(Zheng *et al.*, 2017); (Azizi *et al.*, 2021)
Carassius auratus	Gold fish	Cyprinidae	Lake	g GIT	1.000 0.800	(Jabeen *et al.*, 2017); (Yuan et al., 2019); (Azizi *et al.*, 2021)
Hemiculter bleekeri	Cyprinid fish/ Minnow	Cyprinidae	Lake	g	1.100	(Jabeen *et al.*, 2017); (Azizi *et al.*, 2021)
Megalobrama amblycephala	Wuchang bream/ Blunt snout bream/ Bluntnose black bream	Xenocyprididae	Lake	g	1.700	(Jabeen *et al.*, 2017); (Azizi *et al.*, 2021)
Pseudorasbora parva	Stone moroko	Cyprinidae	Lake	g	1.800	(Jabeen *et al.*, 2017); (Azizi *et al.*, 2021)
Hypophthalmichthys molitrix	Silver carp/ Silver fin	Cyprinidae	Lake	g	2.000	(Jabeen *et al.*, 2017); (Azizi *et al.*, 2021)
Gambusia holbrooki	Livebearers/ Eastern mosquitofish	Poeciliidae	Wetland	W	0.885	(Su *et al.*, 2019); (Azizi *et al.*, 2021)

Pygocentrus nattereri	Red bellied piranha/ Red piranha/ Characid/ Characin	Characidae	River	S	0.010	(Andrade, 2019); (Azizi *et al*., 2021)
Metynnis guaporensis	Silver dollar	Serrasalmidae	River	S	0.030	(Andrade, 2019); (Azizi *et al*., 2021)
Tometes kranponhah	New pacu/ Kranponhah	Serrasalmidae	River	S	0.200	(Andrade, 2019); (Azizi *et al*., 2021)
Myloplus rubripinnis	Red hook myleus	Serrasalmidae	River	S	0.200	(Andrade, 2019); (Azizi *et al*., 2021)
Serrasalmus rhombeus	Redeye piranha/ Black piranha/ White piranha/ Spotted piranha/ Yellow piranha	Serrasalmidae	River	S	0.200	(Andrade, 2019); (Azizi *et al*., 2021)
Tometes ancylorhynchus	*****	Serrasalmidae	River	S	0.200	(Andrade, 2019); (Azizi *et al*., 2021)
Pristobrycon cf. scapularis	Pirambeba/ Caribito/ Palometa/ Paña/ Piranha/ Caribe	Serrasalmidae	River	S	0.400	(Andrade, 2019); (Azizi *et al*., 2021)
Ossubtus xinguense	Parrot pacu/ Eagle beak pacu	Serrasalmidae	River	S	0.060	(Andrade, 2010); (Azizi *et al*., 2021)
Laides longibarbis	Schilbeid catfish/ Asian schilbeids	Ailiidae	River	W	0.450	(Kasamesiri & Thaimuangpho, 2020); (Azizi *et al*., 2021)
Labeo chrysophekadion	Black shark minnow/ Black shark/ Black labeo	Cyprinidae	River	W	0.560	(Kasamesiri & Thaimuangpho, 2020); (Azizi *et al*., 2021)
Labiobarbus siamensis	Barb/ Carp	Cyprinidae	River	W	0.570	(Kasamesiri & Thaimuangpho, 2020); (Azizi *et al*., 2021)
Henicorhynchus siamensis	Siamese mud carp	Cyprinidae	River	W	0.700	(Kasamesiri & Thaimuangpho, 2020); (Azizi *et al*., 2021)
Mystus bocourti	Silver Lancer/ Hi Fin Mystus/ King Bagrid/ Koenigs-Stachelwels	Bagridae	River	W	0.700	(Kasamesiri & Thaimuangpho, 2020); (Azizi *et al*., 2021)
Hemibagrus spilopterus	Bagrid catfishes	Bagridae	River	W	0.960	(Kasamesiri & Thaimuangpho, 2020); (Azizi *et al*., 2021)
Puntioplites proctozyson	Smith's barb/ Pla mang	Cyprinidae	River	W	1.050	(Kasamesiri & Thaimuangpho, 2020); (Azizi *et al*., 2021)

Cyclochelichthy repasson	Boeng/ Malay	Cyprinidae	River	W	1.330	(Kasamesiri & Thaimuangpho, 2020); (Azizi *et al.*, 2021)
Notropis atherinoides	Emerald shiner/ Eastern shiners	Cyprinidae	Creek	GIT	0.950	(Campbell *et al.*, 2017); (Azizi *et al.*, 2021)
Esox lucius	Pike/ Pickerel/ Northern pike/ Mud minnow	Esocidae	Creek	GIT	1.220	(Campbell *et al.*, 2017); (Azizi *et al.*, 2021)
Catostomus commersoni	White sucker	Catostomidae	Creek	GIT	1.580	(Campbell *et al.*, 2017); (Azizi *et al.*, 2021)
Eucalia inconstans	Brook stickleback	Gasterosteidae	Creek	GIT	2.206	(Campbell *et al.*, 2017); (Azizi *et al.*, 2021)
Oreochromis mossambicus	Mozambique tilapia	Cichlidae	Mangrove	W	0.650	(Naidoo *et al.*, 2019); (Azizi *et al.*, 2021)
Ambassis dussumieri	Asiatic glassfish/ Malabar glassy perchlet/ Bare-headed perchlet	Ambassidae	Mangrove	W	0.750	(Naidoo *et al.*, 2019); (Azizi *et al.*, 2021)
Terapon jarbua	Crescent banded grunter/ Crescent perch/ Spiky trumpeter/ Thorn fish/ Tiger perch	Terapontidae	Mangrove	W	0.810	(Naidoo *et al.*, 2019); (Azizi *et al.*, 2021)
Mugil sp.	Mullet	Mugilidae	Mangrove	W	1.355	(Naidoo *et al.*, 2019); (Azizi *et al.*, 2021)
Misgurnus anguillicaudatus	True loach	Cobitidae	Farm	g	0.500	(Lv, 2019); (Azizi *et al.*, 2021)

GIT-Gastrointestinal Tract; g-Gut/ Intestines & Stomach; m-Muscle Tissues; S-Stomach; W-Whole Organism; (Results taken from Azizi *et al.*, 2021)

According to Table 5 (as shown above), sixty-one (61) species of fishes belonging to thirty (30) different fish families and adapted to nine (9) different water resources were represented. From the data reviewed, the results revealed: three (3) of the species belong to the family Soleidae; one (1) of the species belong to the family Carangidae; two (2) of the species belong to the family Callionymidae; three (3) species belong to the family Gadidae; one (1) species belong to the family Triglidae; one (1) species belonging to the family Cepolidae; one (1) species belonging to the family Zeidae; one (1) species belong to the family Osmeridae; one (1) species belong to the family Pleuronectidae; sixteen (16) species belonging to the family Cyprinidae; one species belong to the family Clupeidae; one (1) species belonging to the family Sciaenidae; five (5) species belonging to the family Bagridae; one (1) species belong to the family Moronidae; one (1) species belong to the family Sparidae; one (1) species belong to the family Lutjanidae; two (2) species belong to the family Xenocyprididae; one (1) species belong to the family Channidae; one (1) species belong to the family Poeciliidae; one (1) species belong to the family Characidae; seven (7) species belong to the family Serrasalmidae; one (1) species belong to the family Ailiidae; one (1) species belong to the family Esocidae; one (1) species belong to the family Catostomidae; one (1) species belong to the family Gasterosteidae; one (1) species belong to the family Cichlidae; one species belong to the family Ambassidae; one (1) species belong to the family Terapontidae; one (1) species belong to the family Mugilidae and one (1) species belong to the family Cobitidae.

Subsequently, the family Cyprinidae (minnows and carps) with sixteen (16) species reviewed in this research demonstrated the most prevalent fish family in which microplastics were discovered and documented on in prior studies. Additionally, microplastics are very prevalent in a variety of aquatic habitat with the river being the most prevalent habitat to twenty-nine (29) species of fishes; the channel being the habitat for ten (10) species of fishes; the bay and the lake accounting for six (6) species each; the mangrove habitats and the creek both having four (4) species of fishes' present and the wetland habitat and local fish farm having one (1) specie each present in those respective habitats. Further, microplastics are found in a variety of body parts on fishes. Among the sixty-one (61) species reviewed, twenty-seven (27) species had MP detected in their gastrointestinal tract; thirteen (13) species of fishes had MP discovered throughout their entire bodies; ten (10) species of fishes had MP detected in their gut/ intestine and stomach; twelve (12) species of fishes had MP found in their stomach only and two (2) species of fishes had MP located in the muscle tissues. In addition, three (3) species of fishes (*Platichthys flesus* from the family Pleuronectidae and *Cyprinus carpio* & *Carassius auratus* both from the family Cyprinidae) had microplastics detected and discovered in the gastrointestinal tract as well as their gut/ intestine and stomach.

4.4 Possible solutions to control microplastic contamination in marine environments

A byproduct of packaging materials is microplastic, it is well known that microplastics degrade slowly and have a heterogeneous makeup, including additive content in plastics and pollutants absorbed on them. Processes for recycling microplastics must therefore be modified appropriately. Some likely options are as follows:

4.4.1 Solvent Extraction

Reusing microplastic using solvent extraction, also known as dissolution reprecipitation, is one of the more recent methods. This is the process where a polymer is dissolved in a solvent, heated to a particular temperature, cooled, and then added to a new non-solvent. It is possible to finish this mixture (the polymer in the new non-solvent, or anti-solvent) by re-precipitating and examining the original polymer. In one work, Achilias & Antonakou (2015) used solvents to chemically recycle the polymers from plastic packaging. For the majority of polymers, chemicals like xylene seemed to be an excellent solvent with high recovery yields. It was also demonstrated that varying dissolving temperatures had an impact on the yields.

For instance, a higher temperature may increase the yield of recovering PS from around 88 percent to 94 percent when toluene is used as the dissolving solvent and n-Hexane is used as the non-solvent [115]. Here, the dissolution/ reprecipitation method for recycling polypropylene (PP) is suggested. It entails dissolving the plastic in the proper solvent, reprecipitating the material with a non-solvent, thoroughly cleaning the resultant material, and drying. Additionally, fractional distillation is used to separate the solvent mixes involved so they can be reused [110].

4.4.2 Chemical and thermo-chemical recycling methods

In order to produce useful products (such as monomers or fuel-type oils), thermal cracking, also known as pyrolysis, entails heating polymeric materials in the absence of oxygen (often in a nitrogen atmosphere). Depending on the kind of polymer, high temperatures during pyrolysis might result in the production of a fuel-like liquid fraction, which is mostly found in polyolefins (LDPE, HDPE, PP), or huge amounts of monomer (such as in polymethyl methacrylate). A new and outstanding book by Scheirs & Kaminsky 2006 and Achilias & Antonakou, 2015 provides an overview of the science and technique of pyrolysis of waste plastics.

4.4.3 Use of microorganisms

According to the Auta *et al.*, 2017 article graph, adding microorganisms is an additional potential technique. Due to their small size and low visibility, microplastics appear to be very difficult to manually remove, which is why the pollution of the marine environment by these particles has become so prevalent. Furthermore, the pace at which microplastics are removed from the environment is outpaced by their entry. It will be much easier to establish mitigation strategies if the potential sources of plastics and microplastics on land and in the ocean are identified. But using bacteria that can break down microplastic polymers—a process known as biodegradation—might offer a more viable solution.

The process of using microorganisms to break down a synthetic polymer is called biodegradation. The polymer serves as a carbon and energy source for microbes [11] [23]. Due to their opportunistic nature, bacteria may enter and adapt to any type of habitat. It has been documented that a number of bacterial species break down plastic polymers. For instance, Singh *et al.* (2016) described how soil-isolated *Staphylococcus sp.*, *Pseudomonas sp.*, and *Bacillus sp.* degraded plastic. In a comparable manner, Asmita *et al.*, 2015 and Auta *et al.*, 2017 isolated microorganisms from several soil samples with the capacity to break down polystyrene (PS) and polyethylene terephthalate (PET).

Species of *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Aspergillus niger*, *Staphylococcus aureus* and *Streptococcus pyogenes* were among the isolates. Two additional researchers' work [11] revealed that *Rhodococcus ruber* can break down polystyrene. It was shown that this particular variety of bacteria could break down polystyrene more effectively by producing biofilm. Using the clear zone and weight loss method of assay, microorganisms isolated from Andhra Pradesh and Telangana areas of Hyderabad were reported to be able to degrade polyethylene, suggesting that the isolates could be potential microplastic degraders [11] [35].

These bacteria could be used to break down microplastics in a way that is safe for the environment. Since this could reduce inputs from residential applications, such bacteria could then be used to clean sewage effluent. Their use could also extend to the cleaning up of polluted areas. Furthermore, *Pseudomonas putida* has been observed to degrade polyvinyl chloride (PVC) [23]. *Alcaligenes faecalis*, *Streptomyces sp*., Pseudomonas stutzeri, *Brevibacillus borstelensis* and other bacteria can also break down plastic polymers. These organisms break down polymers by producing extracellular polymer-degrading enzymes [11] [23] [55].

4.4.4 Microplastic extraction using magnets

Using a magnet to extract microplastics is another possible approach Ferrerira is the one who devised this method. It dawned on him that plastic may be drawn to oil. Ferreira made ferrofluid, a magnetic liquid, by simply combining vegetable oil with iron oxide particles. He then mixed this combination with a variety of everyday objects, such as paint, vehicle tires, plastic bottles, and washing machine water, to create a mixture of microplastics [47]. It dawned on him then that the microplastics had adhered to the ferrofluid. After that, the solution was eliminated using a magnet, leaving only water in its place. After putting this technique through several tests, it was discovered to be 87% successful at removing microplastics from water. However, the inventor is attempting to integrate this into residential pipes, cleansing the air as it enters or exits the building. Additionally, this method is being tried globally in many bodies of water [47].

4.4.5 Involvement of government and organizations

Microplastics represent a significant and expanding environmental hazard, with the commercial and public sectors knowing very little or nothing about the possible negative effects they may have. To lessen the entrance of microplastics into the aquatic ecosystem, the original sources and types of plastics and microplastics entering the marine environment must be determined. Additionally, it will be very beneficial to increase public, private, and government sector knowledge of microplastics through education. Ivar do Sul *et al*. (2013) reported the first thorough investigation of the consequences of microplastics on the maritime environment and biota [11].

In order to find temporal patterns of different hazardous compounds, they brought the scientific community's attention to the monitoring of contaminated pellets, which could help with decision-making in subsequent initiatives. Many organizations have proposed management standards in response to concerns regarding microplastics. For example, the United Nations Expert Panel of the United Nations Environmental Programme (UNEP) has argued for swift action to remove microplastics from the oceans, citing the fact that many marine organisms swallow microplastics, which harms them chemically and psychologically [11].

A program involving over 40 million people in 120 countries has been developed by organizations like as UNEP. Additionally, educational programs have been implemented to advocate for the decrease of plastic consumption, promote awareness, encourage recycling, and evaluate disposal facilities [11] [23] [143]. Guidelines for evaluating marine litter, including microplastics, have been developed by the UN Environment Program/Mediterranean Action Plan (UNEP-MAP), the Oslo/Paris convention (for the protection of the marine environment of the North-East Atlantic; OSPAR), and the Baltic Marine Environment Protection Commission-Helsinki Commission (HELCOM) [11] [24].

Workshops may be included in the strategy to support individual capacity building and the spread of best practices. A Joint Declaration of the Global Plastics Associations for Marine Litter Solutions was released by the plastics industry in 2011. It contained suggestions for reducing litter and a commitment to support several litter assessments. Non-Governmental Organizations (NGOs) have also set up extensive programs to help calculate the extent of microplastic pollution and its effects at the local, state, federal, and global levels. The goal of all of these initiatives is to create a secure environment for people and marine species [11] [24].

By promoting businesses to use plastics more sensibly and efficiently and by increasing public understanding of how to use plastics in daily life, the Plastic Disclosure Project (PDP) seeks to lessen the environmental impact of plastic waste. The reduce reuse recycle circular economy is a cost-effective way to reduce the quantity of plastic objects and microplastics particles entering and gathering in the ocean. The combined Group of Experts on Scientific Aspects of Marine Environmental Protection advocates for all nations to lead urgent efforts to reduce the number of plastics entering the ocean. The California Microbead Ban, or AB 888, was enacted in 2015. The restriction, which forbids the use of any kind of plastic microbead, aims to provide the greatest defenses possible for the nation against plastic microbead contamination. The measure encourages the use of natural substitutes including apricot pits, sea salt, and walnut husks. AB 888 aims to outlaw the sale of goods with plastic microbeads by 2020 [11] [24].

5 Conclusion

Studies have revealed that, regardless of species and habitats, microplastics often have a detrimental impact on the functional characteristics of organisms. Microplastics have the potential to have devastating impacts on the marine environment. They can be consumed physically, which has been known to result in asphyxia, malnutrition, and other problems like death. Through the process of bioaccumulation and/or their position in the trophic chain, the plastics can also have an impact on humans who eat these commercial fish and not just on the marine ecosystem. The body's white blood cells and the chemicals they produce can cause inflammation and tissue damage can be caused by the immune system, which is normally protective. Microplastics have the potential to spread dangerous pollutants to seafood, such as fish and prawns, raising the risk of cancer in people [87]. In addition to problems with development and reproduction. If these microplastics get into the body, toxins may accumulate in adipose tissues [114]. MPs and metallic nanoparticles may control autophagy in similar ways (Issues in autophagic clearance may set off positive feedback loops that ultimately result in the death of autophagic cells. Similar to metallic nanoparticles, MPs may control autophagy) [32]. At the very least, these processes would be categorized as a form of cellular stress. Stresses in and endo-lysosomes might activate cellular stress responses. Reactive oxygen species (ROS) (NOXs) are produced by the NADP oxidases in response to stress. Mitochondrial dysfunction lowers the efficacy of electron transport chain (ETC) activities, ROS generation may rise due to endosomal MPs/NPs or stress. MPs and NPs can enter the circulatory system or potentially spread to other organs by transcytosis if the gut-vascular barrier is broken. Larger animals treated with MPs may also have behavioral changes as a result of microplastic. Blood arteries may block if significant concentrations of these aggregated protein-plastic complexes are found. Additionally, while loading red blood cells (RBCs) at a low ratio of 1:50 did not affect RBC activities, loading RBCs at a ratio of 10–50 times greater resulted in RBC damage because of oxidative, osmotic, and mechanical stress [103]. However, it is hard to envision a significant acute accumulation of NPs in the human circulation in natural environments. Microplastics have been known to present possible hazards to the ecological environment, but a thorough investigation of their various effects on the environment has not yet been conducted. Yet, a review of the current methodology has been conducted with an emphasis on the most appropriate methodologies and procedures for assessing the concentration of microplastics in the marine environment. The majority of current research focuses on techniques for microplastic identification and quantification. However, due to a lack of standardization, typical detection techniques including sampling and separation procedures would inevitably produce erroneous or incomparable final data [60] [86]. Lv *et al*., 2021 state that the development of standardized techniques, such as microplastics sampling and identification techniques, is required in order to collect comparable monitoring data [86] [122]. It is well known that microplastics degrade slowly and have a heterogeneous makeup, including additive content in plastics and pollutants absorbed on them. Potential remedies that could help mitigate the effects of microplastic pollution. Dissolution reprecipitation, also known as solvent extraction, is one of the more recent methods for recycling microplastics. This is the process where a polymer is dissolved in a solvent, heated to a particular temperature, cooled, and then added to a new non-solvent. It is possible to finish this mixture (the polymer in the new non-solvent, or anti-solvent) by re-precipitating and examining the original polymer. In one work, Achilias & Antonakou (2015) used solvents to chemically recycle the polymers from plastic packaging. For the majority of polymers, chemicals like xylene seemed to be an excellent solvent with high recovery yields. It was also demonstrated that varying dissolving temperatures had an impact on the yields. For instance, a higher temperature may increase the yield of recovering PS from around 88 percent to 94 percent when utilizing toluene as the dissolving solvent and hexane as the non-solvent [115]. Efficiently and accurately identifying microplastics in environmental samples is a difficult undertaking. Residential wastewater treatment, microbe introduction and other techniques or treatments that can help with the remediation or solution for microplastic pollution that can lessen these harmful impacts are also available. To lessen the toxic effects of microplastics on marine species and how it will benefit humans in the long term by reducing plastic pollution, additional research and conclusions are thought to be necessary. Based on the findings of the literature review, many of the published literatures that provided information on countries external to the neotropics. Therefore, there is a need for more research to be done in relation to microplastics on fishes and marine species since there is a limited and dearth of data in this biodiversity rich region. Systems that offer political direction should also have ongoing monitoring of the quantity of plastics utilized. Reusable plastic goods that can be thrown away and reused are preferable to everyday plastic items that should be recycled or converted to biodegradable materials.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors hereby declare that this manuscript does not have any conflict of interest.

Statement of informed consent

All authors declare that informed consent was obtained from all individual participants included in the study.

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