Received: 10 February 2023 | Revised: 24 March 2023 | Accepted: 27 March 2023

https://doi.org/10.56946/jzs.v1i1.118

Journal of Zoology and Systematics

Review article

Effects of Microplastic Pollution on Marine Environment: a Mini Review

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Abstract

Global awareness of microplastic contamination and its effects on the environment has grown. Plastics are resistant to breakdown and penetrate aquatic environments and are ultimately easily accessible to a wide range of aquatic animals and ultimately transported along the food web. Microplastics in cells and tissues have long-term consequences for marine organisms. A major factor in the spread of microplastics to the environment is their high adsorption capacity on the water surface. Microplastics and persistent organic pollutants interact to make the pollutants even more dangerous to living things. Microplastic pollution and its impact on the ecological environment have attracted worldwide attention. To effectively control microplastic pollution, there is a need to understand how Microplastics affect the ecological environment. This review discusses the formation, transfer and distribution of Micro plastics and the current physical, chemical and biological impacts on the environment. It is crucial to prevent plastic additives' overuse and enact laws and regulations to control plastic waste on account of the current threats posed by Microplastics to marine life and human health. We can eliminate marine litter by establishing plastic recycling schemes in the future or by promoting plastic awareness programs through both social and informational media.

Keywords: MP Micro plastic pollution, Marine animals, polyethylene (PE), POPs, plastic degradation

1. Introduction

The first reports of the plastic waste structure appeared in the early 1970s. In the mid-20th century, notice an increase in plastic manufacture. Global plastics demand has risen to 245 million tonnes [1-3]. Plastics have a wide range of applications since they are strong, lightweight, and adaptable. The book Marine Pollution by Plastics examines how plastics affect the marine environment toxicologically. Pathogens, metals, and organic contaminants in the environment can all be absorbed by Microplastics. The presence of Micro plastics in the marine environment is extremely harmful to marine ecosystems. Pesticides, POPs (persistent organic pollutants), hydrocarbons, heavy metals, plastics, and Microplastics are among the contaminants in the marine environment. Marine life can consume small particles that are high in POPS (Persistent Organic Pollutants). Food webs can be thrown off if marine animals ingest these POPs [4, 5].

Around 60-80% of the world's litter is in the form of plastic, with almost 10% of annual plastic production ending up into oceans. Plastic pollution is now highly visible in oceans across the planet and it can take several hundred years to degrade in the environment. Surface to seafloor and pole to pole, micro plastic waste can move, reproduce, and accumulate in the ecosystem. This kind of pollution threatens marine life since it is pervasive and persistent in waters all around the world. Degradation of the plastic on the beach results in surface fractures that produce tiny particles that are blown into the ocean by the wind or waves. It is reported that 44% of seabird species in the world consume plastic [6, 7]. Micro plastic pollution has an adverse effect on a large variety of marine creatures. Plastic contamination has an impact on 267 marine species, according to estimates. The environment, human health, food quality, and other factors are threatened by plastic pollution. Ingesting plastics results in intestinal blockage, illness, mortality, and damage to the intestinal mucosa in marine creatures and mammals. People do not directly consume organs since Micro plastics are discovered in the intestines of living things [8]. The dangers of consuming Micro plastics by humans include tissue injury, displacement, redistribution, and retention with other body tissues. Micro plastics contaminate the most aquatic ecosystems on Earth. Micro plastics may enter the food chain by being directly eaten by marine animals but can also adhere to the surface of micro-organisms that form the prey for higher levels of the food chain, such as fish [7, 9].

Humans who consume Micro plastics may have biological impacts include intestinal obstruction or injury, decreased energy absorption, and food chain disruption. Another method of introducing micro plastic into the ocean is the breakdown of micro plastic waste [10-12]. There are an increasing number of and demand for small marine plastic particles worldwide. Zooplankton waste is another way that Micro plastics might infiltrate the marine environment. Studies have shown that different marine creatures may consume various forms of Micro plastics. Once the body can consume Micro plastics, it can expel them in the feces and produce pseudo-feces, which are harmless to the body. Around 65 million Micro plastics per day are released into rivers by wastewater treatment facilities (WWTW). The efficiency of removing Micro plastics can be raised from 72 to 99.4% [13]. Wastewater contains nitrogen and phosphorus from human waste, food, certain soaps, and detergents. Once the water is cleaned to standards set and monitored by state and federal officials, it is typically released into a local water body, where it can become a source of nitrogen and phosphorus pollution. Global demand for plastic can be change over time. As plastic is made from a range of petrochemical products, largely derived from crude oil, increased consumption of plastic is set to propel demand for raw materials like naphtha that are needed to make petrochemicals — in other words, spurring the need for more oil. For that reason plastic demand is increasing day by day.[11, 12, 14].

1.1 Types/sources of micro plastics

There are numerous different types of Micro plastics that can be found in the marine environment, and they range in size, shape, chemical makeup, and other characteristics.

Micro plastics are the main source of micro-pollution in the marine environment.

Primary Micro plastics are those produced in industrial and home settings. It is made up of synthetic raw plastic ingredients. The size of primary Micro plastics is tiny. Scrubs, infant creams, toothpaste, cleansers, and other products contain the majority of micro plastic particles. Size ranges from around 0.5 mm in diameter to about 0.1 mm [15].

Secondary Micro plastics: These are produced when macro plastics break down during specific spatial processes like ageing and weathering.

Table 1. Micro plastic types and their potential sources

Micro plastic type	Definition	Potential sources
Fragment	Hard, jagged plastic Particle	Bottles; hard, sturdy plastics
Fiber	Thin or fibrous, straight Plastic	Fishing line/nets; clothing or textiles
Pellet	Hard, rounded plastic Particle	Virgin resin pellets; facial Cleansers
Foam	Thin plane of flimsy plastic	Plastics bags, wrappers, or sheeting
Film	Lightweight, sponge-like plastic	Foam floats, Styrofoam, cushioning

Table 2. Impact of micro plastics on marine organism

Species name	Effects	References
Blue mussel (*Mytilus edilus*)	Decreased feeding activity Formations of granulocytoma in digestive glands and lysosome membranes' destabilization	[37, 38]
Mytilus galloprovincialis	Ingestion of resin pellets	[39]
Zooplankton	Zooplankton ingested and accumulated phthalic acid esters, organophosphate ester flame retardants, and plasticizers.	[38, 40]
Blue mussels (*Mytilus galloprovincialis*)	PCBs absorbed at higher amounts, which had harmful effects. The blue mussels' increased desorption of pyrene caused anomalies and fatal effects on their DNA, which suggested neurotoxic effects.	[3, 41]
Pelagic fishes and holothurians	A pelagic fish named Boops absorbed 70% of the fibers from Micro plastics. Holothurians ingesting plastic pellets through the food chain	[3, 42]
Copepod (*Calanus helgolandicus, C. cristatus*, *Euphasiapacifa*)	Consumption, decreased eating, lowered reproductive success, and decreased egg output	[43, 44]
European flat oysters (*Ostreaedulis*)	Ingestion and abnormal respiration rates	[45]
Mussel	Cytotoxicity, decrease in phagocytic activity, and increase in lysozyme activity	[46]
Sea turtles (Chelonioidea)	Ingestion	[47]
Mussel, amphipods (*Allorchestes compressa*)	Consumption, the development of Granulocytom, and lysosome membrane destabilization/accumulation of POP	[48]
Lugworm (*Arenicola marina*)	Ingestion may result in enhanced metabolic rates, a reduction in the development of fecal casts, and fitness effects.	[38, 49]
Oyster	Significant decrease in fertilization and embryo–larval growth deformities	[38, 50]
Marine fish (*Pomatoschistus microps*, *Artemia nauplii*, *Danio rerio*, *Oryzias latipes*)	Ingestion, liver inflammation, pathological and oxidative stress, lipid accumulation in liver	[51]
Mussels	Superoxide dismutase (SOD) activity was temporarily increased after exposure to Micro plastics (for 24 hours and for seven days), whereas exposure to Nano plastics resulted in an innate immunological reaction.	[52]
Commercial fish	Gastro intestinal system and fish gills. Micro plastics have Cr and Fe found on them.	[38, 40]

They are widely distributed in marine and coastal habitats worldwide. Secondary pollutants are the term for larger particles found in the soil and water. Larger plastic debris that may wash up on beaches and in the sea might cause secondary contamination [12, 16]. Optically decomposing plastic results from larger plastic waste or particles being exposed to ultraviolet (ultraviolet radiation) from the sun. Both forms of Micro plastics can be observed in marine habitats.**[15, 17](Table 1)**

1.2 Occurrence of microplastic pollution in terrestrial ecosystem

Soil, the ecosystem's foundation, is under severe stress from anthropogenic pollution. Plastic breaks down relatively gradually in soil. According to several studies, there is a little breakdown of synthetic polymers in soil [12, 18].

Some research indicates that after 800 days in soil, PE only loses weight by 0.1% to 0.4%. Some claim that polyvinyl chloride (PVC) does not disintegrate in soil after 10-35 years, but polypropylene loses 0.4% of its weight after a year of incubation. Soil texture is a significant component that influences polymer breakdown [19]. By influencing soil structure, bulk density, water holding capacity, and microbiological activity, particulate matter disturbs the interactions between water and soil. There are three ways to describe soil particle matter. The first technique uses pressure fluid extraction (PEF) to detect particle matter in soil samples. However, this technique can't measure all of the MP size [18, 20].

Using this technique, the Sydney region's topsoil near industrial areas includes between 0.03% and 0.67% particle matter. Show a 0.5–5mm range for PM particle size. Another straightforward and affordable approach is adopted to extract, quantify, and differentiate the luminance of PM in soil. With a recovery rate of about 90%, this technique uses distilled water to remove soil particles [20, 21].When the sample was subjected to higher temperatures, the soil-related particles melted and transformed into rounded clear particles. This technique typically determines the particle's light-limited density. FT-IR microscopy is the most recent technique for examining soil particles' size, concentration, distribution, and composition. The amount of particles retained, deposited, and transported is influenced by a variety of factors, including particle qualities (such as size, shape, and density), human activity, weather (precipitation), water, and environmental topography [22].

2. Transport of MPs in aquatic ecosytem

Waste has a greater ecological impact now than it did in previous decades due to increased exposure to the marine environment. Dispersion and movement of PM in the ocean, including sediments in shallow and deep waters, beaches etc [23]. There is a lot of MP, PP, and PE content on the water's surface. The following are some sources of PM in the Southern Ocean: (a) wastewater discharged to research facilities 52% of research facilities lack wastewater treatment equipment. High quantities of ultraviolet light in the Southern Ocean cause PM to be produced there through bleaching of synthetic fibers (d) deterioration of floating garbage. % found in marine sediments from the Arctic. Due to this high PM concentration, sea ice creatures and seabirds are at risk [24]. Marine plastic is thought to originate between 75 and 90 percent from land and between 10 and 25 percent from oceanic sources. In the marine environment, the primary source of PM is wastewater treatment plants (WWTPS)[20, 25].Higher daily concentrations of PM are discharged into WWPTS. The treatment facility is thought to discharge 1.76 trillion PM, of which 1.28 trillion are deposited in the primary tank, 0.36 trillion are deposited in the secondary tank, and 0.03 trillion are released into the receiving marine environment. It is anticipated that 13 billion particles per day will be discharged to the wastewater treatment facility annually such as hurricanes, choppy seas, and tsunamis etc [26, 27].

3. Plastics used in marine environment

Plastics are advantageous for a variety of applications because they are strong, flexible, transparent, and lightweight. Its low cost and superior resistance to oxygen and moisture make it a great packing material. Plastic packaging or more modern designs replace metal, paper, and glass materials. Plastics of all kinds, including polystyrene (PS), polyethylene terephthalate

(PET), polyethylene (PE), polypropylene (PP), and polyvinyl chloride, are utilized in packing materials (PVC). [28].Future marine uses, overfishing, and recreational activities may increase the amount of plastic garbage entering the oceans. Around 80% of plastic garbage is generated on land, including beach trash. Polyolefin (PE and PP) and nylon are used in fishing gear and applications. Fishing is responsible for about 18% of the plastic garbage in the oceans.[29, 30]. The accumulation of plastic garbage in the oceans is also facilitated by aquaculture. As a result of excluding plastic in sediments and other bodies of water, the amount of floating plastic trash is significantly understated. Sea water weights approximately 1.025. In the maritime environment, various plastics are utilized that have densities comparable to those of saltwater. Nylon and other polymers frequently melt in the water column and in coastal sediments [30, 31].

4. Microplastic pollution in ocean

Over the past forty years, so-called micro plastic debris has accumulated in the world's waters. There are various definitions for Micro plastics and micro waste. Visible particles larger than 500 microns, stopping at 67 microns, and measuring 0.67 to 0.5 mm in diameter are referred to as microliters; otherwise, these larger particles are known as Mesolithic. The size of the other micro particles ranges from about 5 mm. The size of the plastic particles in seawater ranges from a few millimetres to 500 microns (5mm). Mesolithic are larger particles, such as primary plastics. Even when combined with sand, the minuscule particles visible to the unaided eye do not have as large chunks as plastic particles. Some of the suggested techniques are [32]based on the author's personal experience. To eliminate Mesolithic, a coarse filter was used on the water sample. Brine was added to sand and sediment samples to help the micro particles float to the top. To make the water denser and enable the plastic flakes to float, mineral salts are dissolved in the mud or water sample that was taken [28, 33].

Surface water samples and floating micro particle samples were collected for testing. Micro plastics may build on the surface of saltwater samples due to concentration and evaporation. These samples can be seen under a microscope by staining them with a lipophilic dye. Although the water samples contain plankton and other microbes, lipophilic dyes cannot be used to stain them [34, 35]. Since the treatment does not affect the micro plastic fraction, pollutants can be removed from biomass by diluting with hot, diluted mineral acid. Additionally, FTIR Spectroscopy, Raman Microscopy, Light Microscopy, and Electron Microscopy can all be used to identify micro plastic suspensions [35, 36]

Table 3 Toxicological effect of plastic on fish species

Fish species	Particle size	Micro plastic type	Effects
Acanthochormis Polyacanathus	1-2 mm	Polyethylene terephthalate	Decrease the growth
Pomatoshistos microps	1-5micrometer	Polyethylene	AChE activity decrease
Dictrarchus labrax	1-5micrometer	Polymer	swimming speed decrease
Carrassius Carassius	(24.7±0.2) nm	Polystyrene	vitality decrease
Daniorerio	70µm	Polyethylene polyvinyl Chloride	intestinal injury

5. Plastic degradation under marine conditions

A chemical reaction called degradation lowers a polymer's average molecular weight. Because the high average molecular weight and level of material weakening determine the plastic's integrity. Plastic has suffered considerable degradation, which makes it brittle and hard enough to crumble into dust when handled. Microbial biodegradation further breaks down these invisible fragments, which turns the polymer's carbon content into CO2 and incorporates it into the biomass [53]. Complete mineralization is the term used when this process is finished and all of the macromolecular organic carbon has been transformed. The organism that caused the deterioration is typically used to classify it.(a) Biodegradation - the result of living things (usually bacteria), (a) Photo degradation caused by light exposure (outdoors, usually sunlight), (b) Slow oxidative thermal oxidative degradation mild temperature decomposition, (c) High-temperature service and thermal deterioration and (d) Hydrolysis is a water-based reaction. Common polymers exposed to the marine environment include LDPE, PP, HDPE, and nylon. Sunlight's UV-B photons are primarily what start photo-oxidative damage [54]

Once decomposition has begun, thermal oxidation can continue without additional UV exposure for a while. As long as the system has access to O2, automated catalytic decomposition reaction sequences can continue to operate. The polymer's molecular weight drops and oxygen-rich functional groups are generated following decomposition. Other types of decay happen more slowly than light-induced oxidation [55]. All biological materials, including plastics, harm the marine environment when they are hydrolyzed, and bottom sediments degrade plastics more slowly than light-induced oxidative degradation does. The plastic is exposed to the air and even the beach surface through an efficient method called solar UV radiation-induced deterioration. However, degradation is greatly postponed if the same plastic material is exposed to the sun in the same location [56]. Other polymers also degrade when they come into touch with water or sand. For instance, sunlight damage to fishing equipment has a variety of effects. Plastic gear exposed to air in marine environments, such as nylon liners and polyethene textiles, weather. The slow pace of deterioration may cause blockage. The energy of the resin affects the initial rate of color. The physicochemical polymeric properties of the PWs, as shown in Fig. 1, as well as several environmental factors, define the plastic degradation process [39].

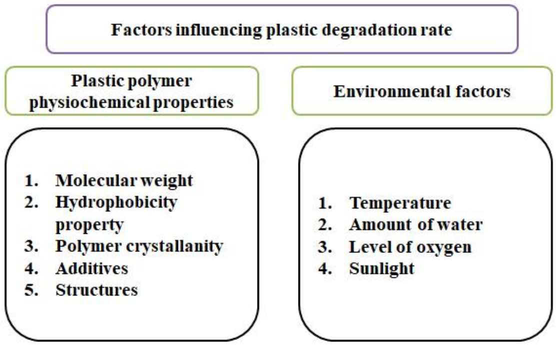

Figure 1 Factors influencing plastic degradation rate

6. Toxicological effect of micro plastics

Micro plastics can harm the ability of marine species to reproduce. The amount of eggs laid by Crassostrea gigas is significantly decreased when it is exposed to Styrofoam Micro plastics, for example. The amount of sperm motility decreased, indicating that Micro plastics would severely impair sperm motility [37].

After Micro plastics, biological tissues and organs engage a variety of immune responses in the direction of marine fishing. For instance, white blood cells from Sparus aurata and Dicentrarchus labrax can be oxidative damaged by polyvinyl chloride (PVC) and polyethylene (PE) Micro plastics with a particle size of 40–150 m, leading to immune toxicity [57] (table 3).

Conclusions and recommendations

Micro plastics are prevalent, common, and persistent on a global scale [58]. When paired with increased amounts of chemical pollutants in the water that are easily absorbed and condensed into Micro plastics, which can be consumed indiscriminately by aquatic organisms, they offer a serious threat that calls for worldwide action. Global contamination occurrences due to micro plastic pollution of the oceans are rising; however, no viable solutions are available. We must begin to purge other toxins using a variety of techniques. Future research should study size, shape, and associated impurities to better evaluate Micro plastics. It is essential for all parties involved to raise awareness of the harmful impacts of Micro plastics and the incorrect treatment of plastic waste. Strict regulations are required at the local, national, regional, and worldwide levels to limit the use and consumption of plastics and to provide incentives for the prevention of plastic pollution and garbage reduction.

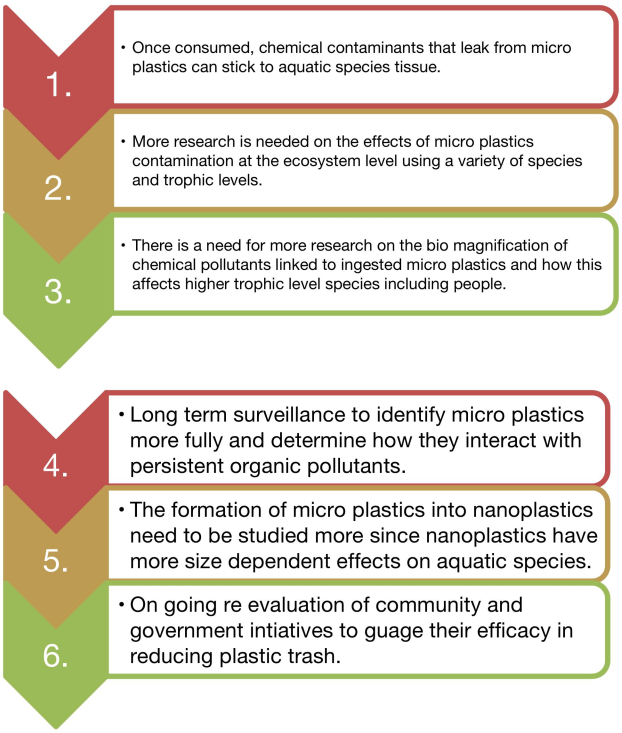

Figure 2 Future directions for Micro plastics mitigation.

Data Availability statement

The data presented in this study are available on request from the corresponding author.

Conflicts of Interest

All authors declare that, they have no conflict of interest.

Author Contributions

Formal analysis, Zainab Riaz; Investigation, Dr. Shakeela Parveen, Urwa Ishaq, and Mehwish Sultana; Software, Muhammad Tyyab; Writing – original draft, Zainab Riaz, Dr Shakeela Parveen; Writing – review & editing, Zainab Riaz, Zainab Shafqat, Saman Shabbir and Zunaira Faiz.

Acknowledgements

The authors feel grateful to Dr. Shakeela Parveen for her technical support and guidance.

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How to cite this article:

Riaz, Z., parveen, D., Tayyab, M., Ishaque, U., shabbir, saman, Sultana, M., Faiz, Z., & Shafqat, Z. Effects of Microplastic Pollution on Marine Environment: a Mini Review . *Journal of Zoology and Systematics*, *1*(1), 1–9.