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International Journal of Epidemiology and Public Health Research
Review Article

MicroPlastic in Aquatic Ecosystems: Assessing the Ecological Consequences and Mitigation Strategies

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Article Info

Received: June 11, 2024
Accepted: June 19, 2024
Published: June 28, 2024

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Citation: Muhammad Muzamil, Nimra and Muhammad Kabir.(2024) "MicroPlastic in Aquatic Ecosystems: Assessing the Ecological Consequences and Mitigation Strategies"". International Journal of Epidemiology and Public Health Research, 5(1); DOI: 10.61148/2836-2810/IJEPHR/064

Abstract:

The presence of microplastics in aquatic ecosystems has raised concerns about their ecological consequences and the need for effective mitigation strategies. These tiny plastic particles, originating from various sources such as plastic waste and synthetic fibers, pose significant risks to aquatic organisms and ecosystem health. Their ingestion by marine life can lead to physical harm, bio accumulation of toxins, and disruption of food chains. To address these challenges, it is crucial to assess the environmental impact of microplastics comprehensively.This includes studying their distribution,interaction with organisms,and long-term effects on ecosystem dynamics. Mitigation strategies involve reducing plastic pollution at its source, enhancing waste management practices,promoting sustainable alternatives to plastics,and raising awareness among communities and policy makers. Collaborative efforts among scientists, policy makers,industries, and the public are essential to mitigate the ecological consequences of microplastics and ensure the health and sustainability of aquatic ecosystems.

Keywords:

microplastics; aquatic ecosystems; ecological consequences; mitigation strategies; plastic pollution

Introduction:

Micro plastics are defined as plastic particles less than 5 mm in size. It has become a significant concern in aquatic ecosystems worldwide (Rochman et al., 2016). These micro plastics are defined into two states; first one is micro beads and second which break down from large plastics(Li. J et al., 2020). Micro plastics come from different places, like when big plastic things break into smaller pieces or from tiny plastic beads used in products like face scrubs. These tiny plastics can be harmful to animals in the water because they're so small that animals can eat them without realizing it (Patterson, 2011). This can be a problem for our water friends and the whole water world.The accumulation of micro plastics in aquatic environments causes ecological threat sand requires effective mitigation strategies (Galloway, 2015).

Plasticis every where and alot of it ends up in the ocean.When plastics break down in the ocean, they turn into tiny pieces called micro plastics. Some plastics, like micro beads in beauty products, are made small on purpose and also end up in the ocean. Animals in the water can mistake these tiny plastics for food (Browne et al., 2008). Scientists are studying this issue,but there's still a lot we don't know. In 2015, the U.S. banned micro beads, but micro plastics are stilla big problem in the ocean. We can all help by reducing our use of plastic to keep it out of the ocean(Ziani et al., 2023).

Sources of Micro Plastics:

In adequate handling of plastic waste has caused a rise in pollution in both freshwater and marine environments.Plastic waste makes up a significant portion of marine debris,with estimates ranging from 60% to 80% of marine waste and 90% of floating waste in oceans. This pollution poses a threat to marine life as animal scaningest plastics,leading to harmful consequences. Studies show that at least 267 species worldwide, including birds, mammals,turtles,and various fish species,are affected by plastic pollution(Millican &Agarwal, 2021).

Micro plastics, which are tiny plastic particles, are a major concern as they can enter the food chain through sea food and other sources. Humans are exposed to microplastics through food ingestion and inhalation, especially from contaminated sea food, processed fish, sea salt, and bottled water. These micro plastics can carry chemical contaminants and pollutants, affecting both marine life and human health (Pradeau, 2006).

The origin of micro plastics can be primary, from directly produced micro particles like micro beads, or secondary, from the fragmentation of larger plastic debris. They are found in various forms such as fragments,spheres,fibers,and pellets.The degradation of plastics in the environment, known as secondary microplastics, also contributes to pollution. The impact of microplastics on human health is still being studied, but there are concerns about their potential toxicity and bio accumulation in the food chain. Chemical compounds from plastics, such as bisphenol A (BPA) and phthalates, can leach into the environment and be harmful to marine organisms and humans alike (Faure et al., 2015).

Ecological Consequences:

Micro plastics are a big problem for water animals. They get eaten by fish, bugs, and tiny sea creatures, making them sick and storing bad chemicals in their bodies (Koelmans et al.,2013;Weight et al., 2013). These make it hard for them to eat, have babies, and stay healthy,messing up the balance in their homes. Also, these tiny plastics carry around more bad stuff,spreading it to other animals and changing how the whole water world works (Thompson et al.,2005).This can mess up where animals live, what kinds of animals are there, and make it toughfor the water world to stay healthy. Because these plastics stick around for a long time, they keep causing problems and making life harder for animals and us who eat seafood (Andredy, 2011).We really need to do more to stop this and learn more about how it's affecting our water homes(Freeetal., 2014).

Microplastics come from different places and can end up in water environments:

Plastic Breakdown:

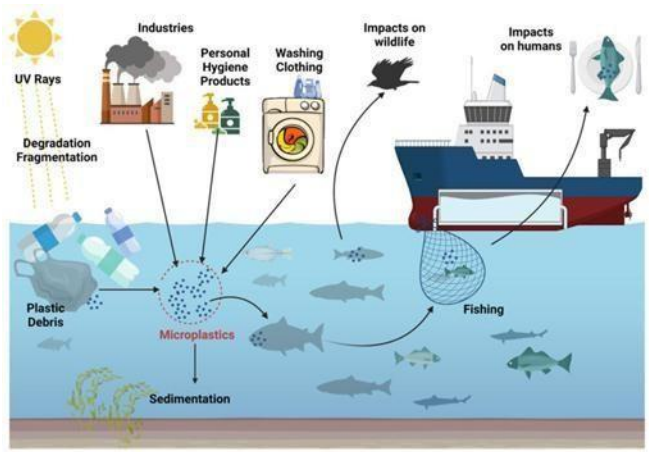
When big plastic things like bottles or bags break into tiny pieces over time, they create micro plastics. This happens because of things like sunlight (UV radiation), rubbing against surfaces (mechanical abrasion), and bacteria breaking down the plastic (microbial degradation)(Browneetal., 2011).

Microbeads:

Some personal care products, like face scrubs and toothpaste, contain very small plastic beads called microbeads.When we use these products and wash them off,them micro bead scan go into water directly through sink sand drains,adding to the microplastics in water bodies(Jembacket al., 2015).

Industrial Activities:

Industries that make things like clothes (textiles), paints, and coatings also release microplastics during their manufacturing processes. These micro plastics can end up in water ways through various channels, contributing to the pollution(Fendell&Sewell, 2009).



Ecological Impact of Micro Plastics:

Micro plastics are tiny pieces of plastic that are causing big problems in our water homes.When animals like fish, bugs, and small sea creatures eat these tiny plastics. They can get sickand store harmful chemicals in their bodies. This makes it hard for them to eat properly. It has babies,and stays healthy.It also messes up how they interact with each other and their environment. These micro plastics don't just stay in one place. They travel around and carry more bad stuff with them, spreading it to other animals in the water. This can change where animals live,what kinds of animals are there, and make it tough for the water world to stay balanced and healthy.It's like if some one brought alot of garbage to your neighborhood and start eddumping it every where.It would make your neighborhood messy and hard to live in.Because these plastics don't break down easily, they stay in the water for a long time, causing more and more problems.And when we eat sea food,we might also be eating these tiny plastics and the chemicals they carry,which can be bad for our health too(DeWitte al.,2014).

To solve this problem, we need to find ways to stop micro plastics from getting into the water in the first place and clean up the ones that are already there. It's a big challenge, but by working together and learning more about how micro plastics affect our water homes, we can make things better for the animals and forus.

Detection Strategies for Microplastic Pollution:

Various methods are employed to detect microplastics. Initially, samples are visually inspected for particles sized 1–5 mm, or they are examined under a microscope after collecting water and sediment samples. This is a straight forward and cost-effective approach. However,more advanced techniques like Raman spectroscopy or Fourier transform in frared (FTIR) spectroscopy are also used for precise detection. Detecting microplastics comes with challenges:capturing the particles,separating plastic fragments from other particles in the sample, and identifying the type of plastic. In sediment analysis, plastic particles are first sorted by size through sifting and filtering. Density differences are then utilized to separate particles from sediment sand water (Li&Duan, 2019).

Raman spectroscopy and FTIR spectroscopy are commonly used for accurate microplastic identification, detecting particles as small as about 10 µm. FTIR sends infrared rays to microplastics and analyzes the reflected radiation to determine composition and chemical makeup(Maetal.,2016).Raman spectroscopy exposes sample stolaser light,providing structural information about the polymer (Leslie et al., 2017). These methods reduce cross-contamination risks compared to other techniques (Mason et al., 2016). To ensure accurate results, maintaining a clean environment during sample handling is crucial, and avoiding plastic use during analysis is recommended. Scientists may wear natural material aprons and disinfect surfaces with ethanol (Li et al., 2018). Procedural blanks are also essential to assess and mitigate contamination risks during analysis,preventing mis leading results(Wang etal.,2017).

Mitigation Strategies for MicroPlastics:

The emergence of bio plastics present sapotential solution to some challenges posed by traditional plastics.Bioplastics encompass bio based plastics and biodegradable plastic(Decostaetal.,2016).Bio based plastics substituten on-renewable plastic monomers with renewable sources(VonMoosetal.,2012).Forinstance,bio-PE utilizes sugarcane starch instead of petrochemicals to produce the ethylene monomer(Dobaradaranetal.,2018).However,despite the shift to plant sources reducing petrochemical demand,issues like deforestation, pesticide usage, and extensive chemical processing persist (Bakir et al., 2016).Biomass-basedplastics shareproperties and additive sak into conventional plastics.Biodegradable plastics can decompose into water and carbon dioxide under specific conditions inthe environment through microbial action (Dris et al., 2015). However, they require suitable environments for degradation and it can persist if conditions are unfavorable (Hussain, 2001;Liebezeit &Dubaish, 2012; Vianello et al., 2013). The regulatory landscap econcerning plastic pollution has evolved significantly.Regulations focuson production,transport,commercialization,collection,and recycling to minimize environmental pollution. Initiatives like the Microbead-Free Waters Act in the United States and the Commonwealth Clean Oceans Alliance in the United Kingdom target microplasticpollution and promote biodegradable alternatives, and aim to reduce single-use plastic usage.Globally,legislative measure sare being taken to combat plastic pollution and promote sustainable practices (Woodall et al., 2014). Efforts to engage the public in reducing plastic pollution are also underway (Lambert, S & Wagner, 2016; Michielssen et al., 2016). Initiatives like the Plastic Bank in centivize individuals incertain region sto collect plastic waste in exchange for rewards. Moreover, countries like China, France, Italy, and ASEAN member states have implement edvarious law sand planstor egulate plastic usage and mitigate pollution(Avioetal., 2017; Castañedaet al., 2014).

On an international level, agreements such as the Ocean Plastic Charter, signed by G7countries and the EU, propose policies to achieve 100% recyclable or recoverable plastic usageby 2030 and reduce single-use plastics (Fendall & Sewell, 2019). These policies aim to prevent environmental contamination,encourage alternative materials,and boost recycling efforts(Sutherlandet al., 2010).

Conclusion:

The impact of micro plastics on aquatic ecosystems is significant, with implications forthe health of marine life. Studies suggestvaried responses among species, high lighting the complex nature of this pollution.Effectiv emitigation strategies include reducing plastic production,improving waste management,and raising public awareness.Collaborative effort sare crucial for implementing sustainable solutions and addressing this global environmental challenge. Continued research is needed to monitor micro plastic levels, assess their impacts, and develop innovative technologies for removal and prevention.

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