IRJMETS

e-ISSN: 2582-5208

International Research Journal of Modernization in Engineering Technology and Science

(Peer-Reviewed, Open Access, Fully Refereed International Journal)

Volume:05/Issue:11/November-2023 Impact Factor- 7.868 www.irjmets.com

MICROPLASTICS IN PNW, BIVALVES, AND THE IMPACT ON OCEANIC ECOSYTEMS AND HUMAN HEALTH

Sahana Ballabh[*1]

[*1]Student, Eastlake High School, Sammamish, Washington, United States.

DOI : https://www.doi.org/10.56726/IRJMETS45906

ABSTRACT

The presence of microplastics (MPS) in the Pacific Northwest (PNW) ecosystem has emerged as a pressing environmental concern, affecting both the local ecosystem and human health. Bivalves, integral members of the local ecosystem, are vulnerable to ingesting microplastics, which bioaccumulate in their tissues, leading to adverse health effects and contributing to biomagnification in the food chain, endangering keystone species and ecosystem stability. The unintentional ingestion of microplastics through seafood consumption raises significant health concerns for humans. These threats are a huge cause for alarm as they have the potential to irreparably damage our enviornment and health, and we should address these issues before they become a reality of the world.

I. INTRODUCTION

In recent years, the presence of MPS, plastics that are <5mm in diameter (Ding 2022), in our ocean has emerged to be a pressing environmental concern. The PNW, which is known for its coastal biodiversity and is home to over 150 species of bivalves, has become a focal point for research investigating the impacts of microplastics on the local ecosystem and human health. Bivalves, such as mussels, clams, and oysters, play a crucial role in the ecosystem as filter feeders that clean the ocean of debris and as a source of prey to a wide variety of creatures. MPS ingested by bivalves that accumulate in their tissue has adverse health effects on not only the creatures themselves, but also the organisms that consume them.

This includes several different animals in different ecosystems but also includes humans who consume both bivalves and their predetors. This review aims to explore the interactions between organisms' parts of the different ecosystems in the PNW and how microplastics affect them and the enviornment around them. Additionally, it also addresses the different health concerns that rise with microplastics inadvertently ingested by humans with the prevalence of seafood in our diets. And lastly, it proposes potential solutions to implement to mitigate the risk that microplastics pose to our wellbeing and the condition of the ecosystems we are responsible for.

II. MICROPLASTICS IN THE ECOSYSTEM

Bivalve mollusks, such as mussels, clams, and oysters, are organisms that are considered good indicators of MPS pollution in an area due to their widespread distribution, responses to environmental stressors, filtering capabilities, and their direct association to the seafood industry (Hossein Khanjani 2023). Bivalves are filter feeders, organisms that extract phytoplankton, zooplankton, and oceanic debris from their surroundings by filtering large amounts of water through their gills and moving them to their mouth for consumption (Ding 2022; Murphy 2018;). There is a huge abundance of MPS found in bivalve mollusks in the PNW (Baechler 2019, Martinelli 2020). Their feeding behavior makes them particularly vulnerable to consumption of microplastics, as the sizes of these plastics are like the size of particulates that they tend to consume (Baechler 2019, Browne 2008).

Once ingested, MPS then accumulates in the different parts of the bivalves, including their digestive system, gills, and mantle. Over time the MPS will slowly degrade in the tissue that it's present in, slowly releasing harmful chemicals such as Bisphenol A (BPA) which is a proven Endocrine Disrupting Chemical (EDC). EDCs disrupt the workings of an animal's endocrine system which includes the functionality of various organs that use hormonal signals (Campanale 2020; Yuan 2020). This can interfere with normal physiological processes and causes severe health disparities in these organisms.

While the impact on the individual species' health is significant, the presence of microplastics in bivalves also has a negetive effect on the surrounding ecosystem. Microplastics can reside in bivalve tissue for extended

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periods of time without completely breaking down, indicating that predetors higher up in the food chain that consume bivalve tissue are highly likely to have these plastics transferred into their tissue (Baechler 2019, Hantoro 2019). The trophic transfer of MPS in bivalves and other organisms in the food chain brings up concerns of biomagnification of the plastics in predetors in the ecosystem (Ding 2022).

This is particularly concerning, as some keystone species in the PNW's ecosystems consume bivalves in large quantities as part of their diet. Sea Otters (Enhydra lutris) and Ocher Stars (Pisaster ochraceous), both of which are keystone species, are predetors of clams and mussels, which are common bivalves in the PNW. Keystone species play crucial roles in stabilizing ecosystems by keeping populations of certain organisms in check or serving as a primary prey species necessary to maintain predator populations.

The bioaccumulation of MPS in these keystone species can have detrimental effects. Studies have shown that the presence of MPS in various organisms can cause decreased reproductive success, an increase in mortality rates, and various health issues (Cole 2011, Baechler 2019, Hantoro 2019). This sort of impact on keystone species is of great concern as some of these species are in a state of declining population and are listed by the ICUN as threatened species. Sea otters, for instance, were popular targets for hunters as the commercial value of their fur was revered. They were on the brink of extinction before laws such as the endangered species act and the marine mammal protection act were passed. The presence of MPS in their tissue further hinders their recovery efforts and poses a threat to the stability of the entire ecosystem. Similarly, ochre stars, which are important predetors of the intertidal ecosystem, have experienced a decline in their population due to the sea star wasting disease outbreak (McFadden 2002). The additional effects from MPS add another stressor to their already vulnerable population.

Another major ecosystem interaction affected by the bioaccumulation of MPS in bivalves and the indirect impact it has through bioaccumulation is with the Chinook Salmon (Oncorhynchus tshawytscha) and the Southern Resident Killer Whales (Orcinus Orca). While chinook salmon do not directly consume bivalves, during much of their adult life spent in the ocean they consume a variety of prey species including squid, shrimp, and small fish like herring, anchovies, and smelt (NOAA). The majority of the prey species mentioned above consume plankton, which includes bivalve larvae, and sometimes small bivalves that might be available for them to feed on. Squids are the exception in which they consume mussels and clams as part of their varied diet. In which case, chinook salmon have a much higher concentration of MPS than their prey due to bioaccumulation. But with chinook salmon as an endangered keystone species, their primary predetors, especially Orcas are affected tremendously by not only the lack of prey, but also due to the biomagnification especially prevalent with them as the top predator in the ecosystem. And much like Sea otters and Ochre stars, the extinction of chinook salmon and orcas would lead to the collapse of the Salish Sea ecosystems.

III. MICROPLASTICS AND HUMAN HEALTH

Seafood is the largest traded food commodity around the world, with nearly 3 billion people around the world relying on it as their main source of animal protien and sustenance (WWF, Ding 2022). More than a quarter of the world's population relies on seafood for their diet, not to mention the billions more that consume it (Hantoro 2019). There are many chemicals that go into making plastic, most of them hazardous. As mentioned previously BPA is one of these chemicals that if ingested or inhaled can cause irreversible damage to our endocrine system. But there are many others like BPA such as Phthalates, Heavy Metals, and Flame-Retardants (Yuan 2022). The unintentional ingestion of chemicals through the consumption of seafood is an issue that has not been comprehensively studied as it should be, especially when you consider the extensive number of people that eat it (Yuan 2022).

BPA exposure is linked to various health issues, including obesity, cardiovascular disease, reproductive disorders, and breast cancer (Campanale 2020). As humans consume seafood, microplastics laden with BPA may enter the food chain, raising concerns about the indirect exposure of humans to this harmful compound. In addition to the risks with the consumption of BPA, phthalates such as di-n-octyl phthalate (DnOP) & Di-2ethylhexyl phthalate (DEHP) are causes of abnormal development of the human body and affect reproductive health, pregnancy health, and respiratory health (Yuan 2022). Another concern that should be raised is the presence of heavy metals and their potential impact on human health. Heavy metals are often used as additives in polymer products, including flame retardants, stabilizers, pigments, and more, to enhance various properties

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of plastics (Campanale 2020). These heavy metals (Sn, Al, Cd, Pb, and Hg) have been linked to adverse health effects, including metal-estrogen activity, carcinogenicity, neurological disorders, bone fractures, oxidative stress, and DNA damage (Yuan 2022, Campanale 2022).

The long-term implications of microplastic exposure are of particular concern. Chronic exposure to microplastics through contaminated seafood consumption may result in cumulative effects on human health (. The potential for bioaccumulation and the persistence of microplastics in the environment suggest that the risks associated with their ingestion may extend beyond immediate consequences. Long-term exposure to microplastics and associated toxic substances may have significant implications for the overall well-being and quality of life of individuals, particularly those living in coastal communities heavily reliant on seafood as a primary food source (Yuan 2022, Cavalca Bom 2022).

IV. POTENTIAL SOLUTIONS

Microplastics pose significant threats to both human health and the environment. To address this complex issue, there are two main aspects that require attention and comprehensive solutions. The first crucial step is to halt the flow of microplastics into the environment. The relentless addition of microplastics intensifies the problem, making it more challenging to mitigate. One major contributor to microplastic pollution is the widespread use of mass-produced goods, particularly synthetic fabrics. When these textiles are washed, they shed tiny fibers that eventually find their way into the ecosystem. While strengthening the polymers in these fabrics to minimize wear and tear could be a potential solution, it is not a practical approach. Instead, a more viable option is to shift towards using natural and recyclable fabrics, reducing the production of synthetic fibers, and reusing existing materials. Research should also focus on developing fibers that are safe to be released into the environment or that can break down over time.

Another such contributor comes in the form of cosmetic products. Plastic pellets, beads, and non-degradable glitters used in cosmetics and skincare items contribute to pollution. It is crucial to replace these non-degradable materials with smarter, eco-friendly alternatives that are degradable and have minimal environmental impact. And lastly, the biggest contributor to this issue is single-use plastics. Over time due to direct contact to UV radiation from the sun, these plastics break down into smaller fragments that are difficult to detect with the naked eye. These plastics, when found in landfills, roads, streets, alleyways, etc will break down bit by bit, and when it rains, the water erodes the small, degraded filaments of plastics from the trash into the sewers where it's filtered back into the ocean.

The extent of microplastic pollution is alarming, as demonstrated by the Great Pacific Garbage Patch. Contrary to popular belief, this patch is not a massive floating island of visible plastic; it primarily consists of microplastics that create an impenetrable layer, blocking sunlight and disrupting marine ecosystems. The vast amount of unseen microplastics in the ocean far surpasses the visible plastic debris, highlighting the urgency to address this issue. With an estimated 380 million tons of plastic produced annually, and more than 50% of it being single-use plastic, it is crucial to find recyclable alternatives and improve the efficiency of plastic decomposition processes. While acknowledging the value of plastic as a versatile material, it is imperative to explore more sustainable solutions and develop better alternatives to existing plastic products.

In addition to preventing further input of microplastics, it is crucial to remove existing pollutants from the environment. Unlike visible plastic debris that can be collected through clean-up efforts, microplastics pose a significant challenge due to their small size. Traditional methods are ineffective in capturing these tiny particles. Therefore, increased research funding and collaboration among the scientific community are necessary to develop innovative techniques for microplastic removal. This issue transcends national boundaries and requires global cooperation to find effective solutions. By pooling resources, knowledge, and expertise, scientists and researchers can make significant advancements in tackling microplastic pollution.

V. CONCLUSION

The presence of microplastics in the Pacific Northwest ecosystem is a complex issue with far-reaching consequences. Bivalves, as filter feeders, are highly susceptible to ingesting microplastics, which bioaccumulate in their tissues, affecting their health and the stability of the ecosystem. The bioaccumulation of microplastics in these organisms, including the release of harmful chemicals, poses a direct threat to their well-being and contributes to biomagnification in the food chain, endangering keystone species and disrupting the PNW ecosystem.

Additionally, the potential risks to human health through the consumption of seafood contaminated with microplastics laden with hazardous chemicals are a growing concern. Chronic exposure to these microplastics may result in various health issues, from obesity to reproductive disorders and cancer, impacting the well-being of individuals, especially those in coastal communities heavily reliant on seafood.

Addressing the problem of microplastics and their impact on human health and the environment requires a comprehensive approach. Collaboration among the scientific community on a global scale is essential to accelerate research and find sustainable solutions to this pressing issue. By taking these steps, we can mitigate the harmful effects of microplastics and safeguard the health of our planet and future generations.

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