Micro Plastic Pollution in Freshwater Ecosystems: Sources, Fate and Effects

[1] Dr. Kwame Asante, University of Ghana, Ghana.

[2] Dr. Ama Agyeman, University of Ghana, Ghana.

Abstract: Concern over microplastic particles smaller than 5 mm is growing, particularly in aquatic areas like the ocean. Primary sources include fiber fragments from clothing washing and microbeads (less than 1 mm) found in cleaning products and cosmetics, while secondary sources include decomposing plastic waste and detritus. Polyesters, Polystyrene (PS), polypropylene (PP), polyethylene terephthalate (PET), and polyethylene (PE) make up the majority of these particles. They can enter human food chains through a variety of routes and are consumed by a large range of aquatic creatures, including fish, shrimp, mussels, oysters, and zooplanktons. Policymakers, corporations, and scientists are placing a greater emphasis on understanding and controlling plastic pollution. However, rivers are both a potential sink that can accumulate plastic from various sources and the main source of Marine environment plastic pollution. Although reducing the amount of microplastics in rivers is essential for protecting freshwater and marine habitats, little is known about the possible sources, routes, and storage of this pollution. Our study examines the variations between microplastics estimated from litter rates and those reported in freshwater and marine habitats.

Keywords: Freshwater Ecosystem; Microplastics; Source; Fate; Effects.

(Submitted: June 12, 2024; Revised: July 18, 2024; Accepted: August 16, 2024; Published: September 30, 2024)

I. Introduction

One of the most urgent issues confronting humanity in the twenty-first century is plastic pollution. In 2015, the world produced 4.9 billion metric tons of plastics; by 2050, that amount is predicted to rise to 12 billion metric tons annually. Microplastics, which are produced by improper human disposal of plastics and inadequate waste management, can be found in sediments, landfills, lakes, rivers, estuaries, air, and wastewater treatment facilities. Solid waste is one of the main sources of microplastics in the environment, despite receiving less attention than the sources mentioned above. One of the biggest environmental issues of our time is plastic waste. There is now more awareness of the possible harm to the world's waters. Businesses, governments, and the general people are starting to act, frequently in a disorganized fashion and with no information. According to research, rivers carry up to 80% of the plastics that wind up in the oceans of the world. Marine plastics have received a lot of study attention, whereas freshwater plastic pollution has only been covered in 13% of published papers. Most of these (76%) are on Microplastics are identical plastic particles that are less than 5 mm in size. The types and amounts of microplastics (>5 mm in size) in freshwater ecosystems may be similar to those in the marine environment, according to the scant knowledge on freshwater settings and the hydrological relationship between source and sink. Despite the fact that this knowledge is essential for managing the freshwater pollution load through targeted and dispersed mitigation strategies, no research have compared these ecosystems. According to recent data, freshwater habitats both contribute to and absorb plastic pollution in the marine environment, possibly preventing some of it from entering the oceans. In figure 1, Illustrate the Routes that Microplastics follow and their Global Effect on the Ecosystem below.

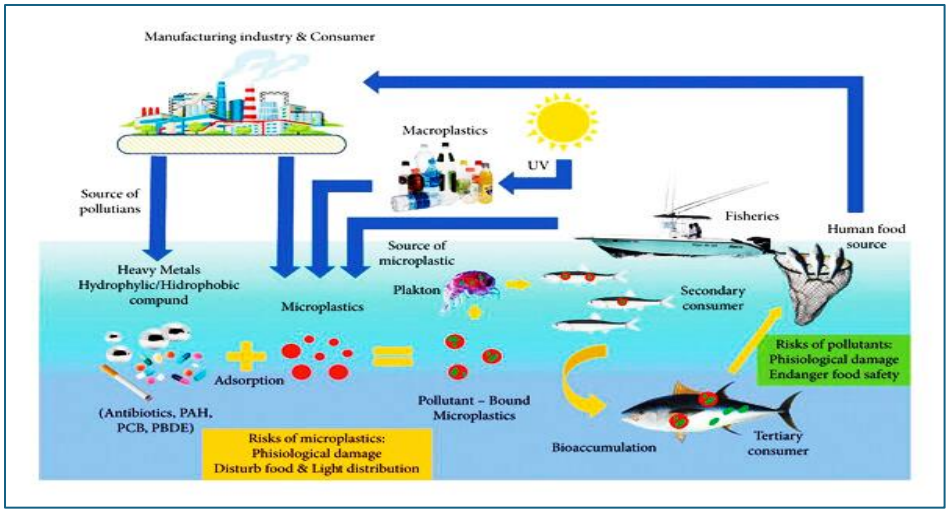

Figure 1: An Illustration of the Routes that Microplastics follow and their Global Effect on the Ecosystem

This sink is demonstrated by the presence of plastics in river and lake sediments as well as the significant disparity between estimates of the total trash intake and the amount of plastic debris found in the ocean (1%). The movement, sedimentation, breakdown, and persistence of microplastics in freshwater settings are influenced by a variety of processes. These consist of the type of polymer, the creation of biofilms, size, shape (which affects density), and the river or lake's hydrological features. Since polymer type, litter size, form, and density all provide unique characteristics that may affect its destiny, there is an obvious correlation between product type and several of these attributes. Their persistence is demonstrated by the fact that they can be found in even the most isolated freshwater habitats. According to recent surveys, more and more individuals now consider plastic pollution to be a major environmental issue. International and national legislative changes pertaining to plastics have increased, as has corporate response and environmental advocacy groups' campaigns. Focused research and efficient action (by consumers, corporations, and policy-makers) are obviously needed. The most common macroplastic items found in freshwater ecosystems are identified and prioritized in this study along with their source, fate, and consequences.

II. Literature Review

Plastics are artificial macromolecules made from synthetic or naturally occurring product conversions of monomer compounds (do Sul & Costa, 2014). They produce more (in m^3) globally than steel and aluminum because of their great economic and technological significance. However, the material's many benefits—such as its low cost, durability, and light weight—are contributing to an ever-growing environmental issue: 3% of the plastic produced leaks into the marine environment and builds up there because of its persistence, which is caused by high production values, short product life, and careless handling. Additionally, the "missing plastic" becomes apparent since measured levels of (micro-)plastic in certain environmental areas don't seem to be rising. The two globally accepted types of microplastics are primary and secondary MPs. Primary MPs are particles that are intentionally produced at specific small sizes for commercial applications. The abrupt increase in synthetic textile fibers, microbeads from cosmetics and personal care products, and pre-production pellets used as a middleman in the production of plastic are important sources of primary MPs worldwide. Secondary MPs are produced when large MPs items weather or deteriorate due to environmental factors.

They can be released by using any type of plastic bottle, packaging, or agricultural plastic film, as well as by the wear of tires, synthetic turf, marine paints, and other materials (Van Cauwenberghe et al., 2013). MPs can be carried from land into water systems and eventually into the seas and oceans by wind and surface water movements, even though their sources can be on land or at sea. Microplastics in surface water

came from stormwater runoff from rural and roadside areas, combined sewer overflows, and sewage discharge. Sewage treatment plants were a major source of microplastic pollution in surface water, and the residual sludge from these facilities was capable of carrying microplastic pollution (Erdogan, 2020). Point source pollution was under control after decades of study and control. Consequently, one of the primary routes for microplastics to reach water was through non-point source contamination caused by surface runoff, though it was unclear how much of an impact it had. In addition to typical non-point source pollutants from agriculture, microplastic particles can collect in soil and enter rivers as a result of plastic mulching, fertilization, and irrigation employed in agricultural production. This can lead to ecological pollution of water (Dugan, 2012). Microplastics in agricultural rainwater runoff and combined sewage pipe overflow have not been reported. The buildup of microplastics in soil is becoming a major problem. To effectively control the microplastics pollution in surface water, it is essential to investigate the accumulation mechanism and the process of microplastics pollution in rural non-point sources (Horton & Dixon, 2018).

III. Microplastic Sources, Fate and Effects in Freshwater Ecosystem

Even for marine habitats, the pace at which plastics break down and degrade is uncertain. Plastic deterioration is believed to be influenced by a variety of physical forces, including waves in maritime systems, environmental factors like sunshine, pH, and temperature, as well since the chemical and physical properties of the plastic itself. Despite less severe physical stresses than in marine environments, plastics in freshwater systems also deteriorate physically and environmentally. The contamination of freshwater habitats by microplastics is widespread and worldwide shows in figure 2 (Booth & Sørensen, 2022).

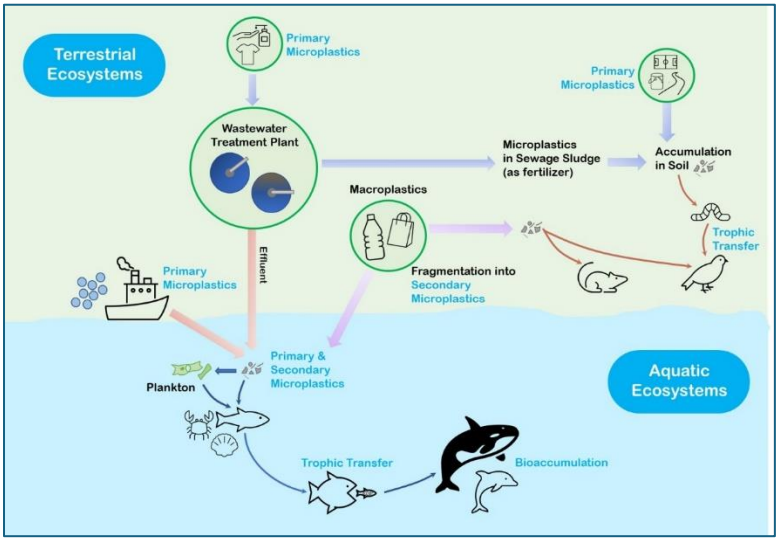

Figure 2: Microplastic Pathway in Organisms

Marine creatures have been the primary focus of research on the ecotoxicological impacts of microplastics thus far. Because human activities are closer to the freshwater ecosystem, there may be a greater risk of pollution there than in the marine environment. According to reports, microplastics have an impact on genes, cells, tissues, plants, and animals, among other levels. There is still little information available on the harmful mechanism and human impacts of microplastics. Both primary and secondary microplastics may enter the water ecological system through non-point sources, and urban rainfall runoff carried microplastics linked to dust, construction, artificial turf, and landfill leachate (Eerkes-Medrano & Thompson, 2018). Road marking paint debris, vehicle waste, and tire fragments have also been linked to microplastic contamination in urban surface runoff. Thus, one of the primary ways that microplastics enter aquatic bodies is through non-point source pollution brought on by surface runoff, and the extent of its impact is still unknown (Mehra et al., 2020).

IV. Conclusion

The attempt to search for MPs' effects on life has accelerated due to their existence in freshwater bodies. Since many species are elusive, gathering data becomes challenging. The principal techniques used in ingestion studies today include invasive procedures that take a lot of time and resources. Due to ethical considerations, this also makes data collection challenging. Due to the widespread awareness of plastic pollution, a confusing number of proposals have been made, the most of which are predicated on a scant comprehension of the situation. The government (waste management and policy), companies (producers and distributors), and the general public should prioritize taking steps to reduce the amount of plastic pollution that enters freshwater habitats. Both public pressure and internal procedures are causing many corporations to take action. An informed public, however, has very little direction on which businesses and brands to support, which "environmentally-friendly" products to select, or what steps to take. The presence of the top ten priority microplastics in the environment would be significantly reduced with a sustained public effort aimed at ensuring their appropriate management by all stakeholders.

References

[1] do Sul, J. A. I., & Costa, M. F. (2014). The present and future of microplastic pollution in the marine environment. *Environmental pollution*, *185*, 352-364. https://doi.org/10.1016/j.envpol.2013.10.036

[2] Van Cauwenberghe, L., Vanreusel, A., Mees, J., & Janssen, C. R. (2013). Microplastic pollution in deep-sea sediments. *Environmental pollution*, *182*, 495-499. https://doi.org/10.1016/j.envpol.2013.08.013

[3] Erdogan, S. (2020). Microplastic pollution in freshwater ecosystems: A case study from Turkey. Ege Journal of Fisheries and Aquatic Sciences, 37(3), 213–221. https://doi.org/10.12714/egejfas.37.3.02

[4] Dugan, P. (2012). *Biochemical ecology of water pollution*. Springer Science & Business Media. https://doi.org/10.1007/978-1-4613-4389-9

[5] Horton, A. A., & Dixon, S. J. (2018). Microplastics: An introduction to environmental transport processes. *Wiley Interdisciplinary Reviews: Water*, *5*(2), e1268. https://doi.org/10.1002/wat2.1268

[6] Booth, A. M., & Sørensen, L. (2022). Microplastic fate and impacts in the environment. In *Handbook of Microplastics in the Environment* (pp. 757-779). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-39041-9_29

[7] Eerkes-Medrano, D., & Thompson, R. (2018). Occurrence, fate, and effect of microplastics in freshwater systems. In *Microplastic contamination in aquatic environments* (pp. 95-132). Elsevier. https://doi.org/10.1016/B978-0-12-813747-5.00004-7

[8] Mehra, S., Sharma, K., Sharma, G., Singh, M., & Chadha, P. (2020). Sources, fate, and impact of microplastics in aquatic environment. *Emerging Contaminants*. http://dx.doi.org/10.5772/intechopen.87857