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Impacts of Microplastics on Mangroves - A Review

Rohini P[1], Ayona Jayadev[2]

[1, 2] Research Center and Post Graduate Department of Environmental Sciences, All Saints' College, Thiruvananthapuram 695007, Kerala, India

Corresponding Author: Rohini P

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ABSTRACT

Microplastics are an escalating pollutant that poses risks to the health of both marine and terrestrial environments. These tiny plastic particles have multiple avenues to infiltrate marine ecosystems, including mangrove forests. Notably, mangrove areas exhibit distinct ecological characteristics, leading to varying levels of microplastic contamination compared to other coastal locations. The unique way in which mangrove plants crisscross in the water creates an efficient filtering system, effectively reducing wave energy and turbulence. This, in turn, creates an environment where plastics are more likely to accumulate. Additionally, this accumulation can trigger the production of secondary microplastics through physical processes. Consequently, microplastic pollution is notably high along mangrove zones, impacting mangrove ecology both directly and indirectly. Research studies have demonstrated that varying degrees of microplastic absorption and subsequent translocation in plants can affect plant morphology, physiology, biochemistry, and genetic traits. An analysis of mangrove health has indicated that the presence of microplastic pollution has led to deteriorating or unsatisfactory conditions in all mangrove vegetation. This review is primarily focused on elucidating the impact of microplastics on mangroves.

Keywords: Mangroves Ecosystem, Microplastics, Mangroves, Pollution impact

INTRODUCTION

The ecological importance of mangroves is substantial. Apart from enhancing coastal waterways, they also play a vital role in supporting coastal fisheries and protecting and stabilizing coastlines. Numerous epibenthic, infaunal, and meiofaunal invertebrates inhabit the muddy or sandy sediments of the Mangal. Unfortunately, mangroves worldwide have experienced alarming levels of habitat loss due to human activities. Limited research has been conducted on the extent of the plastic problem in mangroves. Plastics can be classified into three size categories: macro (>25 mm), meso (<25-5mm), and micro (<5-1mm).[1] Microplastics, a newly recognized pollutant derived from plastic, pose a severe threat to the mangrove ecosystem. Microplastic contamination in the mangrove ecosystem varies across different mangrove zones and affects mangrove plants both directly and indirectly. The characteristics of microplastics, including their shape, flexibility, roughness, resistance, and durability, vary depending on their intended use. Primary microplastics are intentionally manufactured,[2] while secondary microplastics are the result of breakdown of larger plastic debris. Secondary microplastic sources include illegal dumping, improper waste management, and unintentional losses, such as lost fishing gear or shipping cargo. Despite the prevalence of plastic waste in areas where mangroves are rapidly disappearing, our understanding of the effects of microplastics remains limited. This study aims to investigate the impact of microplastics on mangroves.

Microplastics

Microplastics are categorized as either primary microplastics, intentionally created for specific purposes, or secondary microplastics, formed through the breakdown of macro/meso-plastics, posing a significant environmental hazard.[3] Both abiotic and biotic processes contribute to the formation of secondary microplastics. Abiotic factors such as light, temperature, air, water, and mechanical forces can lead to changes in the physical or chemical properties of plastics.[4] Photodegradation is one of the most prominent mechanisms initiating plastic degradation, as explained by Crawford and Quinn (2017).[1] Oxygen availability and thermal characteristics of plastics influence the temperature required for thermal breakdown of plastics. Mechanical degradation, on the other hand, describes how polymers break down due to external influences. Environmental forces, resulting from plastics interacting with rocks and sand due to wind and waves, contribute to this degradation. Biotic degradation refers to the breakdown of polymers by organisms. Dawson et al.(2018)[5] highlight that organisms can physically break down plastics by biting, chewing, or fragmenting them in their digestive tracts. Chen et al. (2021)[6] note that microplastics come in various morphologies, including films, foams, fragments, sponges, beads, fibers, flakes, and pellets. The most commonly encountered microplastic materials include polystyrene (PS), polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polyvinyl chloride.[7]

Mangroves

Mangroves serve as a natural fortress protecting coastlines from the forces of wind, waves, water currents, and other natural disasters. Their remarkable morphological, biological, ecological, and physiological adaptations to challenging conditions set them apart from other plant groups.[8] Mangroves feature such as robust support roots, buttresses, exposed breathing roots, leaves capable of excreting salt, and viviparous water-dispersed propagules, all of which enable them to thrive in coastal environments. These plant adaptations vary depending on the physico-chemical characteristics of their habitats and taxonomic diversity.[9] Mangrove leaves lack vein sheaths and possess a nearly leathery texture with concealed leaf veins. The thick, smooth, and hairless cuticle imparts a glossy appearance to the plant. Some plant species found exclusively in mangrove ecosystems are unique to their respective regions or continents. A healthy mangrove ecosystem offers numerous benefits to adjacent ecosystems and humanity alike. According to Sandilyan and Thiyagesan (2010),[10] traditional medicinal uses of mangroves encompass the treatment of ulcers, bacterial and viral infections, blood pressure, asthma, leprosy, and snake bites. B. gymnorrhiza is employed for diarrhea treatment, R. mucronata for blood pressure, and Acanthus ilicifolius for asthma, leprosy, and rheumatism.

Sources of microplastic pollution in mangroves

Microplastics have the potential to directly contaminate water environments and contribute to microplastic pollution due to inadequate management of plastic waste from urban areas, tourism, agriculture, industrial shipping, fishing activities, and other processes.[11] During storms or floods, runoff from landfill sites can disperse microplastics across the surrounding area.[6] Furthermore, the inefficiency of wastewater treatment plants (WWTPs) contributes to microplastics in the environment. Microplastics from various consumer products, including toothpaste, shampoos, and shower gels, can enter the environment through effluents, sludge, or biosolids. Microplastics used in agriculture persist in soil for extended periods and can be transported through runoff, air, and agricultural waste. Stormwater can carry microplastics from various sources, such as tires, road markings, and other plastic litter.[11] In regions where plastic mulching is common, the abundance of microplastic particles increases over time.[12] Microplastics can also provide clues about their origins. For instance, microfibers from synthetic clothing may be a source of microplastics in WWTPs. Secondary sources of microplastics include municipal waste like plastic bags and bottles, discarded fishing gear, agricultural films, and other large-scale plastic waste, with industrial waste being the primary contributor.[13]

Prevalent microplastics in mangrove ecosystem

Microplastics in mangrove ecosystems have been extensively reported in recent studies. Most reported types of microplastics from mangrove ecosystems are polystyrene, polyethylene, polypropylene and polyethylene terephthalene. At all study locations, researchers discovered a significant positive correlation between the quantity of microplastics and the content of particulate organic carbon.[14] These microplastics take on various shapes, the fibrous forms being the most prevalent one.[15] In a study by Nabizadeh et al. (2019)[16] on the Persian Gulf shoreline, the abundance of polystyrene, polyethylene, polypropylene, and polyethylene terephthalate was found to surpass that of other polymers. Similarly, Nair et al. (2020)[17] documented microplastics in Kerala, highlighting fragment-type microplastics as a prominent component, with black colour microplastics being widespread in the study area. Li et al. (2020)[18] examined the distribution, characteristics, and ecological risk of microplastics in southern China's mangroves, concluding that the dominant polymer types included polypropylene (67.5%), polyethylene (13.1%), and polystyrene (10.5%). Cordova et al. (2021)[19] studied microplastics in Muara Wildlife Reserve, Indonesia, revealing that the predominant polymers were polystyrene (44.62%), polypropylene (29.23%), and polyethylene (15.38%).

Consequences of microplastic pollution on mangroves

Growing microplastic pollution may affect plant growth and development.[20] Mangrove pneumatophores, which act as filters for preventing large objects from re-dispersing in the marine environment and play a crucial role in retaining floating debris due to their unique features.[21] Duan et al. (2021)[22] found a significant positive relationship between the number of microplastics and pneumatophore density, indicating that denser pneumatophores influence microplastic distribution. Microplastics can accumulate in plants through foliar or root uptake, impacting plant metabolism, physiology, and morphology.[23,24] These particles can interfere with metabolic pathways and phytohormone-related processes.[24]
Microplastics pose various threats to plant growth, including direct absorption into plant cells and modulation of cellular functions.[25] They can also physically damage mangrove seedlings, particularly roots and branches, while their charged nature facilitates electrostatic attraction to plant roots, altering nutrient immobilization and photosynthesis processes.[26] Plastic debris, particularly films and fibers, can entangle in vegetation, block sunlight, inhibit photosynthesis, and lead to seedling mortality, a phenomenon known as the 'Christmas tree' effect.[27] Microplastic abundances on non-submerged mangrove leaves are primarily influenced by atmospheric content of microplastic, while those on submerged leaves are significantly affected by tidal water.[28] Exposure to microplastics has been shown to interfere with chlorophyll production, inhibiting plant photosynthesis.[29] Furthermore, when microplastics remain fixed on the forest floor, within sediment, or through burial in sediment over several tidal cycles, they can create an anoxic environment and it potentially suffocate mangroves. In soil,

microplastics have a profound impact on microbial diversity in the rhizosphere and can disrupt the plant-soil microbial interface.[30] These particles can also influence the microbial-mediated transformation of nutrients in soil, despite their low nitrogen and phosphorus content [31]. Additionally, microplastic contamination in soil and plants increases the risk of heavy metal and pathogen infiltration, damaging plant defense mechanisms.[24]

Figure 1: plastic pollution in mangroves

CONCLUSION

Microplastic has had a significant adverse impact on the health of mangroves. This review aims at establishing an idea about impact of microplastics in mangroves. The effect of microplastic pollution on various plant species and soil types can vary based on factors such as the form, type of polymer, concentration, and other characteristics of the microplastics. The complex topography, diverse fauna, and intricate spatial features of mangrove environments provide ample opportunities for waste entanglement. Notably, the presence of trash has been positively correlated with the pneumatophores of different mangrove species. Furthermore, mangrove trees have exhibited additional signs of stress due to microplastic pollution, including inhibited root growth, reduced seedling germination, and impaired photosynthesis. A comprehensive study on mangrove health revealed that areas contaminated with microplastic pollution consistently exhibited unsatisfactory conditions for mangrove vegetation. The vital biological functions and ecosystem services provided by mangroves suffer as a consequence of microplastic pollution. To ensure the preservation of mangrove forests, urgent action is needed to mitigate this grave threat. Additionally, further research is required to elucidate the links between inadequate waste management systems, a lack of awareness regarding the benefits of mangroves, and the extent of microplastic pollution in these ecosystems.

Declaration by Authors

Ethical approval: Not Required

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REFERENCES

1. Crawford, C. B., & Quinn, B. *Microplastic pollutants*. Microplastic identification techniques. Elsevier. 2017. p.219-267.
2. Wang, J., Liu, X., Li, Y., Powell, T., Wang, X., Wang, G., & Zhang, P. Microplastics as contaminants in the soil environment: A

mini-review. *Science of the total environment*. 2019; *691*: 848-857.
3. Camins, E., de Haan, W. P., Salvo, V. S., Canals, M., Raffard, A., & Sanchez-Vidal, A. Paddle surfing for science on microplastic pollution. *Science of the Total Environment*, 2020; *709*:136178.
4. Andrady, A. L. Persistence of plastic litter in the oceans. *Marine anthropogenic litter*. 2015; 57-72.
5. Dawson, A. L., Kawaguchi, S., King, C. K., Townsend, K. A., King, R., Huston, W. M., & Bengtson Nash, S. M. Turning microplastics into nanoplastics through digestive fragmentation by Antarctic krill. *Nature communications*, 2018;*9*(1): 1001.
6. Chen, X., Chen, X., Liu, Q., Zhao, Q., Xiong, X., & Wu, C. Used disposable face masks are significant sources of microplastics to environment. *Environmental Pollution*, 2021; *285*: 117485.
7. Thompson, R. C., Moore, C. J., vom Saal, F. S., & Swan, S. H. Plastics, the environment and human health: Current consensus and future trends. *Philosophical Transactions of the Royal Society B: Biological Sciences.* 2009;*364:* 2153–2166.
8. Kathiresan K., Bingham B. L., Biology of mangroves and mangrove ecosystems. Advances in Marine Biology. 2001; 40:81-251.
9. Duke, N. C. Mangrove floristics and biogeography. *Tropical mangrove ecosystems*. 1992; *41*, 63-100.
10. Sandilyan, S., Thiyagesan, K., Nagarajan, R., & Vencatesan, J. Salinity rise in Indian mangroves–a looming danger for coastal biodiversity. *Current Science*. 2010; *98*(6), 754-756.
11. Kole, P. J., Löhr, A. J., Van Belleghem, F. G., & Ragas, A. M. Wear and tear of tyres: a stealthy source of microplastics in the environment. *International journal of environmental research and public health*. 2017; *14*(10), 1265.
12. Huang, Y., Liu, Q., Jia, W., Yan, C., & Wang, J. Agricultural plastic mulching as a source of microplastics in the terrestrial environment. *Environmental Pollution*, 2020; *260*, 114096.
13. Golwala, H., Zhang, X., Iskander, S. M., & Smith, A. L. Solid waste: An overlooked source of microplastics to the environment. *Science of the Total Environment*. 2021; *769*: 144581.
14. Zhang, H., Huang, Y., An, S., Zhao, J., Xiao, L., Li, H., & Huang, Q. Microplastics trapped in soil aggregates of different land-use types: a case study of Loess Plateau terraces, China. *Environmental Pollution*. 2022; *310*: 119880.
15. Maghsodian, Z., Sanati, A. M., Tahmasebi, S., Shahriari, M. H., & Ramavandi, B. Study of microplastics pollution in sediments and organisms in mangrove forests: A review. *Environmental Research*. 2022; *208*: 112725.
16. Nabizadeh, R., Sajadi, M., Rastkari, N., & Yaghmaeian, K. Microplastic pollution on the Persian Gulf shoreline: A case study of Bandar Abbas city, Hormozgan Province, Iran. *Marine pollution bulletin*. 2019; *145*: 536-546.
17. Nair, M. P., Wilson, M. M., Mathew, J., AV, R., & Gopinath, A Seasonal microplastic documentation in Kerala mangrove sediments. Eco. Env. & Cons. 2020. 27 (1) :436-438
18. Li, R., Yu, L., Chai, M., Wu, H., & Zhu, X. The distribution, characteristics and ecological risks of microplastics in the mangroves of Southern China. *Science of the Total Environment*. 2020; *708*: 135025.
19. Cordova, M. R., Ulumuddin, Y. I., Purbonegoro, T., & Shiomoto, A. Characterization of microplastics in mangrove sediment of Muara Angke Wildlife Reserve, Indonesia. *Marine Pollution Bulletin*, 2021; *163*, 112012.
20. Silva, A. L., Prata, J. C., Duarte, A. C., Soares, A. M., Barceló, D., & Rocha-Santos, T. Microplastics in landfill leachates: The need for reconnaissance studies and remediation technologies. *Case Studies in Chemical and Environmental Engineering*. 2021; *3*, 100072.
21. Martin, C., Corona, E., Mahadik, G. A., & Duarte, C. M. Adhesion to coral surface as a potential sink for marine microplastics. *Environmental Pollution*. 2019; *255*, 113281.
22. Duan, J., Han, J., Cheung, S. G., Chong, R. K. Y., Lo, C. M., Lee, F. W. F. & Zhou, H. C. How mangrove plants affect microplastic distribution in sediments of coastal wetlands: Case study in Shenzhen Bay, South China. *Science of the Total Environment*. 2021; *767:*144695.

23. Sun, H., Lei, C., Xu, J., & Li, R. Foliar uptake and leafto-root translocation of nanoplastics with diferent coating charge in maize plants. Journal of Hazardous Materials. 2021;416: 125854.
24. Roy, T., Dey, T. K., & Jamal, M. Microplastic/nanoplastic toxicity in plants: An imminent concern. *Environmental Monitoring and Assessment*. 2023; *195*(1), 27.
25. Rillig, M. C., Lehmann, A., de Souza Machado, A. A., & Yang, G. Microplastic effects on plants. *New Phytologist*. 2019;*223*(3): 1066-1070.
26. Lian, J., Wu, J., Zeb, A., Zheng, S., Ma, T., Peng, F& Liu, W. Do polystyrene nanoplastics affect the toxicity of cadmium to wheat (Triticum aestivum L.)?. *Environmental Pollution*. 2020;*263*: 114498.
27. Manullang, C. Y. Distribution of plastic debris pollution and it is implications on mangrove vegetation. *Marine Pollution Bulletin*. 2020; *160*: 111642.
28. Li, R., Wei, C., Jiao, M., Wang, Y., & Sun, H. Mangrove leaves: an undeniably important sink of MPs from tidal water and air. *Journal of Hazardous Materials*, 2022; *426*: 128138.
29. Gao, M., Liu, Y., & Song, Z. Effects of polyethylene microplastic on the phytotoxicity of di-n-butyl phthalate in lettuce (Lactuca sativa L. var. ramosa Hort). *Chemosphere*, 2019; *237*:124482.
30. de Souza Machado, A. A., Lau, C. W., Kloas, W., Bergmann, J., Bachelier, J. B., Faltin, E. & Rillig, M. C. Microplastics can change soil properties and affect plant performance. *Environmental science & technology*. 2019; *53*(10): 6044-6052.
31. Chen, G., Feng, Q., & Wang, J. Mini-review of microplastics in the atmosphere and their risks to humans. *Science of the Total Environment*. 2020; *703*:135504.

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