POLICY BRIEF

JUNE 2025

MICROPLASTIC POLLUTION IN BHUTAN'S FRESHWATER AND FISH: POTENTIAL RISKS AND INTERVENTIONS

Background

Plastics in the environment never fully disappear, rather, slowly degrade into smaller fragments like macroplastic (2.5 cm to 1 m), mesoplastic (5 mm to 2.5 cm) and microplastic (less than 5 mm). Microplastics are classified as primary (intentionally produced for commercial use) or secondary microplastics (formed from the fragmentation of larger plastic due to environmental and mechanical processes).

Microplastic pollution is a growing concern, found everywhere—soil, river to lake, snow, air, and living organisms. Rivers transport these pollutants across regions and to the oceans. Plastics contain toxic additives that leach into the environment, while also adsorbing toxic compounds such as heavy metals and pesticides from the environment thus increasing its ecotoxicity. Exposure to microplastics through contaminated food systems raises serious concerns for health and food security[1].

Source of Microplastics

Based on the shape (pellet, line/fibre, film, foam, or fragment), density and type of microplastic, its source can be traced. For instance, fibre type microplastics are generally shed from clothing, fabric, and carpet, while pellets and beads often originate from personal care products. The common source of microplastic includes widely used plastic-based items such as carry bags, containers, bottles, wrappers, synthetic textiles, fishing gears, insulating materials, and pipes. Furthermore, microplastics enter the environment through various pathways including improper waste disposal, poor waste management, urban drainage systems and sewage treatment plants directly discharging into rivers.

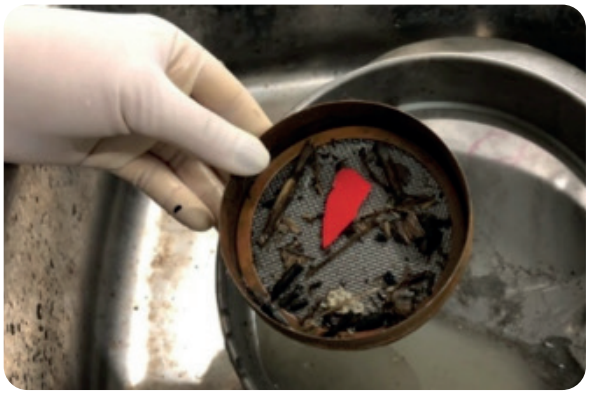
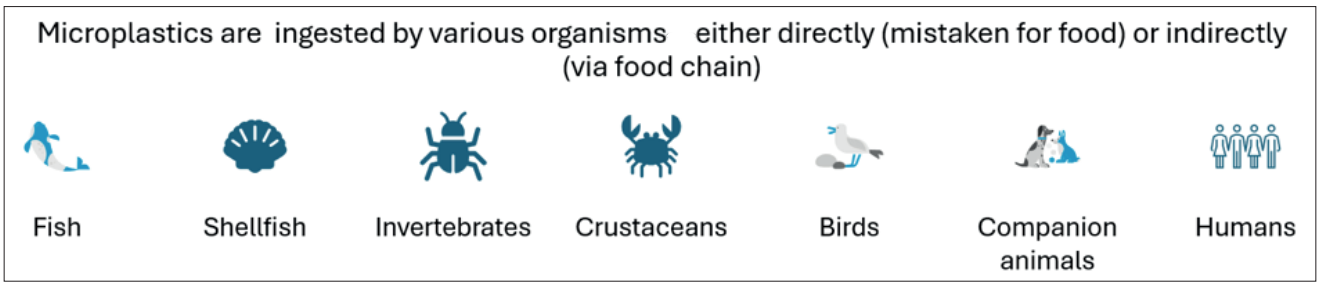


Image 1. Fragmented macroplastic (in red) (approx. 4 cm) along with rocks and organic debris from Manas River sediment.

Image 2. Floating plastic waste and organic debris, Toorsa river (September 2024)

Microplastic: Silent threat in Bhutan

Limited research on microplastics in Bhutan's freshwater systems leaves critical gaps in understanding both our exposure to microplastics—an emerging and poorly understood pollutant—and its effects on freshwater ecosystems, environmental health, and human well-being.



Accumulation of microplastics in the food web

The size of microplastics plays a critical role in ecological impacts. Smaller microplastics are more likely to translocate and bioaccumulate in the food web. Additionally, their shape influences the retention time, as irregular fragments and longer microplastics could get entangled in organisms' intestines, prolonging its exposure and bioaccumulation[2]. Studies indicate that microplastic negatively affect organisms by disrupting habitat quality, survival, reproduction gene expression, and growth, highlighting broader ecological risks of microplastics[3]. The varying sizes and type of microplastic found in fish guts indicate their widespread contamination and their transfer from the freshwater environment, leading to accumulation in living organisms. Some organisms mistake microplastics for food (color resembling their food) and eat them directly while some indirectly ingest microplastics without realizing it.

Evidence of Microplastic in Rivers of Bhutan

The study conducted in the rivers of Bhutan (Manas in Zhemgang District, Toorsa in Chukha District, and Harachhu in Wangduephodrang District) in the summer and winter months of 2024, found microplastics in freshwater river surface, river sediment, and fish guts. Ten different colours of microplastics (black, blue, orange, pink, red, yellow, white, green, purple, and brown) were detected in the same study. Majority of the microplastics were coloured black (62%), followed by white (9%), blue (8%), red (8%), green (4%), and pink (3%). Similarly, in fish gut, most abundant microplastic color was black (50%), blue (20%), followed by red (10%), brown (8%), and pink (6%). Coloured microplastics indicate the variety of plastics contaminating our freshwater aquatic environment. To increase the service life of plastics and enhance its durability, manufacturers incorporate various pigments and toxic additives[4]. A related study found higher microplastics concentrations in riparian soils of urban areas in Bhutan underscoring the pervasive

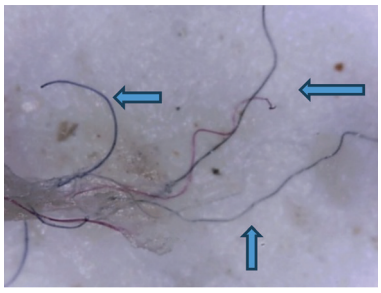


Image 3. Blue and pink line microplastic (2000 - 5000 µm) from fish gut.

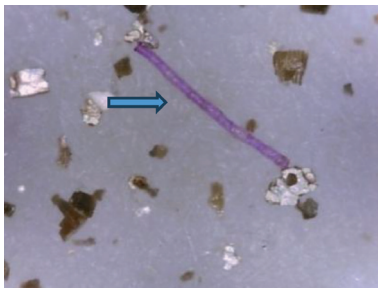


Image 4. Purple foam microplastic (500 - 1000 µm) from Manas river sediment

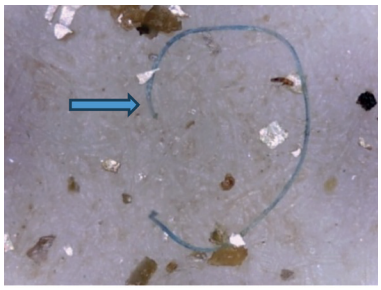


Image 5. Blue line microplastic (2000 - 5000 µm) Toorsa river surface.

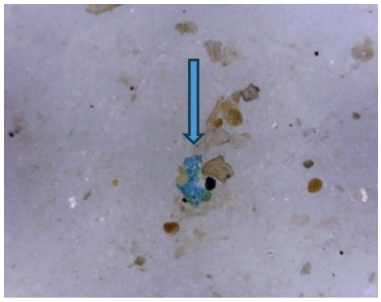


Image 6. Fragmented Mixed coloured (blue, yellow, and green) microplastic (10 - 300 µm) from Toorsa river sediment

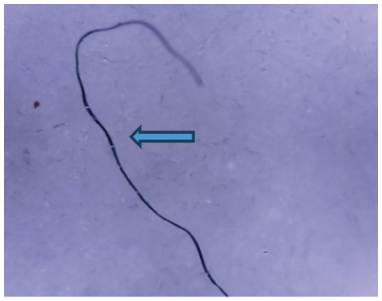


Image 7. Blue microplastic, line type (2000 - 5000 µm), from fish gut from Toorsa river

Image 8. Purple microplastic, fragment type, (10- 300 µm), from surface water, Toorsa river

nature of microplastic pollution and the necessity of reclaiming surface plastic waste and disposing waste in low-impact landfill[5].

Recommended Policy Actions to Address Plastic and Microplastic Contaminations in Freshwater

1. Prior to implementation of policies aimed at controlling and banning of plastics, the Ministry of Energy and Natural Resources (MoENR) should prioritize affordable biodegradable plastics by supporting market innovation of eco-friendly substitutes that will facilitate smooth transition. Furthermore, the Department of Media, Creative Industry and Intellectual Property (MoICE), the Department of Trade (MoICE) in collaboration with Ministry of Education and Skills Development (MoESD) can advocate on the use of plastic alternatives during mass gatherings (private, official, or religious), and among individuals. Re-enforcing penalties and monitoring for non-compliance could enhance policy acceptance. Successful policy execution requires strategic approach taking care of multiple steps along with long-term plan for monitoring.

2. With support from the Ministry of Energy and Natural Resources (MoNER), thromdes in all dzongkhags could establish reverse vending machines that offers financial incentives for returned plastic bottles. This initiative would boost public participation in plastic collection, reduce littering, lower collection and clean up costs and promote sustainable habits.

3. The departments under the Ministry of Energy and Natural Resources (Department of Water, Department of Environment and Climate Change, and Department of Forests and Park Services) could collaborate to identify, and address plastic pollution effectively by mapping plastic pollution hotspots through community engagement, schools, and general citizens to generate data via online platforms on plastic pollution hotspots in their locality and use technologies such as satellite images and aerial visual assessments for large-scale monitoring.

4. A strong collaboration among agencies like Bhutan Food and Drug Authority (BFDA) and Public Health (MoH), Colleges under the Royal University of Bhutan (RUB) like College of Natural Resources (CNR) and Sherubtse College, Royal Thimphu College (RTC) and Khesar Gyalpo University of Medical Sciences of Bhutan (KGUMS) is needed to research and study the health risks associated with microplastic exposure. Furthermore, develop strategies to monitor and eliminate microplastic contamination from the environment and food systems.

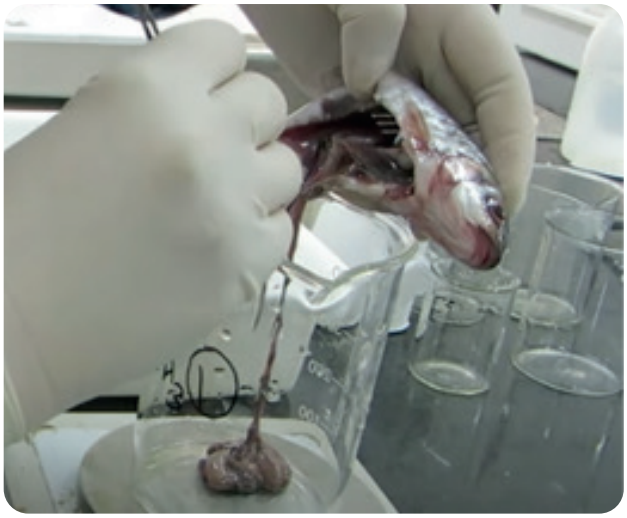


Image 9. Removing fish gut for isolation of microplastics

Microplastic: how small are they?

Megaplastics: bigger than 1 m
Macroplastics: 2.5 cm to 1 m
Mesoplastics: 5 mm to 2.5 cm
Microplastics: < 5 millimetres (1 millimetre = 1000 µm), requires magnification
Nanoplastics: < 1 micrometre (µm), invisible, requires magnification

Note: Images 3 to 8 are generated using digital microscope that magnify the plastic particles which otherwise are not visible to the naked eye.

References

Eze, C. G., Nwankwo, C. E., Dey, S., Sundaramurthy, S., & Okeke, E. S. (2024). Food chain microplastics contamination and impact on human health: a review. Environmental Chemistry Letters, 22(4), 1889-1927.

Rochman, C. M., Brookson, C., Bikker, J., Djuric, N., Earn, A., Bucci, K., Athey, S., Huntington, A., McIlwraith, H., Munno, K., De Frond, H., Kolomijeca, A., Erdle, L., Grbic, J., Bayoumi, M., Borrelle, S. B., Wu, T., Santoro, S., Werbowski, L. M., & Hung, C. (2019). Rethinking microplastics as a diverse contaminant suite. Environmental toxicology and chemistry, 38(4), 703-711

Allen, S., Allen, D., Karbalaei, S., Maselli, V., & Walker, T. R. (2022). Micro (nano) plastics sources, fate, and effects: What we know after ten years of research. Journal of Hazardous Materials Advances, 6, 100057.

Zhao, X., Wang, J., Yee Leung, K. M., & Wu, F. (2022). Color: an important but overlooked factor for plastic photoaging and microplastic formation. Environmental Science & Technology, 56(13), 9161-9163.

Jamtsho, K., Lund, M. A., Blake, D., & Van Etten, E. (2024). Microplastic pollution in riparian soils of the rapidly growing city of Thimphu, Bhutan. Water, Air, & Soil Pollution, 235(11), 714.

Acknowledgements

We gratefully acknowledge the collaborative efforts of our project partners—Bangladesh Agriculture University, Assam Agricultural University, University of North Carolina Wilmington, College of Natural Resources—whose research contribution underpins this policy brief. We thank Asia-Pacific Network for Global Change Research for the project fund and Centre for Rural Development Studies (CRDS) at CNR for encouragement and providing necessary guidance and resources in developing this document. This project was made possible with the support of staff from the Department of Forest and Park Services, Ministry of Agriculture and Livestock, Harachhu community, fisherman form Zhemgang, Toorsa, and Harachhu. This document is produced through the funding support of Department of Academic and Research Services (DeARS), Office of the Vice Chanceller RUB, B-KIND Tarayana Foundation, Royal Society for Protection of Nature (RSPN), and Asian Food and Agriculture Cooperation Initiative (AFACI).

Contact

Ms. Yogeeta Dahal
Lecturer, College of Natural Resources
Royal University of Bhutan
E-mail: yogeeta.cnr@rub.edu.bt

Harachhu Fishing Community and their exposure risk to microplastic via food pathways

The Harachhu Captured Fishery Management Group receives special permit for fishing as farming remains a challenge. They rely on snow trout (Schizothorax spp.) caught from the Harachhu river to prepare a traditional smoked fish, locally called as Nya-Dosem. The community is dependent on fishing for income generation, and the local fish is an important part of their diet. Their diet includes fresh fish as well as dried fish.

Image 10. Nya-dosem (pen for scale reference) prepared by Harachhu community.

Image 11. Traditional fish capture set up in Harachhu

The exposure to microplastic via fish depends on the fish processing and food preparation method. In Harachhu community, the smoked dry fish 'Nya-Dosem' is prepared after dissecting and removing the fish intestines. At the same time, some members of the community consume cooked fish with the gut intact as it is believed that it has medicinal values. Additionally, while preparing smoked dry fish or while cooking fresh fish, the fish gills are never removed.

Studies have found that bioaccumulation of microplastics occurs in fish gills, fish gut, and fish tissues. This suggests a plausible pathway of microplastics transfer to humans via the food chain. Additionally, Bhutan heavily imports dry and fresh fish, where chances of ingestion of microplastics from the imported fish could have broader health implications.

Given the bioaccumulation of microplastics in fish organs and their potential transfer to humans, more research, awareness campaigns, and preventive measures are needed to safeguard public health reduce plastic pollution.

Project Partners