


The chronicles of plastic from boon to bane: A case of resilience in Bangladesh

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Letter to the Editor

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Abstract

Plastics have come to symbolize the lifestyle and technological advancements of the 20th century, representing modern convenience and progress. In recent years, global plastic production surpassed 360 million tons in 2018 and is projected to reach between 500 and 600 million metric tons by 2025. This plastic accumulates as waste in freshwater, marine and land environments, leading to habitat disruption, alterations in nutrient cycles and harm to wildlife through exposure to toxic substances, entanglement and ingestion which pose significant ecological and health risks. The long-term ecological changes resulting from this pollution are likely irreversible. Developing countries in the Global South, including Bangladesh, are particularly vulnerable to the challenges of poorly managed plastic waste due to a lack of institutional, financial and technical resources to combat plastic pollution. The Aquatic Zoology Research Group has focused on addressing plastic pollution in Bangladesh and adopted a comprehensive strategy to tackle plastic pollution, starting with identifying the issue through various methods, followed by a thorough assessment of the plastic pollution situation and finally proposing solutions for mitigation. Our review of the current state of plastic pollution in Bangladesh's aquatic systems highlighted significant research gaps, despite the country's early ban on plastic bags. As a conservation research team from a developing nation facing the severe impacts of plastic pollution, we studied and listed specific expectations for the upcoming INC 5.2 meeting, highlighting challenges faced by many similar countries. We hope that INC 5.2 will move beyond mere statements to implement concrete and equitable actions.

Impact statement

As concerned citizens of the 21st century currently standing at the vantage point of the tumultuous wave that plastic contamination is creating across almost all terrain, we humans as a whole need to be well equipped with all the knowledge that we can get to tackle this crisis. As scientists, we believe it is our obligation to inform the greater audience of the actions that us at Aquatic Zoology Research Group, Department of Zoology, University of Dhaka in association with Oceanography, SUST, Bangladesh are taking from our end to fight this global threat and this is what we aim to appeal with our letter to INC 5.2. With that, we would also like to direct focus on the hurdles and handicaps faced by the Global South countries in the world plastic contamination scene that can be alleviated, if not remedied, through the upcoming INC 5.2 meeting. We look forward to a brighter outcome from this meeting and are optimistic that our succeeding letter in future meetings will draw a better and brighter picture of our sphere.

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The timeline

With the failure of traditional items to provide durability with versatility, plastics became indispensable because of their adaptability, affordability, durability and capacity to be molded into an infinite number of shapes, thus transforming the definition of convenience in daily lives (Rangel-Buitrago et al., 2022). Invented in 1907 by Leo Baekeland from formaldehyde and phenol (Ravichandran and Venkatesan, 2021; Rangel-Buitrago et al., 2022), plastics soon became alternatives to expensive or scarce natural resources (such as metal, wood and ivory) and the first choice to create new product designs and mass-market commodities that were previously unattainable (Crawford and Quinn, 2017). The 20th century's rapid industrialization and consumerist culture, particularly during and after World War II, necessitated efficient and reasonably priced mass production of plastics, causing their manufacture to expand dramatically



(Crawford and Quinn, 2017; Pilapitiya and Ratnayake, 2024). Plastics became a representation of the 20th century's lifestyle and technological innovation, signifying modern progress and convenience (Meikle, 1995).

Coming to present times, the amount of plastic produced annually worldwide exceeded 360 million tons in 2018, and is expected to reach 500–600 million metric tons by 2025 (Hoang, 2022). These plastics build up as debris in freshwater, marine and terrestrial settings, causing habitat disruption, nutrient cycle changes and injury to species through exposure to harmful compounds, entanglement and ingestion (Husaini et al., 2024). An estimated 5.25 trillion plastic particles are present in the ocean alone, posing serious ecological and health hazards (Pal et al., 2024). Long-term ecological alterations may result from these effects, which are unlikely to be reversible (MacLeod et al., 2021).

Developing nations in the Global South are particularly affected by poorly managed plastic waste because they frequently lack the institutional, financial and technical resources to address plastic pollution (Mourshed et al., 2017). Bangladesh is no exception. Despite being the first country in the world to ban polythene bags in 2002 (World Bank, 2021), Bangladesh was among the top 20 mismanaged plastic waste-generating nations back in 2010 as documented by Jambeck et al. (2015). At present, Bangladesh generates over 3,000 tons of plastic waste on a daily basis. Subsequently, a staggering 0.79 million metric tons of mismanaged plastic waste enter the Bay of Bengal annually (Ahmed et al., 2024). The issue of mismanaged plastic waste has been made worse by the fact that metropolitan areas have grown faster than waste management systems have developed, whereas waste management systems are part and parcel of well-managed and well-developed metropolitan areas.

Stripping the stigma

Restrained by financial impediments, Bangladesh lacks the infrastructure needed to manage plastic waste effectively, which leads to inappropriate disposal and more pollution (Mourshed et al., 2017). Despite the situation seemingly appearing to be without help on the surface, the actual scenario is quite contrary. Ever since the plastic bag ban in 2002, numerous researchers from across the country have researched the situation from different angles, making the situation as data-driven and solution-oriented as possible. But it was not limited to publications alone.

Starting from tracking the pathways of plastic bottles using GPS in aquatic systems to mapping out trophic transmission of microplastics in the Sundarbans mangroves, various remedial activities took place and are still taking place here on local, regional and global scales to mitigate the pollution.

With an emphasis on developing a gender-inclusive value chain, Aquatic Zoology Research Group (AZRG) investigated the problem of plastic pollution in Bangladesh. We took a holistic approach to tackle plastic pollution in Bangladesh and the Bay of Bengal. *Initially*, we identified the problem through multi-dimensional approaches. *This is followed by* a rigorous assessment of the plastic pollution situation. *Finally*, we provided a way forward to mitigating the plastic pollution problem.

To identify the problem, we reviewed the current state of plastic pollution in Bangladesh's aquatic systems, revealing significant research gaps despite the country's early ban on plastic bags (Chowdhury et al., 2021). On a global scale, including Bangladesh, nine out of the top 10 Long-Term Climate Risk Index (CRI)

countries' total mismanaged plastics input to the ocean are relatively low despite being most vulnerable to climate change (Chowdhury et al., 2022).

We assessed the magnitude of the problem by participating in the National Geographic Society's "Sea to Source: Ganges" Expedition organized with assistance from groups in Bangladesh and India in the Ganges (when entered Bangladesh, it is known as the Padma and Meghna rivers) to track the movement of plastic debris from the land to the water and collaborate with nearby communities at the same time. The study focused on waste management, microplastics and community involvement, offering a thorough understanding of the problem. In the Sundarbans mangrove forest, we documented the trophic transfer of microplastics, showing higher concentrations in top predators, highlighting biomagnification (Sarker et al., 2022). We also studied the rapid characterization of macroplastic input and leakage in the Ganges River basin (Youngblood et al., 2022). Our large-scale study of the Ganges River demonstrated that billions of microplastics, primarily fibers, are released into the Bay of Bengal daily (Napper et al., 2021). Using GPS tracking, we followed plastic bottles to understand how pollution moves from land to sea (Duncan et al., 2021). Additionally, we investigated plastic pollution from abandoned fishing gear, identifying it as a major source of pollution in the Ganges, posing risks to endangered species like the Ganges River Dolphin and our national fish Hilsa (Nelms et al., 2021; Chowdhury et al., 2024; Emon et al., 2025). We further explored the intersection of plastic pollution, climate change and biodiversity loss, showing how these issues compound environmental stress in vulnerable ecosystems (Sarker et al., 2023). Lastly, we assessed microplastic contamination in air, water and sediment along the Ganges, finding higher levels in densely populated areas, with rayon as the dominant polymer (Napper et al., 2023). These studies collectively illustrate the severity of plastic pollution in freshwater systems and its broader ecological and social impacts. Our research on plastic pollution in Bangladesh and the Ganges River system provides a comprehensive understanding of the crisis.

Based on our findings, we formulated mitigation action plans for plastic waste management. We researched the issue of plastic pollution from fishing nets and multi-film sachets in Bangladesh, focusing on creating a gender-inclusive value chain. Our study explored the feasibility of establishing large-scale net recycling businesses in Cox's Bazar and Charfesson, involving both men and women. We found that women's participation in the value chain is influenced by factors such as safety, income and permission from household heads. Recommendations included creating a gender-equitable recycling enterprise, addressing high-interest microcredit issues and integrating plastic waste into national mitigation policies.

With support (December 2023 to May 2024) from the World Bank Group, we developed a single-use plastic (SUP) Ban Implementation Plan focusing on community engagement and overcoming barriers, particularly in the tourism sector. Our Waste Management Plan emphasizes a structured approach to reduce plastic in the Sundarbans, involving local stakeholders, implementing alternatives and strengthening recycling efforts (Sarker et al., 2024). For alternatives, we explored eco-friendly replacements for common plastic items, like biodegradable bags, bamboo straws and wooden utensils, aiming to promote cost-effective, sustainable solutions tailored to local conditions. We found that the citizen science-based Monitoring-C4CEM approach using the Android application, such as Citizen for Coastal Ecosystem Monitoring (Sarker et al., 2024) is quite effective in an integrated waste

management plan (Das et al., 2024). Based on our findings, we tried to establish our method along the entire coastal zone of Bangladesh.

We have also been collaborating to increase public awareness and assist Bangladesh in achieving the worldwide goals for managing and reducing the plastic pollution disaster. In order to educate teachers and students about the issue, an active learning based educational program called “Teachers for Planet Earth” was created with workshops on the latest findings and insights into the policies imparted to the respective stakeholders. It can be undoubtedly noted that the people of Bangladesh are working twice as hard to make up for the shortcomings in infrastructure with their brains and brawn. Despite these challenges, there is a growing recognition of the need for sustainable practices, recycling initiatives and community involvement in the waste management practices of the country.

Way onward

With unceasing endeavors and resilience to combat Bangladesh’s soaring plastic pollution crisis, the question arises: what is missing in the picture? Alongside implementing a sustainable plastic management system on the national level, a coordinated, legally binding international response that tackles the underlying causes of plastic pollution is crucial to filling the gaps that currently exist in the system. This is where INC 5.2 (Intergovernmental Negotiating Committee on Plastic Pollution) comes into play, essentially the next step in battling plastic pollution. As a conservation research team from a developing country grappling with the severe impacts of plastic pollution, our expectations from the upcoming INC 5.2 meeting are grounded in the urgent realities faced by many other such developing coastal nations. These expectations span across policy, funding, equity and implementation. Here is an overview of what we are looking forward to:

- **Legally Binding Commitments:** The adoption of a strong, legally binding global plastics treaty that prioritizes reduction at source, not just waste management. Many Global South countries lack the infrastructure to handle massive inflows of plastic waste, especially imported waste. Voluntary measures have proven insufficient.
- **Global Financing Mechanism:** Establishment of a dedicated global financing mechanism or fund to support developing countries in mitigating plastic pollution. Countries like Bangladesh face significant resource constraints. Without financial support, we cannot implement ambitious mitigation plans, from cleanup to alternative material R&D.
- **Technology Transfer and Capacity Building:** Most developing countries lack access to scalable recycling technologies and biodegradable alternatives. We need support in training, innovation and infrastructure. Hence, strong provisions for technology transfer, capacity building and technical cooperation will vastly create a difference.
- **Control of Plastic Waste Trade:** Clear, enforceable restrictions on the transboundary movement of plastic waste that close loopholes that allow “recycling exports,” which is dumping in other words, in developing countries.
- **Extended Producer Responsibility (EPR):** Many plastic pollutants on our shores are from international brands. Mandated global EPR frameworks that require multinational corporations to be accountable for the full life cycle of their plastic products, instead of the local communities, are necessary.

- **Inclusion of Informal Waste Workers:** Recognition and support for the informal waste sector, including policies that protect livelihoods while formalizing their role in waste management.
- **Monitoring, Transparency and Accountability:** Robust monitoring and reporting mechanisms, with transparency built into the treaty structure to ensure all nations, especially plastic-producing countries and corporations, are held accountable for their commitments and impacts.
- **Civil Society and Scientific Participation:** Local scientists and activists offer critical on-the-ground perspectives often overlooked in international negotiations. Hence, creating a space for scientific voices and civil society organizations from the Global South in shaping treaty content and follow-up actions will go a long way.
- **Education and awareness raising initiatives:** No mitigation action plan will be effective if local communities cannot be well educated about the problem and awareness cannot be raised at the root level on the ground. But education and awareness campaigns should be successfully translated into long-term behavior change and there are solutions in people.

As the scientists who observe the overpowering consequences of plastic on our ecosystems and communities, we hope INC 5.2 moves beyond platitudes and into tangible, equitable action. This is a moment to craft not only a treaty, but a blueprint for a cleaner, more just planet for all.

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