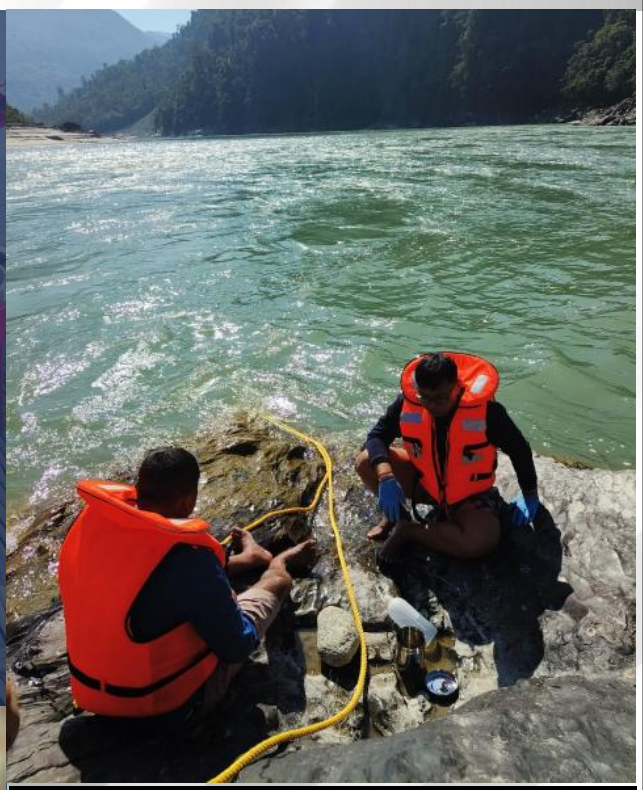
APN

ASIA-PACIFIC NETWORK FOR
GLOBAL CHANGE RESEARCH

FINAL REPORT

Transboundary microplastics contaminations in fish and aquatic food chain along Brahmaputra River



CRRP2021-09MY-Rashid

2025

BANGLADESH AGRICULTURAL UNIVERSITY

ASSAM AGRICULTURAL UNIVERSITY

ROYAL UNIVERSITY OF BHUTAN

UNCW

Project Reference Number: **CRRP2021-09MY-Rashid**

Project Duration: **2 years**

Funding Awarded: **USD 85,000**

Grant DOI: https://doi.org/10.30852/p.18799

Date of Publication:

Project Leader and Contact Details: **Prof. Dr. Harunur Rashid, Bangladesh Agricultural University, Bangladesh** (rashid@bau.edu.bd)

Collaborators and Contact Details:

- **Dr. Kizar Ahmed Sumon, Bangladesh Agricultural University, Bangladesh** (kizar@bau.edu.bd)
- **Dr. Rajdeep Dutta, Assam Agricultural University, India** (rajdeep.dutta@aau.ac.in)
- **Dr. Utpal Kumar Das, Assam Agricultural University, India** (utpal.k.das@aau.ac.in)
- **Ms. Yogeeta Dahal, Royal University of Bhutan, Bhutan** (yogeeta.cnr@rub.edu.bt)
- **Ms. Ugyen Tshomo, National Environment Commission Secretariat, Bhutan** (ugyen.tshomo110025@gmail.com)
- **Dr. Md Shah Alam, University of North Carolina Wilmington, USA** (alamm@uncw.edu)

Recommended Citation:

Rashid, H., Sumon, K.A., Dutta, R., Das, U.K., Dahal, Y., Tshomo, U., Mithu, M.M. & Alam, M.S. (2025). Transboundary microplastics contaminations in fish and aquatic food chain along Brahmaputra River. Technical Report. Asia-Pacific Network for Global Change Research.

1. Summary

The APN-funded project CRRP2021-09MY-Rashid (2023–2025) addressed transboundary microplastic (MP) pollution in the Brahmaputra-Jamuna River and its upper tributaries, a critical waterway spanning Bhutan, India, and Bangladesh, transporting millions of MPs daily to the Bay of Bengal. South Asia's second-highest global plastic emissions underscore the urgency, with MPs threatening aquatic food chains, fish health, and human diets. Led by Bangladesh Agricultural University (Bangladesh), the collaboration included Assam Agricultural University (India), Royal University of Bhutan, and University of North Carolina Wilmington (USA).

The objectives of this project were to: quantifying MPs in water/sediments/fish across upper (Bhutan tributaries: Harachhu, Manas, Toorsa), middle (India: Tuting–Dhubri), and lower (Bangladesh: Kurigram–Humuria) stretches; assessing invertebrate ingestion linking to water pollution; unraveling trophic transfer and fish physiological stresses via in vivo exposures; (4) evaluating human dietary risks through surveys; and formulating policy remedies.

Methods involved dual-season sampling (pre-/post-monsoon) at thirteen stations: plankton nets for water (MPs/km^2), Ekman grabs for sediments (MPs/kg), GIT dissections for fish species and invertebrate analysis. Advanced tools like microscopy and FTIR were employed to identify morphotypes/polymers; ANOVA/MANOVA tested effects; FGDs/KIIs probed dietary risks of fish consumers.

MPs were ubiquitous in collected samples, escalating close to two thousand-fold downstream waters compared to most upstream stations. Fibres/fragments and PVC/PA dominated. Demersal/carnivores highest had highest MP ingestion. In invertebrates MPs were found scaling with water pollution. *In vivo* exposures revealed anemia and histopathology in exposed catfish. Human risk (estimated daily intake, EDI) was 0.50 particles/kg BW daily and two-to-three-fold exposure risk downstream.

Three peer-reviewed papers are published, ten MSc theses are produced, and eight presentations are presented in seminars/conferences. The project has trained around sixty young scientists, held three policy workshops at three collaborating institutions in three countries yielding important policy guidelines regarding transboundary MP pollution.

Policy briefs are expected to influence relevant government organizations toward actions to reduce plastics pollution in this region; notably, BAU ban on single-use plastics bottle enacted. Furthermore, the project has enhanced capacity of other institutions in the collaborating countries and beyond, has shifted perceptions of stakeholders. In long-term, the project aligns with SDG 14 and SGD 12 alignment, and expects MP reduction potential via transboundary pacts, safeguarding fisheries for basin residents.

2. Objectives

By region, South Asia ranks second in the world in plastics pollution. The Bay of Bengal, located south to Bangladesh and India, is fed, among many others, by three mighty rivers - the Ganges, the Brahmaputra and the Irrawaddy. These rivers bring huge amounts of the pollutants off some of the world's most densely populated countries. Considering the huge volume of water transported by the River Brahmaputra and long path of populated human settlements it passes through during its journey, the proposed project was designed with the following objectives.

(1) Detect and quantify microplastics pollution in water and sediment and ingestion by fish in the Brahmaputra River in its upper (tributaries in Bhutan), middle (India) and lower (Bangladesh) stretches.
(2) Investigate ingestion of microplastics by fish's food (e.g. zooplankton & other invertebrates) and their relation with level of plastic pollution in the water.
(3) Unravel trophic transfer mechanisms of microplastics in the aquatic food chain *in vivo* and physiological stresses in fish elicit by microplastics ingestion and consequences on development, reproduction and life history stages of fish.
(4) Find out exposure risks of local people from consumption of riverine fishes through investigations of their dietary habits and dietary dependency on riverine fish.
(5) Furnish with policy recommendations for the Brahmaputra River countries suggesting actions for remedies of microplastics contamination to the river.

3. Outputs, Outcomes and Impacts

The project delivered tangible outputs aligned with each objective, yielding immediate outcomes through stakeholder engagement and knowledge dissemination, while laying foundations for broader impacts on policy, ecosystem health and community resilience. Below is a summary table visualizing these elements, drawing from the empirical findings of the project, workshops, publications, etc.

Outputs	**Outcomes**	**Impacts**
Comprehensive dataset from dual-season sampling at thirteen stations of Brahmaputra-Jamuna River (includes three upper tributaries in Bhutan): variations in MP abundance in the surface water, sediments, ingestion by fish, and characterization of those polymers.	Informed tri-national workshops, raising awareness among stakeholders on pollution hotspots (e.g., Guwahati peaks). Data shared via APN platforms, enabling initial hotspot mapping by local fisheries/ environment agencies.	Enhanced basin-wide monitoring frameworks, helpful of reducing undetected MP loads through integrated protocols; long-term contribution to SDG 14 (Life Below Water) via comprehensive data for regional environmental assessments.
MP ingestion data in invertebrates (snail/mussel; fish's food; also, contributes to environmental monitoring) scaling with water loads of MPs, and morphotype correlations (e.g. fragments, lines) matching water profiles.	Workshop discussions integrated findings into food-chain models, prompting fishers to adapt foraging in high-load zones. Helpful to furnish preliminary advisories for aquaculture to minimize snail/mussel-based feeds.	Informed sustainable fisheries management, implementation will potentially avert biodiversity loss in benthic communities. Also, supports ecosystem service valuation for policy in transboundary conservation agreements.

Trophic ingestion data indicate that demersal/carnivores ingest two-three-fold higher MPs compared to lower trophic fishes. *In vivo* exposures (Asian & walking catfish) showing anemia, enzyme spikes, histopathology in fish, often resulting in growth/ reproduction impairments.	Lab findings briefed regulators, influencing early warnings for relevant policy actors and stakeholders. FGDs shifted fisher perceptions on MP health links.	Catalyzes toxicity thresholds in national water quality standards, mitigating long-term fishery declines; supports resilience in food safety for the river basin residents.
Dietary surveys revealed risks to MP exposure by eating riverine fish, as reviled through EDI outputs - also indicating two to three-fond higher risks to downstream communities.	FGD/KII insights helpful to shape consumption guidelines, adopted by the communities for safer evisceration; media briefs reached a greater audience via newspaper & TV reports and Facebook postings.	Reduces chronic health burdens from MP exposure, informing food safety & nutrition policies; empowers vulnerable groups, enhancing equity in river-dependent livelihoods over decades.
Three policy workshops outputs: EPR mandates, ETP retrofits, 5R campaigns, transboundary observatory proposals. Also, workshop-synthesized brief targeting notable input reduction. Worth to note, during the policy workshop, BAU Vice-Chancellor declared (later, published official order) ban on single-use plastics bottles on campus.	Recommendations furnishing with important guidelines for the actions by national 'environment' and 'fisheries' authorities.	Drives regional accords (e.g. APN-facilitated protocols/policy briefs), curbing basin MP loads; fosters circular economies, aligning with SDGs 12/14 for sustainable development.

4. Key facts/figures

- Microplastics (MPs) were ubiquitous across all matrices with around two thousand-fold upstream-downstream gradients in surface water from Harachhu River of Bhutan to Humuria station of Brahmaputra-Jamuna River in Bangladesh, peaking midstream at Guwahati station of India; sediments showed around sixty-fold span. Pre-monsoon concentrations dominated due to significant season-station interaction. Dominant forms of MPs were fibres in water and fragments in sediments, with black as primary color and PVC/PA/CPVC polymers. Fish ingestion averaged 5–25 MPs/individual pre-monsoon, higher in demersal carnivores/omnivores.
- In the Old Brahmaputra River, a distributary of the Brahmaputra River in north-central Bangladesh, MPs in the surface water and sediments peaked during winter, declining in early monsoon and post-monsoon, with seasonal effects outweighing spatial variation. Lines and

fragments dominated, with blue/red/black colors and PE polymer prevalent, yielding low PLI risk. City/urban drains discharged into this river carried far higher MPs than rural counterparts, with urban sites exhibiting upto six-fold greater loads in both seasons, driven by dense sewage/industrial effluents versus agricultural runoff, highlighting urban hotspots as primary MP vectors.

- Benthic invertebrates like mussels and snails ingested 3-14 MPs/individual pre-monsoon, dropping to 1–5 post-monsoon; mussels accumulated two to three-folds more than snails. Ingestion scaled with water MP pollution, peaking in downstream stations versus upstream; MPs matched water profiles, evidencing direct uptake from polluted water and trophic linkage to fish prey.
- Whild considering trophic transfer in the aquatic food chain, it was revealed that MPs in fish GITs were higher during pre-monsoon and concentrated in demersal/benthopelagic habitats and carnivorous/omnivorous feeders, indicating bottom-up accumulation. *In vivo* exposures of Asian stinging catfish induced significant stresses including anemia, elevated liver enzymes, and reduced hemoglobin, alongside histological damage impairing growth; similarly, walking catfish exposed to PET/LDPE MPs showed decreased RBC/hemoglobin, increased WBC/urea/glucose/SGPT/SGOT, organ histopathology (liver/kidney/intestine/gills) and growth retardation.
- Communities along the Brahmaputra-Jamuna showed strong reliance on riverine fish, favoring small species; incomplete gut removal and intentional consumption of guts or gills heightened MP ingestion risks. Estimated daily intake (EDI) revealed stark transboundary disparities: downstream Bangladesh averaged 0.50 particles/kg BW, which is two to three times higher than upstream India - with peaks in Sirajganj station; males exceeded females, and gut-consumers faced double the exposure, emphasizing downstream cumulative pollution and urgent need for region-specific safe-fish guidelines.
- Collaborative tri-national policy workshops, informed by empirical pollution gradients and stakeholder consultations, generated a suite of stratified, actionable recommendations tailored to the basin's upstream-downstream dynamics: in Bhutan and upstream India, governments should legislate comprehensive bans on microbeads in cosmetics and single-use plastics while enforcing Extended Producer Responsibility schemes targeting textile manufacturers to curb primary emissions at source; midstream urban-industrial clusters such as Phuentsholing and Guwahati require mandatory retrofitting of effluent treatment plants with fibre-capture technologies alongside deployment of reverse vending machines in municipal areas to intercept 60–70% of industrial and consumer-derived microplastics, as benchmarked from Old Brahmaputra interventions; downstream Bangladesh must prioritize large-scale deployment of floating barriers and targeted sediment dredging in high-deposition zones like the Jamuna chars to mitigate cumulative loads. Basin-wide, an APN-facilitated Brahmaputra-Jamuna Microplastics Observatory should be established to enable real-time data harmonization, joint hotspot monitoring via citizen-science applications, and synchronized 5R public campaigns; complementary measures include standardized fish preparation advisories emphasizing complete excision of gastrointestinal tracts and gills, coupled with incentive-driven transitions to biodegradable alternatives and stringent enforcement mechanisms to foster circular economies and equitable transboundary accountability.

5. Publications

Fatema, K., Auditi, T. I., Biswas, S., Ayesha, S. B., Helal Uddin, M., Sumon, K. A., . . . Rashid, H. (2023). Investigations of hemato-biochemical and histopathological parameters, and growth performance of walking catfish (Clarias batrachus) exposed to PET and LDPE microplastics. *Environmental Toxicology and Pharmacology, 102*, 104250. doi: https://doi.org/10.1016/j.etap.2023.104250

Fatema, K., Hawa, M. A., Masnoon, S., Alam, M. J., Islam, M. J., Hasan, M. M., . . . Rashid, H. (2023). Microplastic pollution in surface waters and sediments matrices of the Sundarbans – The largest single block of tidal halophytic mangrove forest in the world. *Regional Studies in Marine Science, 67*, 103226. doi: https://doi.org/10.1016/j.rsma.2023.103226

Fatema, K., Islam, M. J., Sarker, M. A. I., Elahi, K. S., Alam, M. J., Hasan, S. J., & Rashid, H. (2024). Occurrence of microplastics in fish gastrointestinal tracts belongs to different feeding habits from the Bangladesh coast of the Bay of Bengal. *Environmental Science and Pollution Research, 31*(16), 24329-24343. doi: https://doi.org/10.1007/s11356-024-32681-8

Mithu, M. M., Fatema, K., Zaman, F., Anonna, W., Kanok, N. J. R., Zannat, T., Siddiquee, M. A. M., Dahal, Y., Dutta, R., Sumon, K. A., Alam, M. S., & Rashid, H. (2025). Microplastics pollution in water and sediment matrices of the Old Brahmaputra River, Bangladesh: An ecological risk appraisal of an urban river. *Journal of Sedimentary Environments* (Manuscript under review)

Debnath, P., Singha S., Sarmah, R., Deka, S., Das, U.K., Bhagabati, S.K., Rashid, H. & Dutta, R (2025). Occurrence and Characterization of Microplastics in Freshwater Eel Species from the River Brahmaputra, Assam, India. Aquatic Living Resources (Manuscript submitted)

6. Media reports, videos and other digital content

SL	Content	Hyperlink
i	Key workshop on transboundary microplastics and policy action Daily Amar Desh, 27 February 2025	https://www.dailyamardesh.com/feature/campus/amdetywbpolfd
Ii	Workshop on microplastic pollution held at BAU BSS News, 27 February 2025	https://www.bssnews.net/news/250370
Iii	Transboundary microplastics research on River Brahmaputra Ekushey TV, 8 April 2025	https://www.facebook.com/reel/1122882982926818
Iv	Microplastics are to be ingested by fishes in the Brahmaputra-Jamuna Rivers Daily Bangla Tribune, 13 April 2025	https://www.banglatribune.com/country/mymensing/893934/
v	BAU hosts key workshop on transboundary microplastics and policy action APN Website, 21 April 2025	https://www.apn-gcr.org/news/bau-hosts-key-workshop-on-transboundary-microplastics-and-policy-action/
vi	73,000 tons of plastic flow into rivers of Bangladesh every year Views Bangladesh, 30 April 2025	https://viewsbangladesh.com/73000-tons-of-plastic-flow-into-rivers-of-bangladesh-every-year/
Vii	Workshop on Microplastics Pollution Held at Raha BAU-FM Blog Post, 24 October 2025	https://fm.bau.edu.bd/researches/162

7. Pull quotes

"This project is time-demanding research for Bangladesh and the region. The results of this project have demonstrated that Bangladesh is most vulnerable to transboundary microplastics pollution due to its position in the downstream part of many rivers including the Brahmaputra River. I am optimistic about the formulation of effective policy recommendations based on the findings of this project. Addressing the concerns raised by the demonstrated facts of this project, I hereby declare that the use of plastic bottles is strictly prohibited inside the Bangladesh Agricultural University campus from now on."

Prof. Dr. A. K. Fazlul Haque Bhuiyan, Vice Chancellor,
Bangladesh Agricultural University (BAU)

"This APN sponsored project is a very good beginning and it will provide vital support for policy framing which is required to initiate the scientific measures to be adopted to prevent microplastics contamination in future."

Dr. Probodh Bora, Director of Research
Assam Agricultura University, India

"This study revealed an uncomfortable truth, and the findings are a wakeup call that microplastics are already in the aquatic environment and potentially in our bodies. This paves a path from awareness to action demanding collaboration to protect our pristine environment"

Dr. Rekha Chhetri, College of Natural Resources
Royal University of Bhutan, Bhutan

"Fish health depends on river health, so this study is required."

Mrs. Jarina (Rural Women, Fish Consumer)
Gaibandha, Bangladesh

8. Acknowledgments

The successful execution of this APN-funded project owes profound gratitude to the Asia-Pacific Network for Global Change Research (APN) for its generous financial support and unwavering encouragement throughout the project duration, enabling rigorous transboundary investigations into microplastic pollution along the Brahmaputra-Jamuna River. We extend heartfelt appreciation to our institutional partners and their research management systems from - Bangladesh Agricultural University (BAU), Assam Agricultural University (AAU), Royal University of Bhutan (RUB), and University of North Carolina Wilmington (UNCW) for providing essential infrastructure, laboratory facilities, and administrative backing that underpinned sampling, analyses, and capacity-building efforts. Sincere thanks are due to the National Environment Commission Secretariat (Bhutan), Bhutan Food and Drug Authority, Assam Department of Fisheries, Bangladesh Department of Fisheries, Bangladesh Fisheries Research Institute, and local communities in and around all the sampling stations in the three countries and beyond, whose cooperation in field access, focus group discussions, and key informant

interviews enriched grassroots insights. We are deeply indebted to the young scientists, graduate students, and technicians trained under this initiative for their dedication in dual-season fieldwork and data processing. Special recognition goes to workshop participants across the three countries, whose policy canvasses shaped actionable recommendations, and to BAU Vice-Chancellor Prof. Dr. A. K. Fazlul Haque Bhuiyan for his visionary campus plastic ban. Finally, we acknowledge the invaluable contributions of fishers, waste managers, and riparian households whose lived experiences illuminated pathways from evidence to equitable governance.

9. Appendices

Appendix 9(A)	Three Policy Recommendation Workshops on Transboundary Microplastics Pollution along the Brahmaputra-Jamuna River Organized by Bangladesh, India and Bhutan
Appendix 9(B)	Training of Young Scientists in Microplastics Research & Capacity Development
Appendix 9(C)	Journal Articles from this Project
Appendix 9(D)	List of Master Degree Thesis Awarded from this Project
Appendix 9(E)	Conference/Seminar Presentations from the Project
Appendix 9(F)	Few Snaps of the Project Activities

Appendix 9(A):

Three Policy Recommendation Workshops on Transboundary Microplastics Pollution along the Brahmaputra-Jamuna River Organized by Bangladesh, India and Bhutan

The project culminated in a series of three dedicated policy recommendation workshops, one in each partner country, strategically organized to disseminate key findings, foster stakeholder dialogue, and forge consensus on actionable strategies to combat microplastic (MP) pollution in the Brahmaputra-Jamuna basin. These events, held between February and October 2025, brought together over two hundred participants - including scientists, policymakers, fisheries officials, environmental regulators, fishers, and community representatives - transforming raw scientific data into a unified transboundary policy agenda. By employing interactive tools like policy canvasses and focus group discussions, the workshops bridged knowledge gaps, amplified grassroots voices, and emphasized the river's shared vulnerability, where upstream sources inexorably amplify downstream risks.

The inaugural workshop took place on 27 February 2025 at Bangladesh Agricultural University (BAU) in Mymensingh, Bangladesh, attracting 75 attendees from government ministries, research institutes, and academia. Moderated by Project Leader Prof. Dr. Harunur Rashid, the event featured presentations on basin-wide MP gradients - highlighting downstream peaks in the Jamuna - and was graced by BAU Vice-Chancellor Prof. Dr. A. K. Fazlul Haque Bhuiyan as chief guest. Prof. Dr. Kizar Ahmed Sumon detailed transboundary distributions across Bhutan, India, and Bangladesh, while partners from Assam Agricultural University (AAU) and Royal University of Bhutan (RUB) shared complementary insights. Breakout sessions using the 'Policy Canvass' tool pinpointed core issues: inadequate waste management, absent transboundary collaborations, and public awareness deficits. In a landmark moment, the Vice-Chancellor declared an immediate ban on plastic bottles across the BAU campus, symbolizing institutional commitment. Discussions underscored Bangladesh's downstream vulnerability, advocating mass media campaigns, incineration plants, and regional pacts.

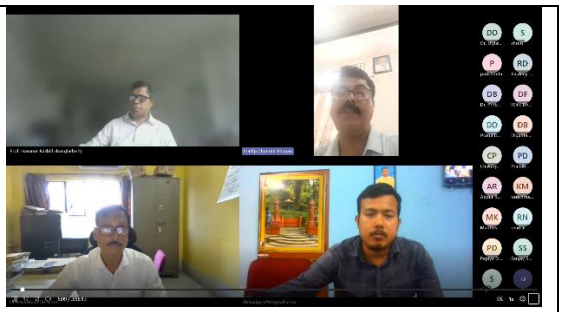
Participants of the Policy Recommendation Workshop organized by BAU, Bangladesh

Complementing this, Bhutan's workshop convened on 26 March 2025 at the College of Natural Resources (CNR), Royal University of Bhutan (RUB), focusing on upstream tributaries like Harachhu, Manas, and Toorsa. Led by Ms. Yogeeta Dahal, it engaged researchers, the National Environment Commission Secretariat, and community fishers from Zhemgang and Wangduephodrang. The session unpacked MP sources (e.g., fibres from textiles, fragments from

packaging) and food-web risks, revealing urban Phuentsholing as a hotspot despite Bhutan's conservation ethos. Participants called for inter-agency collaborations - linking RUB colleges, Bhutan Food and Drug Authority (BFDA), and Ministry of Health - to monitor health exposures and pioneer elimination strategies. Emphasis fell on source tracing via MP morphology, eco-friendly alternatives, and riparian waste curbs, reinforcing Bhutan's Gross National Happiness framework with science-driven safeguards.

Participants of the Policy Recommendation Workshop at CNR, RUB, Bhutan

The series concluded with India's virtual workshop on 22 October 2025, anchored at AAU's Faculty of Fisheries Science, Raha, Nagaon, Assam, drawing 30+ delegates including Assam's Department of Fisheries leadership. Convened by Dr. Rajdeep Dutta and Dr. Utpal Kumar Das, it spotlighted midstream gradients from Tuting to Dhubri, with Prof. Rashid providing basin context. Robust deliberations categorized remedies into four pillars: Prevention at Source (microbead bans, low-shed textiles); Waste Management (EPR, recycling); Cleanup (barriers, dredging); and Policy/Education (fish gut advisories, transboundary research). Fisheries officers like Dr. Pratul Barman stressed enforcement, urging submissions to state governments.



Snaps from the Policy Recommendation Workshop organized by AAU, Assam, India

Collectively, these workshops synthesized a resonant narrative: around two thousand-fold escalation MPs from up- to down-stream demands holistic action - upstream prevention, midstream management, downstream remediation - anchored in APN-facilitated observatories and 5R principles. Common threads included public awareness (e.g., safe fish prep), institutional bans, and equitable burden-sharing, yielding a consolidated policy brief submitted to national authorities. By nurturing trust through dialogue, the events catalyzed momentum toward a microplastic-resilient Brahmaputra, exemplifying APN's vision for adaptive, shared governance.

Appendix 9(B):

Training of Young Scientists in Microplastics Research & Capacity Development

(i) Training of Young Scientists from the Project Collaborating Partner Institutions from India and Bhutan

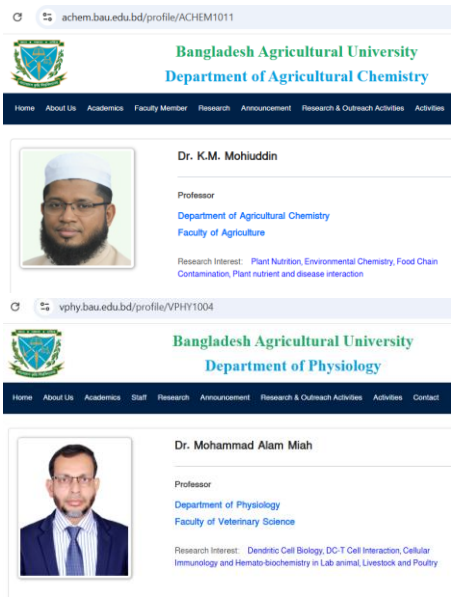
From 15 to 19 October 2023, a hands-on training 'Microplastics Sampling from River and their Laboratory Analysis' was organized at the Lead Institute of this Project – Bangladesh Agricultural University (BAU), Department of Fisheries Management. Ms. Yogeeta Dahal from the Royal University of Bhutan, Bhutan and Mr. Sanayaima Singha from the Assam Agricultural University, India received the training. Some MS students from BAU also received the same training during this time.

(ii) Training on 'Microplastic Pollution in Water: Monitoring, Modelling and Ecological Risk Assessment' offerred to 40 young scientists from Vietnam, Cambodia and Republic of Korea.

The Team Leader of the project was invited by the Institute of Natural Product Chemistry (INPC), Vietnam Academy of Science and Technology (VAST) at Hanoi, Vietnam to offer a training session on 'Ecological Risk Assessment (ERA) of Microplastics in Aquatic Systems' which was part of the training course on 'Microplastic Pollution in Water: Monitoring, Modelling and Ecological Risk Assessment'. Organized by the Asia-Pacific Network for Global Change Research (APN)-funded project entitled 'Establishing a Regional Dataset on Emerging Pollutants to Support Surface Water Management of Seven Large Cities of East and Southeast Asia' (https://lnkd.in/gGGDvB2u) of INPC-VAST, the training was offered to around 40 young scientists from Vietnam, Cambodia and Republic of Korea.

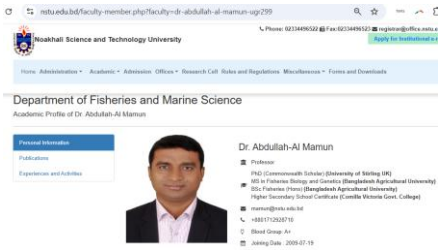
(iii) Supporting training and capacity development in microplastics pollution research at two departments at BAU

The Team Leader Prof. Rashid and his team have supported field study and laboratory study needs assessment for microplastics pollution and exposure research in the two BAU departments. Moreover, Master Degree students of these two departments, under the supervision of Prof. Dr. K.M. Mohiuddin (Department of Agricultural Chemistry) and Prof. Dr. Mohammad Alam Miah (Department of Physiology) were trained to carry out MP sampling from openwater followed by their laboratory study and MP exposure risk assessment in the laboratory setting.



(iv) Training of NSTU students on microplastics isolation and characterization from fish meal

Two master degree students under the supervision of Prof. Dr. Abdullah-Al Mamun of the Department of Fisheries and Marine Science, Noakhali Science and Technology University (NSTU), Bangladesh were trained on the isolation and characterization of MPs for the study of MPs contaminated within the fish meal samples used for preparing fish feed in Bangladesh.



(v) Training of BFRI scientist and DoF official on aquatic microplastics pollution research

One scientist from Bangladesh Fisheries Research Institute (BFRI, Mr. Turabur Rahman, Scientific Officer, Marine Station of BFRI) and one official from the Government Department of Fisheries (DoF, Mr. Md. Mahmudunnabi Mithu) have been trained with different protocols for the study of MPs from natural waterbodies, fish and other aquatic animals; and to perform ecological risk assessments.

Environmental Toxicology and Pharmacology 102 (2023) 104250

Contents lists available at ScienceDirect

Environmental Toxicology and Pharmacology

journal homepage: www.elsevier.com/locate/etap

Investigations of hemato-biochemical and histopathological parameters, and growth performance of walking catfish (*Clarias batrachus*) exposed to PET and LDPE microplastics

Kaniz Fatema [a,b], Tasnia Islam Auditi [a], Shema Biswas [a], Sumaiya Binte Ayesha [a], Md. Helal Uddin [a], Kizar Ahmed Sumon [a], Chayon Goswami [c], Ramji Kumar Bhandari [d], Harunur Rashid [a,*]

[a] Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh
[b] Department of Fisheries Management, Hajee Mohammad Danesh Science and Technology University, Dinajpur 5200, Bangladesh
[c] Department of Biochemistry and Molecular Biology, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh
[d] Department of Biology, University of North Carolina at Greensboro, Greensboro, NC 27412, USA

ARTICLE INFO

Keywords:
Microplastic
Exposure
Walking catfish
Hemato-biochemistry
Histopathology
Growth

ABSTRACT

Fish inhabiting various trophic levels are affected differently as the presence of microplastic (MP) in the water column and their ingestion by fish varies. Walking catfish (*Clarias batrachus*) inhabits the bottom of the water bodies. To understand the effects of MP, we exposed *C. batrachus* to two types of MP – polyethylene terephthalate (PET) and low-density polyethylene (LDPE) for 60 days. After exposure, hematological indices, mainly red blood cells and hemoglobin levels decreased, and white blood cells increased significantly compared to the control group ($p < 0.05$). A significant increase in the levels of blood urea and glucose was observed, and serum glutamic pyruvate transaminase and serum glutamyl oxaloacetic transaminase activity remained elevated ($p < 0.05$). Histopathological examination of the liver, kidney, intestine, and gills showed morphological alterations. Moreover, MP exposure caused growth retardation ($p < 0.05$) in *C. batrachus*. Widespread pollution of water bodies by MP may impose serious ecological risks to bottom-feeding fish in Bangladesh.

1. Introduction

Plastics are polymerization-based monomers with distinct physico-chemical properties and a durable structure that can persist for hundreds of years and pose a severe threat to global contamination (Hamed et al., 2022; Jiang et al., 2018). It is projected that, within a few decades, the amount of plastic entering the marine environment will rise to the level that it will exceed the ocean's fish mass (Simon and Schulte, 2017). Worldwide plastics production rose to 390.7 million tonnes in 2021 after stagnation in 2020 owing to the Covid-19 outbreak (Plastics Europe, 2022). Plastics that enter seas and oceans are converted to macro-plastics, mesoplastics, and microplastics following chemical and biological reactions, including solar degradation, biodegradation, etc. (Jambeck et al., 2015). Due to the small size (1 μm to 5 mm) and global occurrence in coastal-marine waters (Alimba and Faggio, 2019; Amelia et al., 2021; Fatema et al., 2023; González-Ortegón et al., 2022; Napper et al., 2021; Sutton et al., 2016), microplastic (MP) are readily available to different aquatic biota in all water columns (Foekema et al., 2013; Mathalon and Hill, 2014).

The use of manmade synthetic polymeric materials plays a significant influence on our everyday life. Synthetic polymers, including polyethylene (PE), polyethylene terephthalate (PET), polyvinyl chloride (PVC), nylon, etc., are used in a wide range of sectors, including packaging, textiles, paper, automobile, etc. (da Costa et al., 2016; de Sá et al., 2018; Jiang et al., 2019). Particularly, PE [$(C_2H_4)n$], also categorized as LDPE – low-density PE, HDPE – high-density PE and LLDPE – linear low-density PE, is used in a variety of products, including plastic bags, sheets, threads, packaging, toys, and other things (Lusher et al., 2017; Fatema et al., 2023). PET [$(C_{10}H_8O_4)_n$] serves as the primary ingredient in textiles, water bottles, the majority of colorful fibers, several transparent components, etc. (Fatema et al., 2022; Iñiguez et al., 2017; Wang et al., 2017). Given the fact that plastics can persist in the ecosystem for an extended period, MP and their environmental effects are unavoidable (Cole et al., 2011). MP have been found to be ingested by various

* Corresponding author.
E-mail address: rashid@bau.edu.bd (H. Rashid).

https://doi.org/10.1016/j.etap.2023.104250
Received 1 April 2023; Received in revised form 1 August 2023; Accepted 15 August 2023
Available online 16 August 2023

Regional Studies in Marine Science 67 (2023) 103226

Contents lists available at ScienceDirect

Regional Studies in Marine Science

journal homepage: www.elsevier.com/locate/rsma

Microplastic pollution in surface waters and sediments matrices of the Sundarbans – The largest single block of tidal halophytic mangrove forest in the world

Kaniz Fatema [a,b], Mansura Akter Hawa [a], Sabiha Masnoon [a], Md. Jahangir Alam [c], Md Jakiul Islam [d], Md. Mohibul Hasan [a], M.A. Mamun Siddiquee [a], Md. Helal Uddin [a], Kizar Ahmed Sumon [a], Ramji Kumar Bhandari [e], Harunur Rashid [a,*]

[a] Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh
[b] Department of Fisheries Management, Hajee Mohammad Danesh Science and Technology University, Dinajpur 5200, Bangladesh
[c] Department of Fisheries Management, Patuakhali Science and Technolgy University, Patuakhali, Dumki 8602, Bangladesh
[d] Faculty of Fisheries, Sylhet Agricultural University, Sylhet 3100, Bangladesh
[e] Department of Biology, University of North Carolina at Greensboro, Greensboro, NC 27412, USA

ARTICLE INFO

Keywords:
Microplastics
Mangrove ecosystem
Surface waters
Bottom sediments
Contamination
Transport

ABSTRACT

The Sundarbans, which is the largest mangrove forest in the world, are immensely threatened by plastic waste. For Sundarbans, plastic pollution is a relatively recent and serious issue. We investigated the quantitative assessment of microplastics (MPs) in surface waters, and sediments in the Sundarbans mangrove region of the northern Bay of Bengal, Bangladesh coast. The average concentrations of MPs observed during the pre-monsoon sampling period (surface water: 81,056 ± 8085 items/km^2, sediments: 47 ± 11 items/kg) were higher than the post-monsoon (surface water: 73,722 ± 9096 items/km^2, sediments: 41 ± 7 items/kg). MPs abundance was significantly higher in the downstream sampling station compared to the upstream. MPs were dominated by fibers in type, smaller dimensions (301–500 μm) in shape, black in color, and polyethylene terephthalate (surface water: 30%, sediments: 24%) in composition. Comprehensive research is strongly urged for plastic contamination controls and management of this crucial ecosystem.

1. Introduction

Microplastics (MPs) are a kind of particles (1 μm to 5 mm in size), that occur in various forms, such as pellets, fibers, fragments, films, and granules (John et al., 2022). MPs can aggregate in aquatic ecosystems that have raised concerns across the globe due to their potentially detrimental effects on the environment, public health, and food safety (Crew et al., 2020; Napper et al., 2021). MPs can be smeared over large areas of the ocean by storms, currents, waves, tides, and river effluent (Martinez et al., 2009). MPs have been recognized to be found in the mid-ocean Islands (Rey et al., 2021), the Indian Ocean (Hildebrandt et al., 2022), the Atlantic region (Reineccius and Waniek, 2022), the Weddell Sea of Antarctica (Leistenschneider et al., 2021), and from various section of the world (Adyel and Macreadie, 2021; John et al., 2022). Throughout the world MPs have also been found in mudflats (Lo et al., 2018), sandy beaches (Besley et al., 2017; Hossain et al., 2021), Bays (Eriksen et al., 2018; Nakano et al., 2021), rivers (Chauhan et al., 2021; Napper et al., 2021) as well as mangroves and coral reef ecosystems (Naji et al., 2019; John et al., 2022; Kumar et al., 2022). Aquatic environments have become dispersed with plastic waste and MPs (Foekema et al., 2013; John et al., 2022) have toxicological impacts on aquatic organisms, cause tissue inflammation, digestive problems, and other physical obstructions, and act as a possible source of the transmission of different harmful substances (Lambert and Wagner, 2018; Prokić et al., 2019; Hasan et al., 2022; Li et al., 2022). Among others, worldwide mangrove forests are at a gigantic risk of plastic contamination (Adyel and Macreadie, 2021).

The Sundarbans, the world's biggest mangrove ecosystem and a UNESCO World Heritage Site is a low-lying mangrove ecosystem that stretches across India and Bangladesh. This mangrove is densely forested and formed by the convergence of three rivers, the Ganga, the Brahmaputra, and the Meghna, which meet at the Bay of Bengal (BoB)

* Corresponding author.
E-mail address: rashid@bau.edu.bd (H. Rashid).

https://doi.org/10.1016/j.rsma.2023.103226
Received 6 April 2023; Received in revised form 20 September 2023; Accepted 27 September 2023
Available online 29 September 2023

Appendix 9(C): **Journal Articles from this Project** [Article-iii]

Environmental Science and Pollution Research
https://doi.org/10.1007/s11356-024-32681-8

RESEARCH ARTICLE

Occurrence of microplastics in fish gastrointestinal tracts belongs to different feeding habits from the Bangladesh coast of the Bay of Bengal

Kaniz Fatema[1,2] · Md. Jakiul Islam[3] · Md. Ashraful Islam Sarker[1,4] · Kazi Shahrukh Elahi[1] · Md. Jahangir Alam[5] · Shanur Jahedul Hasan[6] · Harunur Rashid[1]

Received: 20 July 2023 / Accepted: 24 February 2024

Abstract
The Bay of Bengal (BoB) is home to a range of commercially important species with different food habits and feeding features. Microplastic (MP) contamination in the fish of BoB, like in many other marine environments, is a significant environmental concern. The study aimed to investigate the presence of microplastics (MPs) in the gastrointestinal tracts (GITs) of selected commercial marine fishes from the Bangladesh coast of the BoB. Six fish species (*Escualosa thoracata*, *Tenualosa ilisha*, *Johnius belangerii*, *Trichiurus lepturus*, *Planiliza parsia*, and *Mystus gulio*) were investigated ($n = 120$) following hydrogen peroxide digestion, and floatation (saline solution) protocols. After analyses, a total number of 696 MPs (dimension 0.3 to 5 mm) were identified. Moreover, the highest occurrence of MPs in fish GITs was found in planktivorous fish (average of 7.7 items/individual), followed by omnivorous (average of 5.2 items/individual), and carnivorous fish (average of 4.6 items/individual) ($p < 0.001$). However, planktivorous *E. thoracata* showed the highest number of MPs per g of GIT (average of 30.99 items/g GIT), whereas *T. ilisha* showed the lowest count (average of 0.77 items/g GIT). Different types of MPs (fibers (19 to 76%), fragments (6 to 61%), films (8 to 35%), microbeads (0 to 5%), and foams (0 to 2%)) were also observed. In terms of the color of MPs, the transparent, black, green, and blue types were the most common. Polymers were found as polyethylene (35 to 43%), polyethylene terephthalate (28 to 35%), polyamide (20 to 31%), and polystyrene (0 to 7%). The study provides a significant incidence of MPs in fish from the Bangladesh part of the BoB, which is very concerning. Therefore, long-term research is indispensable to ascertain the variables affecting the presence of MPs in fish, their origins, and their potential effects on the BoB fisheries. Stringent policies on plastic use and disposal should be strongly urged in this coastal region.

Keywords Microplastic · Commercial fish · Feeding features · Gastrointestinal tract · Bay of Bengal

Responsible Editor: V.V.S.S. Sarma

Kaniz Fatema and Md Jakiul Islam equally contributed as first authors.

✉ Harunur Rashid
rashid@bau.edu.bd

[1] Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

[2] Department of Fisheries Management, Hajee Mohammad Danesh Science and Technology University, Dinajpur 5200, Bangladesh

[3] Department of Fisheries Technology and Quality Control, Sylhet Agricultural University, Sylhet 3100, Bangladesh

[4] Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh

[5] Department of Fisheries Management, Patuakhali Science and Technology University, Patuakhali 8602, Bangladesh

[6] Marine Station, Bangladesh Fisheries Research Institute, Cox's Bazar, Bangladesh

Published online: 05 March 2024

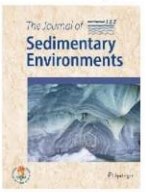
Appendix 9(C): **Journal Articles from this Project** [Article-iv]

[Article Under Review]

Microplastics pollution in water and sediment matrices of the Old Brahmaputra River, Bangladesh: An ecological risk appraisal of an urban river

Md. Mahmudunnabi Mithu[1,2], Kaniz Fatema[3], Fahmida Zaman[1], Wahida Anonna[1], Nayan Jyoti Roy Kanok[1], Tabassum Zannat[1], M. A. Mamun Siddiquee[1], Yogeeta Dahal[4], Rajdeep Dutta[5], Kizar Ahmed Sumon[1], Md. Shah Alam[6], Harunur Rashid[1]

Harunur Rashid
rashid@bau.edu.bd



Abstract

This study aims to quantify spatiotemporal distributions of microplastics (MPs) in the surface water and sediment matrices of the Old Brahmaputra River (Bangladesh), an urban yet ecologically and environmentally important ecosystem, in South Asia, and to appraise the ecological risk of it. The average abundances of MPs in the surface water and sediment were higher in winter (water: 4125609 items/km², sediment: 369 items/kg) than in early monsoon (water: 249742 items/km², sediment: 144 items/kg) and post-monsoon (water: 2344231 items/km², sediment: 292 items/kg). The two-way ANOVA test result showed a significant interaction effect between season and station ($p < 0.05$). The effect of season on abundance variation is more pronounced than that of station. The most common type of MPs found across the three seasons both in water and sediment were line (37-88%), and fragment (9-50%). Blue, red, and black were predominant among 12 other colors. Polypropylene was reported to be the most dominant polymer type both in water and sediment. The overall (covering all seasons) PLI by both surface water (PLI value: 5.14) and sediment (PLI value: 5.55) for the Old Brahmaputra River (municipal area) was at a low-risk level (PLI <10), representing that the MPs had not polluted this ecosystem severely, and in good agreement with each other. This study provides the authority concerned with new insights for evolving strategies to reduce the pollution load, given the ecological importance of the ecosystem as PLI does determine only the degree of contamination nor the toxicity of MPs on aquatic organisms and the associated risk to human health.

Keywords Microplastic; Spatiotemporal occurrence; Urban river; Ecological risk assessment; South Asia

Author contributions MMM: sample collection and analyses, data analysis, writing–original draft preparation, writing–review, and editing. KF: resources, writing–original draft preparation, writing–review, and editing. FZ: sample collection and analyses. WA: sample collection and analyses. NJRK: sample collection and technical support. TZ: sample collection and technical support. MAMS: sample collection and technical support. KAS: resources, supervision, writing–review, and editing. MSA: resources, supervision, writing- review, and editing. HR: conceptualization, supervision, writing–review, and editing. All the authors ratified the best version of the manuscript.

Appendix 9(D):

List of Master Degree Thesis Awarded from this Project

Sl.	Thesis Title	Student Name	Year Awarded
List of MSc Thesis Produced from the Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh			
1	Hemato-biochemical investigations of *Clarias batrachus* exposed to microplastics	Shema Biswas	2022
2	Histopathological changes in internal organs of microplastics-ingested walking catfish	Tasnia Islam Auditi	2022
3	Accumulation of microplastics in the sediments of the Old Brahmaputra River	Wahida Anonna	2023
4	Quantification of microplastics from surface water of the Old Brahmaputra River	Fahmida Zaman	2023
5	A cross-sectional analysis of microplastics exposure risks among locals from consuming fish sourced from the River Jamuna, Bangladesh	Mehzabin Hassan	2024
6	Occurrence, spatial distribution and characterization of microplastics in the surface water and sediment of the River Jamuna, Bangladesh	Sukumar Chandra Das	2024
7	Comparative analysis of microplastics pollution from urban and rural sources in water and sediments of the Old Brahmaputra River	Tabasum Zannat	2025
8	Toxicity of Microplastics in the Freshwater Pearl Mussel: Growth, Hemato-Biochemical and Bioaccumulation Responses	Rubya Binte Rezanur	2025 (thesis submitted in Oct.)
9	Quantification and Characterization of Microplastics from Fishes in the Jamuna River	Jharna Rani Paul	2025 (thesis submitted in Oct.)
10	Microplastics contaminations in fish and aquatic food chain along the Brahmaputra-Jamuna river	Md. Mahmudunnabi Mithu	2026*
List of MSc Thesis Produced from the Department of Aquatic Environment Management, Assam Agricultural University, Assam, India			
11	Study on occurrence of microplastics in some small indigenous fish species of River Brahmaputra, Assam	Papiya Debnath	2025

**PhD thesis due to be submitted in March 2026*

Appendix 9(E):

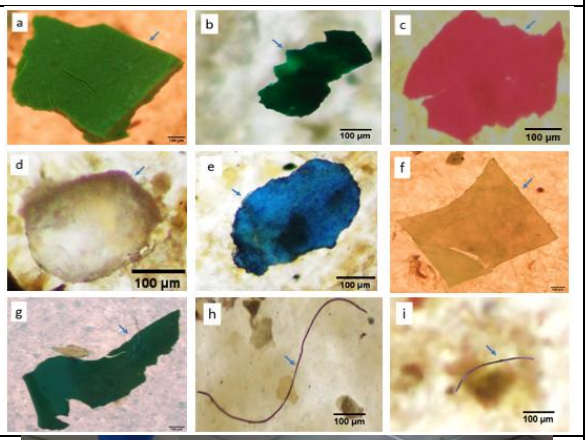
Conference/Seminar Presentations from the Project

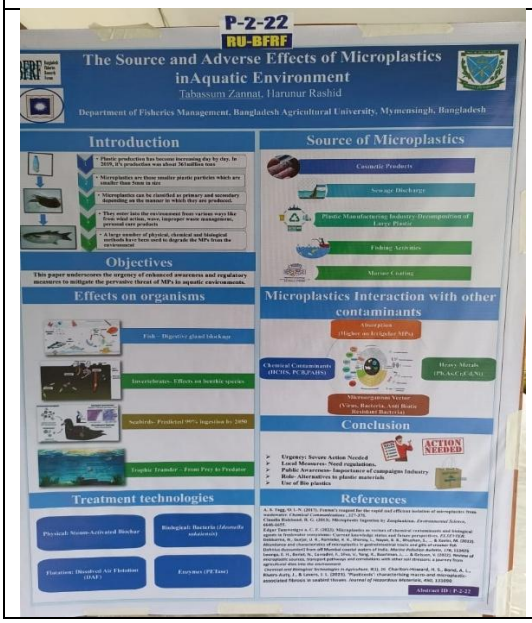
Title of ppt	Authors/Attendees	Conference/Seminar	Year, Month, Date
Spatiotemporal Distribution and Characterization of Microplastic Pollution in the Old Brahmaputra River near Mymensingh City Corporation, Bangladesh	Md. Mahmudunnabi Mithu, Nayan Jyoti Roy Kanok, Fahmida Zaman, Wahida Anonna, Tabassum Zannat, M. A. Mamun Siddiquee, Kizar Ahmed Sumon, Md. Shah Alam, Harunur Rashid	International Fisheries and aquaculture Conference, jointly Organized by Faculty of Fisheries, University of Rajshahi and Bangladesh Fisheries Research Forum (BFRF) https://csa.ru.ac.bd/bfrf/	8-9 June 2024
The source and adverse effects of microplastics in aquatic environment	Tabasum Zannat, Harunur Rashid	International Fisheries and aquaculture Conference, jointly Organized by Faculty of Fisheries, University of Rajshahi and Bangladesh Fisheries Research Forum (BFRF) https://csa.ru.ac.bd/bfrf/	8-9 June 2024
Occurrence of microplastics in fish from Upper and Lower stretches of River Brahmaputra: A comparative study	Sanayaima Singha, Papiya Debnath, Silpisikha Deka and Rajdeep Dutta	Advances in environment management for sustainable fisheries and livestock production – organized by College of Fisheries, Kishanganj, Bihar Animal Sciences University, Bihar, India. https://basu.org.in/wp-content/uploads/2024/05/Seminar-Brochure-22.05.2024.pdf	18-19 November 2024
Assessment of Microplastic Bioaccumulation and Trophic Transfer in Snow Trout via Algae and Surface water in Dagachu and Baychhu rivers	Nima, Yogeeta Dahal	A Symposium on 'Connecting Waste Research with Waste Work: Bhutan's Path to Evidence-Based Waste Solutions' organized by Bhutan Ecological Society & the PLEASE Project, Thimphu, Bhutan https://please-project.org/story/bes-	24 March 2025

		connecting-waste-research-with-waste-work-bhutans-path-to-evidence-based-waste-solutions/	
Transboundary microplastic contamination in Fish and Aquatic Food chain along Brahmaputra River	Yogeeta Dahal	National Conference on 'Climate Crisis, Natural Disasters, Environmental Sustainability, Agriculture and Food', College of Natural Resources and the Department of the Academic and Research Services, Royal University of Bhutan, Bhutan https://www.cnr.edu.bt/wp-content/uploads/2025/07/NationalConference-Proceedings-Connecting-Practitioners-Researchers-March-25-272025.pdf	25-27 March 2025
Comparative analysis of microplastics pollution from urban and rural sources of the Old Brahmaputra River along Mymensingh District of Bangladesh	Tabasum Zannat, Md. Mahmudunnabi Mithu, Md. Al-Amin Shadik, Rubya Binte Rezanur, M A Mamun Siddique, Kizar Ahmed Sumon, Harunur Rashid	1st International Scientific Conference on Sustainable Aquaculture and Fisheries, organized by Faculty of Fisheries, CVASU, Chattjogram-4225, Bangladesh https://www.bssnews.net/district/267423	29-30 April 2025
Occurrence, spatial distribution and characterization of microplastics in the surface water and sediment of the Brahmaputra-Jamuna River, Bangladesh.	Md. Mahmudunnabi Mithu, Sukumar Chandra Das, Kizar Ahmed Sumon, Md. Shah Alam, Harunur Rashid	1st International Scientific Conference on Sustainable Aquaculture and Fisheries, organized by Faculty of Fisheries, CVASU, Chattjogram-4225, Bangladesh https://www.bssnews.net/district/267423	29-30 April 2025
'Microplastics pollution in the Bay of Bengal - a call for regional policy frameworks and transboundary collaboration'	Harunur Rashid	The International Conference on Climate Change and Agriculture in Tropical Latitudes (CCATL 2025), Colombo, Sri Lanka. https://ccatl.tiikm.com/	5-6 May 2025

Appendix 9(F): **Few Snaps of the Project Activities**


National Conference
Connecting Practitioners & Researchers
Royal University of Bhutan
25-27 March 2025
Thematic Areas: Climate Crisis, Natural Disaster, Environmental Sustainability, Agriculture & Food
CONVENTION HALL


a
b
c
d
e
f
g
h
i
100 µm


P-Z-22
RU-BFRF
The Source and Adverse Effects of Microplastics inAquatic Environment
Tabassum Zannat, Harunur Rashid
Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh
Introduction
Source of Microplastics
Objectives
Effects on organisms
Microplastics Interaction with other contaminants
Conclusion
ACTION NEEDED
Treatment technologies
References


CVASU FISH
FESTIVAL 2025


MICROPLASTICS POLLUTION IN THE BAY OF BENGAL –
A CALL FOR REGIONAL POLICY FRAMEWORKS AND
TRANSBOUNDARY COLLABORATION


bhutanecologicalsociety
PLEASE Project Waste Symposium
Blue microplastics are the most common in Dangchu and Baychu Rivers, found in 32.41% of algae, 30.21% of surface water, and 40.11% of snow trout. This highlights the urgent need to address microplastic pollution at its source.
NIMA
Student
BSc Environment and Climate Studies
College of Natural Resources
Royal University of Bhutan
PLEASE Project
UNOPS
THE WORLD BANK