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Liya, Zahra Alam

School of Business and Entrepreneurship, Independent University, Bangladesh (IUB)

Presence & Distribution of Microplastics in the Sediment of The Four Major Rivers in Bangladesh

Zahra Alam Liya[1], Jerin Tasnim[2], Raiyan Ahmed[3], Esfar Ahmed Aditiya[4], Md. Abdul Khaleque*
Department of Environmental Science and Management, Independent University, Bangladesh (IUB) Dhaka, Bangladesh
*Corresponding author: akhaleque@iub.edu.bd
[1]zahraalamliya29@gmail.com, [2]sabatasnim08@gmail.com, [3]ahmedraiyan010@gmail.com, [4]adittyaesfar@gmail.com

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Abstract- **Microplastic is considered a threat to the aquatic environment. This study analyzed the presence and distribution of microplastics in four major rivers- Padma, Meghna, Jamuna, and Old Brahmaputra in Bangladesh, using stereomicroscope and ATR-FTIR analysis. For each river, three districts were chosen, and a total of 36 samples (3 for each location) were collected and analyzed. The result revealed that the Meghna River has the highest level of microplastic contamination, showing 185±27 particles. Across all locations, fibers were more dominant microplastics than fragments, foam, film, and nurdles. Nearly eleven different colors and five types of microplastics were identified, where dark blue was the dominant one. Polyethylene, polypropylene, polystyrene, polycarbonate, polyethylene terephthalate, and cellulose acetate were identified, where polypropylene was the most abundant. The findings of this research will serve as baseline data for future studies aimed at understanding the potential consequences of microplastics and measures to mitigate them.**

Keywords- **Bangladesh, Major Rivers, Microplastics, River Sediment.**

I. INTRODUCTION

Plastics are inexpensive, lightweight, durable, long-lasting, and corrosion-resistant synthetic or semi-synthetic organic polymers [1]. This benefit has resulted in the usage of plastic in several applications, including home and personal items, apparel, packaging, and building materials [2]. Bangladesh, a developing country with a rapidly growing population, is facing numerous challenges in plastic waste management. It was ranked 10th out of the world's 20 most poorly managed countries for producing plastic garbage in 2010 [3]. Every year, Bangladesh produces 800,000 tons of garbage, of which 200,000 tons originate from plastics [4]. Although plastic is widely used due to its durability and cost-effectiveness, its slow decomposition rate and tendency to fragment into microplastics pose a long-term environmental threat [1].

Microplastics, which are small particles that measure less than 5 mm in diameter, are found everywhere - rivers, oceans, and soil (Arthur et al., 2009). As of now, an estimated 4.85 trillion microplastic (MP) particles are present in the global ocean, with up to 80% thought to have originated from river systems [5]. MPs are found in rivers, lakes, and oceans worldwide and build up in sediments due to properties including buoyancy and exceptional durability [6]. Microplastics have negative impacts on the environment and especially on marine life. They are often taken up by fish that mistake them for food and can bioaccumulate in the food chain since these are non-biodegradable. MPs also have various effects on the human body, such as inflammation, developmental and reproductive toxicity, and disrupting the immune system [7].

II. METHODOLOGY

Samples were collected from the riverbanks of four rivers - Padma, Meghna, Jamuna, and Brahmaputra in January 2025. Each river has three location points for collection, with three samples taken at each point for accuracy. Sediment samples were collected, with a combined weight of approximately 9 kg, while maintaining a distance of 10 meters. The sediment samples were collected with the Grab Sampling method with a range of 0-15 cm from the surface using a stainless steel spoon and zip lock bag and immediately transferred to an icebox for cold storage before being transported to the lab, where it was kept in the freezer at 4°C. The samples were later taken out and kept at room temperature before transferring 100 g of sample into a beaker and heating it in the oven for 48 hours at 90°C.

Samples were primarily treated following the method suggested by the National Oceanic and Atmospheric Administration with some modifications. For pretreatment of sediment samples, 100 gm. of dry sediment was weighed, and 30 mL of hydrogen peroxide solution (30%, v/v) was used to eliminate visible organisms from the samples, where 20 mL of 0.05M Fe (II) solution (prepared by adding 7.5 gm. of $FeSO_4.7H_2O$ to 500 mL of water and 3 mL of concentrated sulfuric acid) was added to work as a catalyst [8]. Then, the beaker was placed on a hotplate and heated to 60° Celsius for 20 minutes and stirred continuously using a magnetic stir

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bar. For the density separation process, 36 g of NaCl was added for each 100 ml volume of the solution. The solution was heated for another 20 minutes at 60° Celsius to ensure thorough mixing of NaCl. Then it was covered with aluminum foil and allowed the solids to settle for 24-72 hours. The supernatant of the samples was filtered through a pair of sieves stacked with pore sizes of 5 mm and 0.045 mm. Finally, it was filtered through a Nylon 6, 6 membrane filter with a pore size of 0.45 micrometers, fitted with a water-filtration vacuum pump, and allowed to dry for a while. The dried filter was placed in the petri dish and covered for further analysis.

Study Area

Sediment samples were collected from twelve strategically selected sites along the rivers in Bangladesh to assess spatial variation in sediment characteristics. The selected sites represent three distinct sections of the river:

These sites were chosen based on their geographical locations along the river's course and were selected to provide a comprehensive understanding of sediment composition across varying hydrodynamic conditions. Sampling areas were carefully selected to avoid locations impacted by recent dredging activities, as dredging can alter sediment composition and interfere with analytical accuracy. Agricultural or residential areas were mostly considered to provide a distinct value as well as better relevancy to the effects on human activities and broader environmental health in non-industrial settings. This approach aimed to fill existing knowledge gaps and ensure the study’s findings are both relevant and applicable to public well-being. The coordinates were collected using a GIS tool, and later converted into a map using ArcGIS and Google Earth.

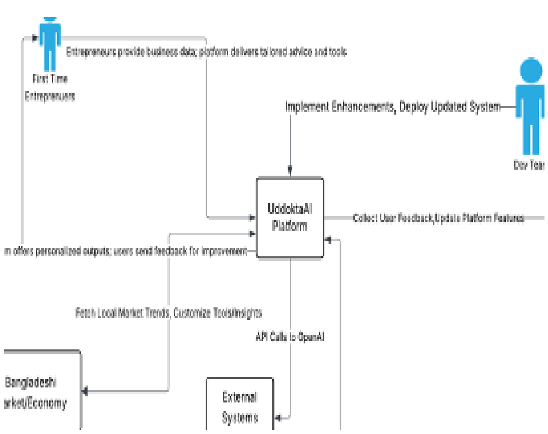

Figure 1: Map of Sampling Locations of Different Rivers

Microscopic Analysis

All the filter papers were examined under a LEICA EZ4E stereomicroscope with a range of 12X to 35X magnification. Microplastics were identified based on their physical characteristics, such as color and shape. A few things were taken into consideration, such as uniform color, no cellular structure, and non-brittle texture to distinguish microplastics from any organic matter or minerals. A careful observation had been performed, and pictures of identified microplastics were taken by software named LAS EZ.

Polymer Type Identification

Using Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) Spectroscopy (Frontier, Perkin-Elmer, UK; Software: Spectrum version 10.4.4), the polymer types of MPs were determined. Comparatively bigger particles from representative MPs samples of each morphotype were chosen from each location. ATR-mode FT-IR spectra were recorded on a diamond crystal. Each measurement began with a background scan and acetone diamond crystal polishing. With 16 scans per spectrum, spectra were captured at 4 cm^{-1} resolution from 650 to 4000 cm^{-1}. Peak values from each spectrum were compared to a paper-based reference spectra library to verify polymer types in the samples [2].

III. RESULT & DISCUSSION

The highest number of microplastics was detected in the samples of the Meghna River, with 111±1.4 particles per 100 g and an average of 37 MPs per 100 g. Fibers were the most prevalent type of MP across all sites. Rajshahi raises questions about localized MP sources. Potential contributors may include agricultural runoff, where degraded plastic mulch and packaging are common, and localized waste mismanagement. Additionally, the hydrodynamic properties of fragments, which allow them to persist in sediments, might explain their high detection rates in this region. The prevalence of fibers could be attributed to urban activities and greater population density, which increase the influx of fibers into the river system [9]. Additionally, the presence of black chemical additives can significantly alter the spectral properties, further complicating their identification.

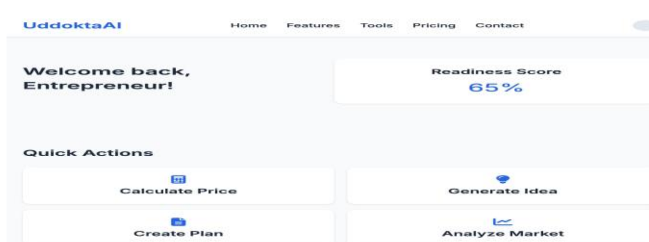

Figure 2: Microscopic images of microplastics from different locations. Particles were grouped into 5 categories:

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microfilm (a), fiber (b, f, h), fragment (d, e), foam (c), and nurdle (g).

- *Microplastic Abundance*

The comparative study on microplastic abundance across the four major rivers Padma, Meghna, Jamuna, and Brahmaputra demonstrated significant spatial differences, with downstream areas exhibiting the highest levels of pollution. The microplastic amounts listed were derived from an average of 100 grams of sediment per sample. The Meghna River has the highest level of microplastics overall (185±27 particles, where ± refers to the standard deviation), followed by the downstream location Lakhsmipur having the most (87±58 particles), which is almost twice as much as the upstream site Chandpur (42±4 particles) and more compared to Brahmanbaria (56±22 particles).Manikganj, which is downstream from the Jamuna River, had the most microplastics (50±14) out of 130±4 total particles. Sirajganj had 41±17 particles, and Bogura had 39±10 particles per 100 g.The Old Brahmaputra River contained 97±13 microplastic particles. The downstream location, Kishoreganj, had the greatest amount (41±3 particles), followed by Mymensingh (29±1 particles) and Jamalpur (27±12 particles).Among the four rivers, the Padma River had the fewest total particles (95±22). However, Munshiganj, which is located in the middle portion of the river, had the highest area concentration (36±1.4 particles), more than Daulatdia (27±0.7 particles) and Rajshahi (32±22 particles). It also indicates that microplastics are building up more along the river's course, which is a sign that contaminants are moving downstream and accumulating.

Microplastic Morphotypes

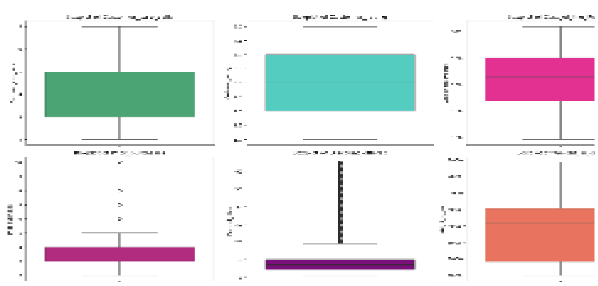

Figure 3: Spatial Distribution of Microplastics along Four Major Rivers in Bangladesh

Fibers were always the most common type of particle at all the locations, with 10–58 particles per site. Fragments were next, while foams, nurdles, and microfilms were less common. The numbers demonstrate that microplastic accumulation increases downstream, indicating the overall transfer of contaminants from upstream areas. Furthermore, variability across rivers reveals that the overall quantity of microplastics is affected by the measurement of the river, the way the water flows, and the amount of water that comes into the river. For example, the Meghna River is bigger and has a greater total quantity and more prominent downstream collections.

- Microplastic color

The four rivers have different colors of microplastics. The Meghna, the Jamuna, and the old Brahmaputra rivers consistently contained an abundance of dark blue and black particles. The two colors made up a major share of the entire microplastics.

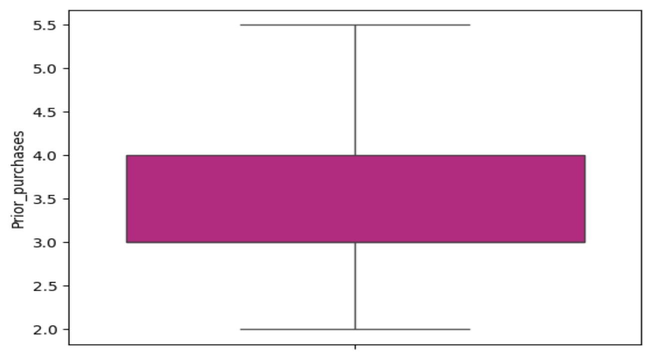

Figure 4: Color Distribution of Microplastics in Four Major Rivers

On the other hand, the Padma River had a larger number of dark blue and red microplastics, which shows that the distribution pattern was distinct from the other rivers. For the majority of parts, lighter colors like light blue, yellow, white, transparent, and orange were less prevalent across all rivers. Other colors, including green, grey, purple, and brown, were more abundant.

Microplastic Polymers

In this study, we identified and characterized a total of 6 types of polymers from 48 microplastic particles using ATR FT-IR spectrophotometry, selecting 12 from each river. These are namely polyethylene (PE), polypropylene (PP), polystyrene (PS), polycarbonate (PC), polyethylene terephthalate (PET), and cellulose acetate (CA). PE, PP, and PS were commonly found in all the rivers in varied percentages; particularly PET (2.1%) was found in the Jamuna River, PC (2.1%) was found in the Padma and Old Brahmaputra rivers, and CA (2.1%) was found in the Meghna. Overall, the most prevalent polymer was 48.5% PP, with PE (31.3%) and PS (14.6%) following in that order for the combined rivers. PE, followed by PP, PET, and PS, respectively, were previously found to be the predominant types of plastic polymers found in the sediment of the Ganga River Basin [10]. The polymers like PET, PP, and PS were also identified in the lower Brahmaputra River [11].

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IV. CONCLUSION

The results of this study indicated considerable occurrence of microplastics (MPs) at every station along all rivers, with an average concentration of 84, predominantly in fiber shape, blue in color, and mostly composed of polypropylene. It also gives a strong indication of an increased potential application in consumer products, plastic packaging, containers, textiles, ropes, bottle caps, food containers, and the straight-up disposal of plastic waste in waterways [12]. Moreover, the consistently highest levels of contamination in downstream accumulation zones reveal the interconnectedness of riverine systems, local human activities, and environmental factors such as rainfall, water discharge, velocity, and depth. The majority of the MPs that have been identified are colored, which is a concern due to their resemblance to marine organisms' prey, which highlights that they have a land-based origin [13]. Despite the ban on single-use plastics in Bangladesh, the significant level of microplastics in the rivers suggests noncompliance and a lack of effort to manage plastic waste, which violates existing policies and regulations. The present data will support the authorities in Bangladesh in taking action against plastic and microplastic pollution by implementing laws and regulations while also enabling research into the effects on aquatic life and habitats, ultimately impacting human health and improving approaches to address the problem.

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