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MICROPLASTIC CONTAMINATION IN FISH AND SURFACE WATER FROM DHALESHWARI RIVER, DHAKA, BANGLADESH

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Abstract: Microplastic (MP) particles, widely acknowledged emerging contaminants are increasingly recognized as a threat to aquatic ecosystems, fish, and human health. This study investigated the abundance and characteristics of MPs in surface water and freshwater fish from the Dhaleshwari River, Bangladesh. A total of 42 samples were analyzed, including surface water samples (n = 12 from each of four sites) and fish gastrointestinal tract samples (n = 30; five individuals from each of six species). Microplastics were isolated from water and fish samples using wet peroxide oxidation and potassium hydroxide digestion methods, respectively, and identified under a stereo microscope. MPs were found in all samples with abundances ranged from 0.09 to 0.21 items mL^{-1} in surface water and 1.6 to 4.2 items per fish species. There was no significant correlation between MPs ingestion and fish total length or body weight. Most of the MPs were fiber-shaped and tiny small (<1 mm). Fourier Transform Infrared Spectrophotometry (FT-IR) for polymer characterization identified polyethylene, nylon, and polystyrene as the major polymer types present in the river system. These findings revealed widespread MP contamination in the Dhaleshwari River and emphasize the need for further investigation to assess the impacts of microplastics on water quality, fish health, ecosystem functioning, and potential risks to human health.

Key words: MPs, Dhaleshwari River, bioavailability, fish, surface water, ecosystem.

INTRODUCTION

Microplastics (MPs) are plastic particles less than 5 mm in size, are already common pollutants in aquatic habitats and poses serious risk to human health and the environment because of their potential toxicity, persistence, and global distribution (Kutralam-Muniasamy *et al.,* 2025). Widespread plastic manufacture, inappropriate waste management, and the breakdown of bigger plastic debris have made MPs as the most prevalent contaminants in aquatic habitats across the world, including rivers, lakes, reservoirs, and oceans (Li *et al.,* 2023; Vethaak & Legler, 2021). Freshwater ecosystems are especially important as they

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serve both as sinks and transport pathways for MPs from terrestrial sources to marine systems (Blettler *et al.,* 2018). According to recent research, waterways in heavily inhabited and industrialized areas have higher levels of microplastics. Important sources include urban discharge; industrial effluents, wastewater treatment outflows, and textile manufacture are the main causes for these levels (Windsor *et al.,* 2019). Asia has become a global hotspot for freshwater microplastic pollution due to its fast urbanization, dense population, and poor waste management infrastructure (Kutralam-Muniasamy *et al.,* 2020). In Bangladesh, there are serious problems with plastic pollution, but a little is known about MPs contamination in its freshwater systems. MPs can be consumed directly from water or indirectly through prey items, making fish one of the most influenced aquatic organism (Lusher *et al.,* 2017). Numerous researches have documented MPs in the gastrointestinal tracts of freshwater and marine fish, with the most common shapes as fibers and fragments (Akhbarizadeh *et al.,* 2018; Barboza *et al.,* 2020). Polymer types such as polystyrene (PS), polyethylene (PE), polyvinyl chloride (PVC), and nylon are commonly found and are known to contain toxic additives or adsorb environmental contaminants (Rochman *et al.,* 2013).

Particularly in areas where fish constitute a major source of protein, the presence of MPs in fish poses high health hazards to the general public. MPs can act as vectors, allowing heavy metals, persistent organic pollutants, and dangerous microorganisms to enter the human food chain (Smith *et al.,* 2018; Revel *et al.,* 2018). Experimental and epidemiological investigations suggest that exposure to MPs may induce oxidative stress, inflammation, endocrine disruption, and other adverse effects to human health (Vethaak & Leslie, 2016; Wright & Kelly, 2017). According to recent estimates, fish and shellfish are substantial contributors to the thousands of microplastic particles that humans may consume each year through their diet and drinking water (Cox *et al.,* 2019).

The Dhaleshwari River, one of main distributaries of the Jamuna River flowing adjacent to Dhaka city, is heavily polluted by industrial discharge, home sewage, and urban runoff. There is insufficient systematic data regarding MP contamination in the Dhaleshwari River and its biota, in spite of its ecological and social significance. As the local residents depend on riverine fish for food, assessment of MP pollution in fish and surface water is necessary to minimize potential ecological and health hazards to humans.

Thus, the purpose of this study is to examine the quantity, properties, and polymer makeup of microplastics in fish and surface water from the Dhaleshwari River in Dhaka, Bangladesh. The findings will add to the expanding body of knowledge on freshwater microplastic pollution and provide essential baseline data for environmental management, food safety assessment, and public health protection in Bangladesh.

MATERIAL AND METHODS

Study Area: Water and fish samples were collected from four locations of the Dhaleshwari River (Fig.1).

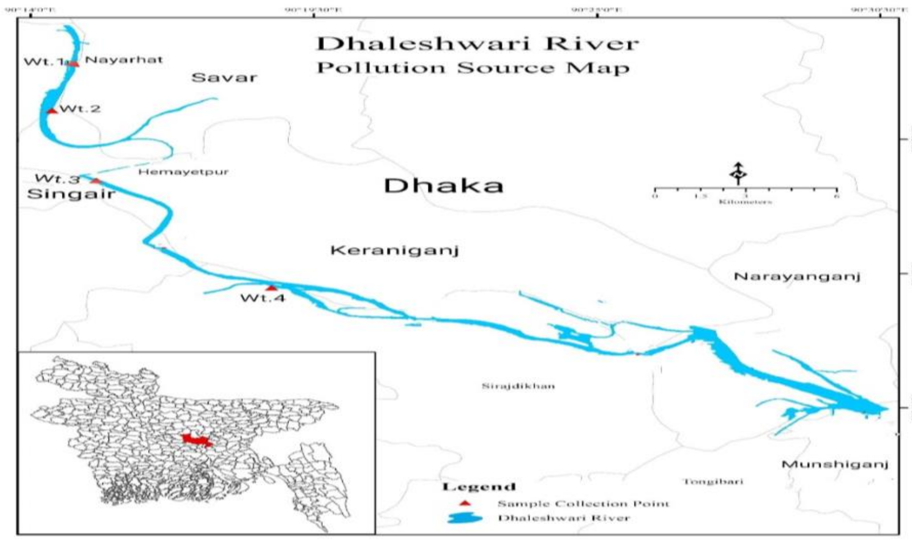

Fig.1. Map showing sampling spots of Dhaleshwari River.

Water sample collection: Twelve water samples (three from each of four locations) were collected along the Dhaleshwari River between December 2021 and June 2022. Samples were taken at a depth of 20 cm using 45μm plankton net, filtered through a 50 mm stainless steel sieve, and the retained material was rinsed, stored in 50 ml glass bottles, and preserved at 4°C until analysis. All equipment was cleaned with distilled water prior to sampling.

Fish sample collection: A total of 30 fish samples (five individuals from each of six species: Punti, Bacha, Chapila, Kakila, Tara Baim, and Foli) were collected monthly from local fishermen along the Dhaleshwari River. Only healthy species were selected. After collection, the fish were brought to the laboratory and preserved at 4°C.

Isolation of MPs from water sample: MPs in water were analyzed following (Nuelle *et al.,* 2014). A 100 ml water sample was sieved (2mm), treated with 30% H_2O_2 for organic matter digestion, incubated in the dark for three days on a rotator, and finally filtered using a 0.45μm Whatman glass microfiber filter

Isolation of MPs from fish samples: MPs in fish were analyzed following protocols (Daniel *et al.,* 2020; Dehaut *et al.,* 2016; Thanaka & Takada 2016; & Hossain *et al.,* 2019). Fish length and weight were measured prior to dissection. Soft tissues and gut contents were digested in 10% KOH at 40°C for five days, then passed through a 0.45μm Whatman glass microfiber filter and viewed microscopically

MPs observation & characterization: MPs retained on the filters were examined under a stereo microscope, photographed, and measured using ImageJ software. Particles were categorized according to their shape (fiber, fragment, foam, film, pellet), color, and size (<0.5mm, 0.5–1mm, and 1–5mm), and their abundance and characteristics were recorded for each sample.

Fourier Transform Infrared Spectrophotometer (FTIR) analysis: Using a Fourier Transform Infrared (FT-IR) spectrophotometer (SHIMADZU, IR Tracer-100, Japan), a randomly chosen subset of typical MPs was analyzed to determine polymer composition. After MPs were combined with KBr crystals to create KBr pellets, FT-IR spectra were acquired in transmission mode across a wavenumber spanning of 400–4000 cm^{-1} (Jabeen *et al.,* 2017; Tanaka & Takada, 2016). Polymer types were identified by comparing absorption bands with the SpectraBase™ database and verified using published literature (Jung *et al.,* 2018).

Quality Assurance and Quality Control: All MP samples were processed using sterile glassware and metal tools under a sanitized bench while wearing personal protective equipment. To avoid contamination, samples were stored in covered Petri dishes, all glassware and instruments were cleaned three times with distilled water, and all liquids were filtered through a Whatman GF/B glass microfibre filter. After creating blank controls, samples were cleaned of externally adhered plastics using distilled water free of MPs (Hossain *et al.,* 2020).

Statistical analysis: MPs in water and fish samples were quantified using Microsoft Office Excel 2010. MP abundance in water was expressed as items mL^{-1}, while fish samples were reported as mean items per species (n = 5) and items per gram of body weight. Results were presented as mean ± SD, and correlation analysis was performed to examine relationships between MP load and fish body weight and length, with significance set at $p<0.01$.

RESULTS AND DISCUSSION

Abundance of MPs in water samples: The study on MPs in the Dhaleshwari River showed varying levels of MPs abundance at four different spots. The concentration ranged from 0.06 ± 0.03 to 0.18 ± 0.03 MPs per milliliter (ml), with an average of 0.11 ± 0.05 MP/ml. The distribution of MPs was highest at Wt.1, followed by Wt.2, Wt.4, and lowest at Wt.3 (Fig.2&3). This indicates uneven distribution of MPs across the river. The MPs contamination was considerably higher in the Wt.1 region whereas significantly lower in the Wt.3 zone. The higher MPs levels in Wt.1 may be attributed to nearby dense residential, industrial and commercial areas. Furthermore, abandoned fishing nets, baskets, polythene bags, ropes, and floats along the riverbank, likely from fishermen, could contribute to the high prevalence of MPs in this region.

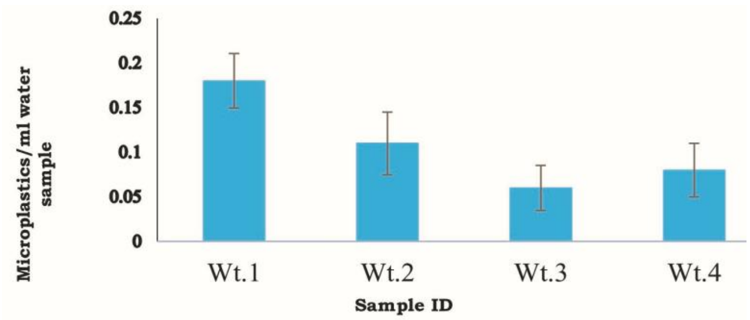

Fig. 2. MPs abundance in water form Dhalshwari River.

An investigation conducted recently by (Hossain *et al.,* 2022) revealed the abundance and distribution of MPs in the Jamuna and Turag rivers. They found a mean microplastic abundance of 16.11 ± 2.22 particles per 100 L in the surface water of the Jamuna River, while a comparatively higher abundance of 29.00 ± 10.68 particles per 100 L was observed in the Turag River. These findings are in concordance with the results of the current study.

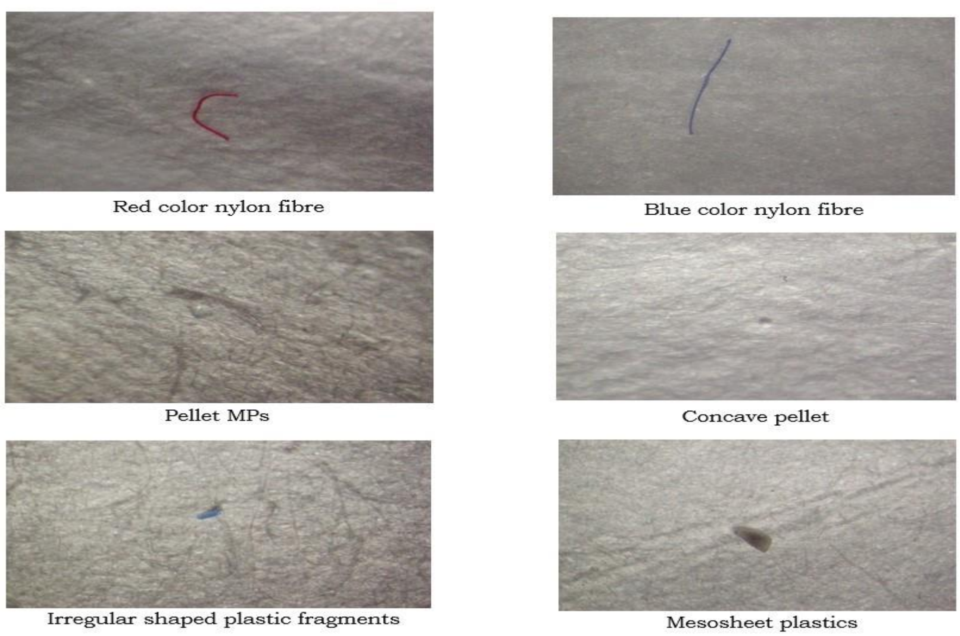

Fig.3. MPs visualization by stereo microscope in water samples of Dhaleshwari River.

Our results for the river are very different from a previous study on the Karnafully River since the Dhaleshwari River is located in a more polluted area because of its near proximity to urban and industrial sectors (Hossain *et al.,* 2022). This study highlights the need for more research on MPs pollution because present levels are higher than those seen in previous studies, indicating an increasing trend.

Abundance of MPs in fish gut: A total of 6 fish species from the Dhaleshwari River, representing six families, were studied for MP presence. MPs were found in all species. A total of 76 MPs were isolated from the gastrointestinal tracts of 30 fish samples, with an abundance ranging from 1.6 to 4.2 MPs per species. The number of MPs found in pooled samples for each species were as follows: *Puntius ticto* (1.8 ± 0.84), *Eutropiichthys vacha* (4.2 ± 1.48), *Gudusia chapra* (3.0 ± 1.00), *Xenontodon cancila* (2.2 ± 1.64), *Macrognathus aculeatus* (2.4 ± 1.14), and *Notopterus notopterus* (1.6 ± 0.55). MPs uptake was found the highest in Fs.2 (*Eutropiichthys vacha*) and the lowest in Fs.6 (*Notopterus notopterus*) which can be seen from the following Fig. 4 & 5.

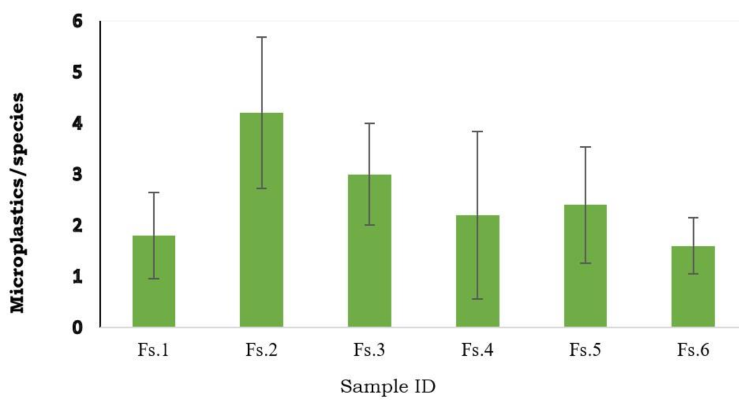

Fig. 4. MPs abundance in fish from Dhaleshwari River.

According to the study, freshwater fish are particularly vulnerable to MPs pollution in river water, and their uptake is a major cause for concern. Compared to earlier studies, the MPs uptake rate is relatively greater. A recent study on a number of freshwater fishes in Bangladesh (Parvin *et al.,* 2021) found 0.5–9 MPs items/species in fish GIT, which is comparable to our findings. These variations could be brought on by different concentrations of MPs pollution in the environment. MPs significantly contaminate the food webs in urban waterways (McNeish *et al.,* 2018). Freshwater fish consumption of MPs is now a global phenomenon, and some authors have backed up the theories that plastic granules can be mistaken for prey and inadvertently consumed (because they may resemble prey in shape and form) or even eaten directly from prey species that are already contaminated with the dangerous MPs pollutants (Lusher *et al.,* 2015; & Ory *et al.,* 2017).

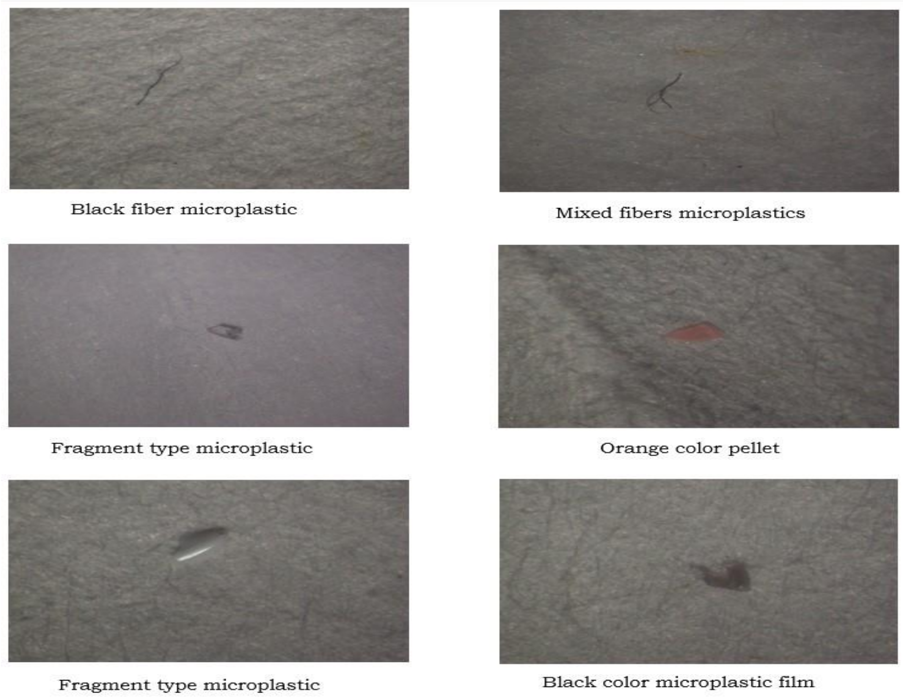

Fig. 5.Microplastic types by stero microscope in fish samples from the Dhaleshwari River.

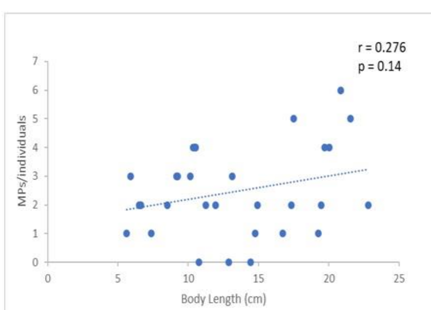

Fig. 6. Correlation of fish body length with MPs abundance in fish species.

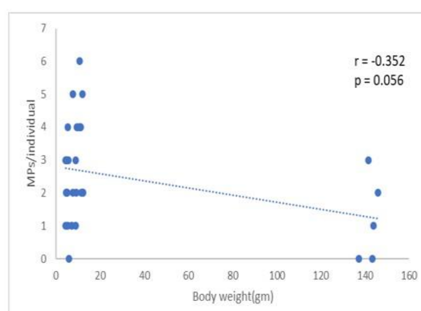

Fig.7. Correlation of fish body weight with MPs abundance in fish species.

Fish body length, weight and MPs abundance: Consumption of MPs by fish and fish length/body weight had been proved to be significantly positively correlated in several earlier investigations (Hossain *et al.* 2019). In this study, we investigated whether MP consumption of fish increases with body weight and length. However, fish body length and MP abundance did not significantly

correlate (R = 0.276, p = 0.14) (Fig.6). A negative association (r = -0.352, p = 0.056) was observed when we looked at the relationship between body weight and MP abundance (Fig.7), but it was not statistically significant (p>0.05).
In this study, we looked into whether fish consumption of MPs rises with length and body weight. Fish body length and MPs abundance, however, did not significantly correlate. We also looked at the connection between body weight and the amount of MPs, and we found that there was a negative association. These results imply that fish consumption of MPs is more impacted by the amount of plastic pollution in their surroundings than by the fish's length or body weight. Carbery *et al.* (2018) came to a similar conclusion, suggesting that fish ingestion of MP is probably driven by environmental plastic levels. The tiny sample size of our study might have obscured any meaningful connections.

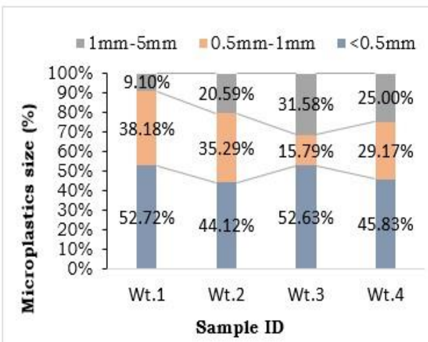

Fig.8. Comparison of MPs size in water samples from Dhaleshwari River.

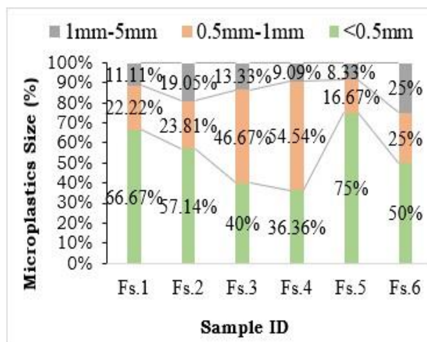

Fig.9. Comparison of MPs size in fish samples from Dhaleshwari River.

Comparison of MPs according to size in fish sample: In the Dhaleshwari River fish, MPs were found in a range of sizes with the majority (36.36% to 75%) falling into the 0.5 mm category. This is probably because larger particles break down into smaller ones. Similar findings were observed in freshwater fish (Parvin *et al.,* 2021) and fish from the northern Bay of Bengal (Hossain *et al.,* 2019; Siddique *et al.,* 2022), both of which had higher percentages of smaller MPs. MP percentages in the 0.5 mm–1 mm and 1 mm–5 mm categories varied from 16.67% to 54.54% and 8.33% to 25%, respectively (Fig.8). In this study, MP levels in fish were shown to be lowest in the 1–5 mm range, with smaller MPs (<1mm) predominating, especially in pelagic species. This pattern aligns with Suwartiningsih *et al.* (2020), who reported that low-density MPs remain on the water surface longer, increasing their ingestion by surface-feeding fish, while larger MPs tend to sink. The observed size distribution followed the order: <0.5 mm>0.5–1mm>1–5mm (Fig.9). Prior research has repeatedly documented significant levels of tiny fiber abundance in aquatic environments. For instance, Lin *et al.* (2018) and Jiang *et al.* (2019) discovered that most fibers in rivers were between 0.02 and 1mm. The Koshi, Seine, Nakdong, Ciwalengke, and Ganges rivers are among the rivers across the world where similar findings have been reported (Yang *et al.,* 2021; Alam *et al.,* 2019). In earlier research (Bessa *et al.,* 2018; Hastuti *et al.,* 2019; Suwartiningsih *et al.,* 2020), fibers were also found to be the predominant MP type in fish, probably because they resemble natural prey items (Hossain *et al.,* 2022).

Identification of MPs by FT-IR spectroscopy: The presence of the identified plastic particles was confirmed by analyzing their chemical makeup using Fourier Transform Infrared (FT-IR) spectroscopy.

Absorption peaks in the 400–4000 cm^{-1} infrared spectrum was indicative of the plastic polymer vibrations. FT-IR analysis was performed on representative water and fish samples, and the findings showed that the particle distribution in the two samples was the same. For FT-IR analysis, seven typical particles were extracted from water samples. After the analysis it was found that five were confirmed MPs. Among them, three were Nylon and two were Polystyrene (PS), one was non-plastic material and the remaining one was unidentified. In case of fish samples, 11 representatives were taken for analyzing chemical composition. Of them, 3 particles were identified as poly vinyl chloride (PVC), 5 particles were polystyrene (PS) and one particles were nylon. But the other two particles were unidentified (Fig.10).

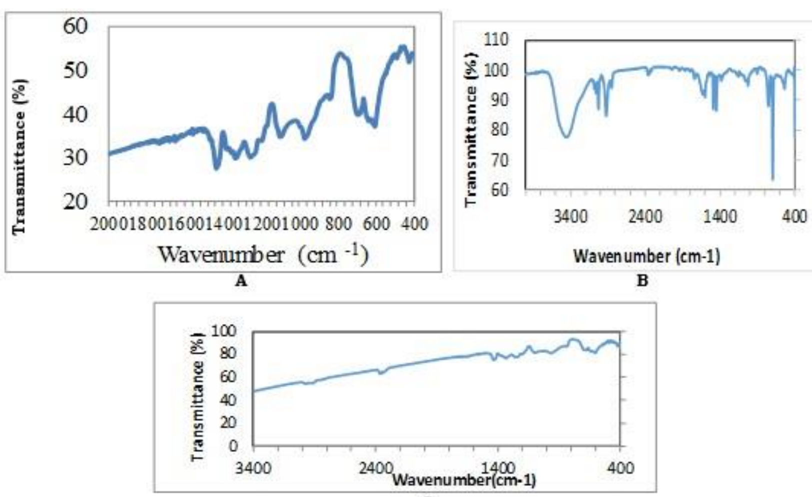

Fig. 10. FTIR spectra of the representative MPs found in water and fish samples from Dhaleshwari River. (A: poly vinyl chloride; B: polystyrine; C: Nylon).

CONCLUSION

This study confirms the occurrence of MP contamination in surface water and fish from the Dhaleshwari River highlighting increasing plastic pollution in this urban river system. MPs were detected in surface water at concentrations of 0.06 ± 0.03 to 0.18 ± 0.03 items mL^{-1} and in fish gastrointestinal tracts at 1.6–4.2 items per fish. Fibers and fragments smaller than 0.5mm were the dominant forms, with transparent particles being most common. The prevalent polymers identified were polystyrene (PS), nylon, and polyvinyl chloride (PVC), reflecting inputs from domestic, industrial, and textile-related activities. The presence of MPs in fish is a serious public health problem since these particles can contain viruses, heavy metals, and harmful chemicals that can enter the human food chain through fish intake. Expert evaluation of food safety and any hazards to human health is desperately needed, as local communities depend on riverine fish as their main source of protein. In order to reduce MP pollution and safeguard aquatic ecosystems and human health, the findings highlight the need for better waste management, increased plastic recycling, and the use of biodegradable alternatives, in addition to increased public awareness and concerted governmental initiatives.

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