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Microplastics occurrence in *Johnius dussumieri* (Doma) fish from Mahim bay, Mumbai, India

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Abstract

This study investigates the seasonal and spatial variations of microplastic contamination in the gut of *Johnius dussumieri* (Doma fish) at Mahim Beach and Worli Jetty across Pre-Monsoon, Monsoon, and Post-Monsoon seasons. Results indicate significant shifts in color and morphology of microplastics, with Black and Transparent particles being predominant. During the Monsoon season, there was a notable increase in fragments, attributed to higher runoff and water flow. Polymer analysis revealed a higher presence of PE (42.9% at Mahim, 58.8% at Worli) and Nylon (23.8% at Mahim, 11.8% at Worli) during the Monsoon. ANOVA results underscored the significant role of color ($p=0.004$), with interactions between location and color ($p=0.002$) and season and color ($p\approx0$). The Monsoon season recorded the highest microplastic contamination, emphasizing the impact of environmental changes. These findings highlight the need for improved waste management, public awareness, policy interventions, and ongoing monitoring to mitigate microplastic pollution in marine ecosystems.

Key words : Microplastics, *Johnius dussumieri,* Mahim bay Cosmetic, abrasives.

Microplastics (plastic particles < 5 mm) have become an alarming environmental issue worldwide because of their common existence and possible detrimental impact on ecosystems as well as human health[1,3,21,25]. Microplastics can originate through fragmentation from larger items of plastic debris and in the production of specific products, such as in cosmetic microbeads and industrial abrasives[4,30]. These particles have been reported in different environmental matrices, such as marine and freshwater bodies, soils and even in the atmosphere[16,28,33,41]. Owing to their small dimensions, these particles are persistent in the environment more easily bioavailable to organisms from all trophic levels thus focusing much attention for their accumulation and transfer through the food web[23,29]. The likelihood of marine microplastic pollution might increase in coastal areas since they are in the vicinity of the majority of urban areas and associations of plastic disposal on land[22,40]. Microplastics can harm marine life by causing ingestion, entanglement, and the transfer of chemical additives or absorbed pollutants to organisms[13].

Fishes, often at the top of aquatic food chains, are increasingly ingesting these microplastics, mistaking them for food[9,34]. This ingestion can lead to physical harm, such as internal abrasions and blockages, and may introduce harmful chemicals into the fishes' bodies[15,48]. These chemicals, often additives or pollutants absorbed by the plastics from the environment, can disrupt endocrine functions, reduce growth rates, and impair reproductive capabilities in fishes[6,42]. Additionally, the presence of microplastics in fishes poses a risk to human health, as these contaminants can transfer up the food chain, ultimately affecting seafood consumers[2,24]. The pervasive issue of microplastics in fishes highlights the urgent need for global efforts to reduce plastic pollution and mitigate its impact on marine ecosystems and human health.

Coastal regions of India are faced with extensive plastic pollution, as there is inadequate infrastructure and absence of solid waste management principles[19,39]. Mahim Bay, in Mumbai, is one of the coastal ecosystems affected by heavy plastic pollution due to its close proximity to densely populated areas and the direct discharge of untreated sewage and industrial effluents[17]. It is important to note that the abundance, distribution and polymer composition of microplastics are poorly understood in Mumbai coastal waters, including Mahim Bay, even in the presence of increasing concerns on microplastic pollution[32,37]. The present study encompasses herewith attempts to address this knowledge gap by exploring the seasonal trends of microplastic occurrence in Doma fish species in Mahim Bay waters.

Study area :

The study area, Mahim Bay, constitutes a significant semi-enclosed segment of the Arabian Sea located in Mumbai, Maharashtra[43]. It stretches from Bandra reclamation in the north to Worli in the south, with Mahim Creek serving as its narrow opening, where the Mithi River converges. Positioned within a semi-circle in the central region are Mahim Beach, Dadar Beach, and Prabhadevi Beach[38]. Two sampling locations (fishery village) were chosen within Mahim Bay for the evaluation of microplastic types and quantities within the fish samples. Spot A-Mahim Beach (19.043469° N, 72.838022° E), Spot B-Worli Koliwada Jetty (19.0261° N, 72.8155° E) as shown in (Figure 1).

Microplastic (MP) extraction :

Specimens were initially rinsed with Milli-Q water to remove surface contaminants. The total length (cm) and weight (g) of each fish were recorded as morphometric data. Each fish was dissected on a metal tray, and the gastrointestinal tract (GT) was isolated to assess the presence of MPs. The GT was weighed and transferred to a beaker, then treated with 10% potassium hydroxide (KOH) to solubilize the organic tissue. The samples

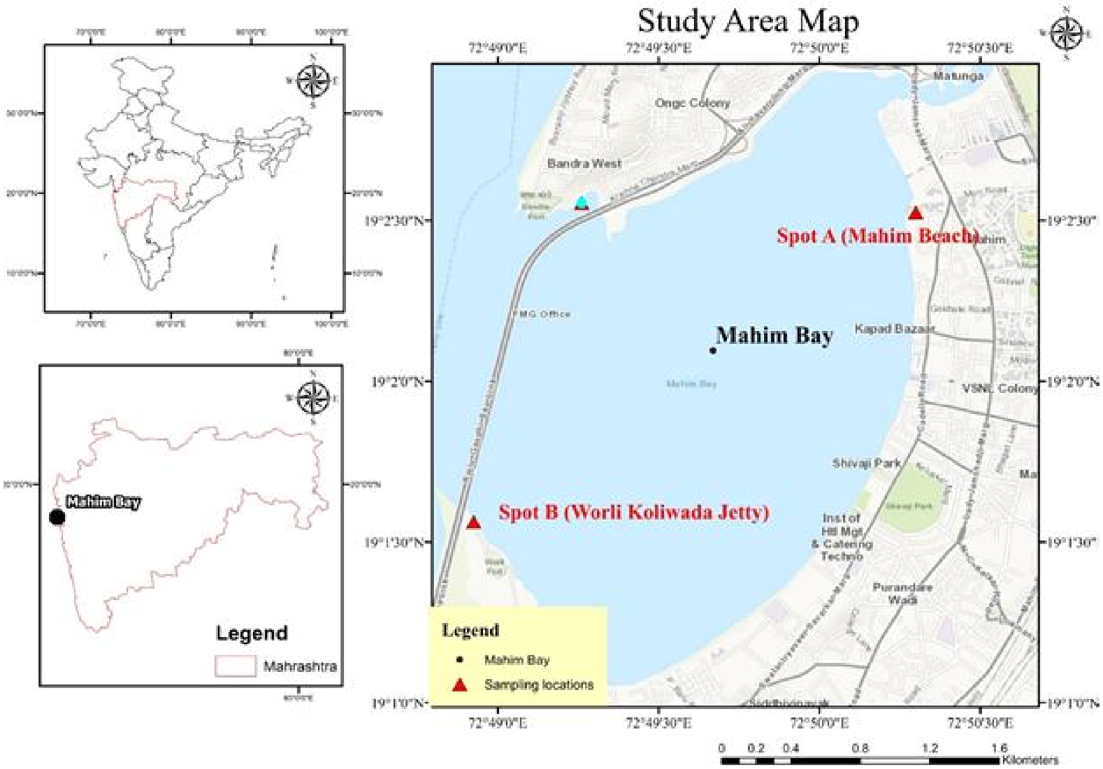

Figure 1. Map of sample collection showing exact locations of the spots.

Figure 2. *Johnius dussumieri*

were incubated in a hot air oven at 60°C until the organic tissue was completely digested. A supersaturated NaCl aqueous solution (1.2 g/mL) was added to separate the MPs by density gradient. The mixture was stirred continuously with a glass rod and left at room temperature for 24 hours. The supernatant containing the floated MPs was filtered using ash-less Whatman filter paper (Grade No. 41, pore size: 20 μm).

Microscopic and Polymer analysis using (FTIR) :

Microscopic analysis and polymer identification using Fourier Transform Infrared (FTIR) spectroscopy were meticulously conducted following a rigorous protocol (Renner et al., 2019). Microplastics were observed and classified using a NIKON SMZ25 stereomicroscope, with particular attention paid to morphological structures, colors, and sizes, in accordance with established methodologies[7,47]. The categorization of microplastic particles included fragments, fibers, films, pellets, and foam, while colors such as black, blue, transparent, white, red, and silver were noted during classification. The FTIR analysis protocol utilized a Spectrum instrument equipped with a model Spectrum 2 (serial number-87109), featuring a Mid-Infrared (MIR) TGS detector and MIR source incorporating an OptKBr beamsplitter. Operational parameters were meticulously set with a resolution of 8 and a strong apodization function applied. The spectrum employed a ratio beam type with phase correction implemented in magnitude. A scan speed of 0.2 was established, utilizing a double IGram type with scanning direction denoted as combined, and zero crossings maintained at 0. An IR-Laser wavenumber of 11750.00 was applied with a JStop value of 8.94.

The sample base plate employed was a diamond Universal Attenuated Total Reflectance (UATR) accessory, exerting a force of 98 N and operating within a default scan range of 4000 to 450 cm^{-1}. The ATR crystal combination specified was diamond with a single bounce configuration, although the specific UATR option remained unspecified. This methodological framework ensured a comprehensive and systematic approach for polymer identification through FTIR spectroscopic analysis, guaranteeing robust and scientifically sound outcomes[31,44].

Contamination control :

All glassware and stainless-steel utensils were prewashed with Milli-Q water to prevent contamination. Nitrile gloves and clean cotton lab coats were worn during the analysis. Specimens were covered with aluminum foil to avoid airborne plastic contamination. Blank replicates containing the salt solution were used to detect contamination, and no contamination was observed after visual inspection of blank filter papers under a stereomicroscope.

Data analysis :

The purpose of this statistical analysis is to evaluate the effects of location, season, color, and their interactions on the measurements of various samples collected from two different sites: Mahim Beach and Worli Jetty. The data comprises counts of different colors and morphological types (Fiber, Fragment, Film) observed during three distinct seasons: Pre-monsoon, Monsoon, and Post-monsoon. By employing Analysis of Variance (ANOVA), we aim to identify whether these factors significantly influence the measurements and to explore any potential interactions among them.

Mahim Beach (Spot A) :

The present study provides an in-depth analysis of the microplastic data collected from the gut of *Johnius dussumieri* (Doma fish) in Mahim Beach across the Pre-Monsoon, Monsoon, and Post-Monsoon seasons.

Colour and shape distribution :

During the Pre-Monsoon season, the most common colors of microplastics found in the gut of Doma fish were Transparent and Black, while Blue and Red microplastics were also present but in lower frequencies. In the Monsoon season, Black and Transparent microplastics were predominant, with Black being the most frequent. Notably, the presence of Blue and Red microplastics decreased compared to the Pre-Monsoon season, indicating a shift in the types of plastic pollution during this period. In the Post-Monsoon season, Black microplastics were the most frequent, followed by Orange and Transparent (Figure 3).

In the Pre-Monsoon season, fibres were more common than fragments, indicating that the microplastics ingested were likely fibrous materials, possibly originating from sources such as fishing nets, ropes, or textiles. During the Monsoon season, a higher frequency of fragments was observed compared to fibres. This shift suggests that environmental degradation of larger plastic items into smaller

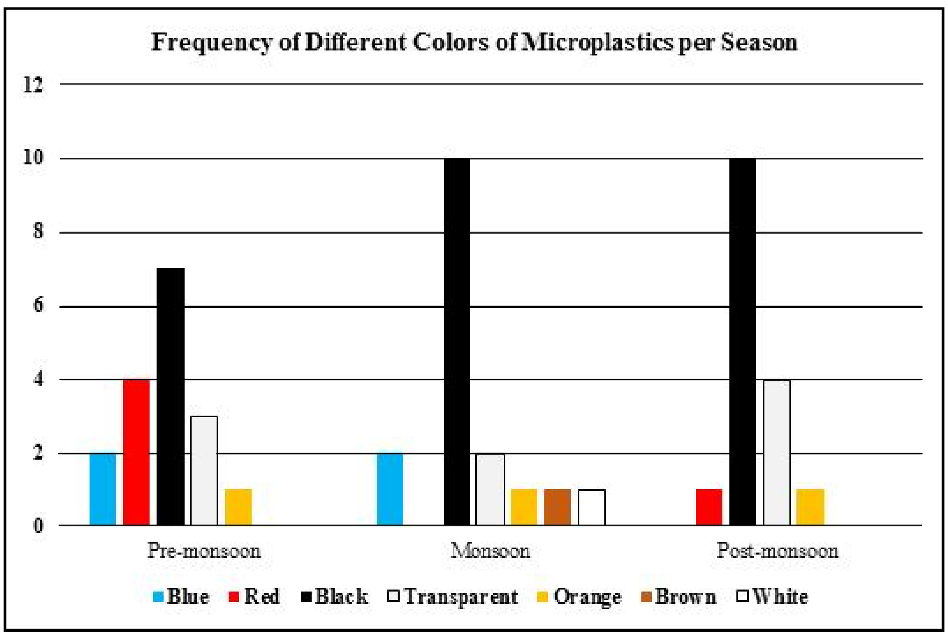

Figure 3. Frequency of Different Colors of Microplastics per Season in Doma gut.

fragments increased, likely due to heavy rainfall and the associated rise in water flow, which can break down plastics more rapidly. In the Post-Monsoon season, fragments continued to be more prevalent than fibres, maintaining the trend observed during the Monsoon season (Figure 4).

Worli Jetty (Spot B) :

The present study provides an in-depth analysis of the microplastic data collected from the gut of Doma fish in Worli Jetty across the Pre-Monsoon, Monsoon, and Post-Monsoon seasons.

Colour and shape distribution :

During the Pre-Monsoon season, the predominant colors observed were Black, Blue, and Transparent. These colors were consistently present, indicating a stable environment before the onset of the monsoon. The Monsoon season showed a marked increase in the frequency of Black-colored fish, suggesting possible changes in the water's turbidity or other environmental factors that could affect fish coloration. In the Post-Monsoon period, the color distribution reverted to patterns similar to the Pre-Monsoon season, with Black, Blue, and Transparent being the most common colors (Figure 5).

The morphology analysis indicated that Fibre was the most common morphology observed during both the Pre-Monsoon and Post-Monsoon seasons. This consistency suggests that the physical environment and food sources remain relatively stable during these periods. However, during the Monsoon season, there was a noticeable shift, with Fragment becoming the dominant morphology.

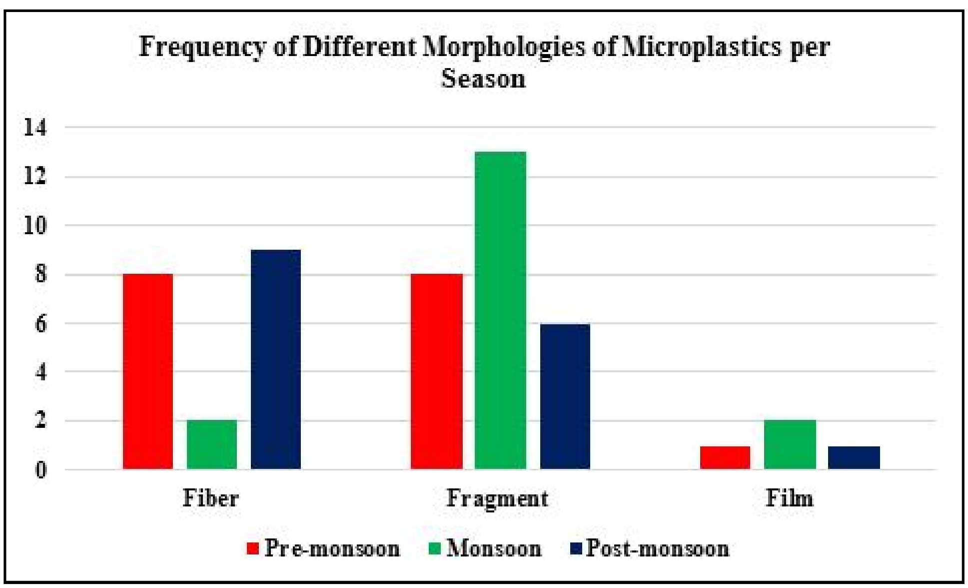

Figure 4. Frequency of Different morphologies of Microplastics per Season in Doma gut.

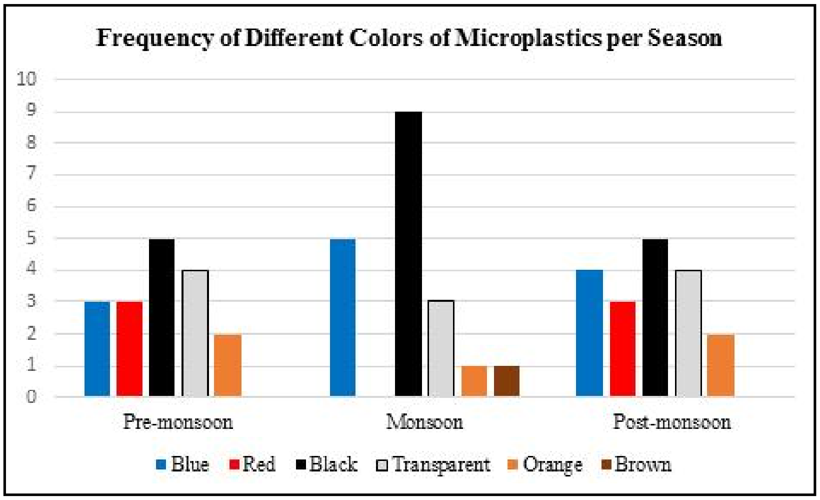

Figure 5. Frequency of Different Colors of Microplastics per Season in Doma gut.

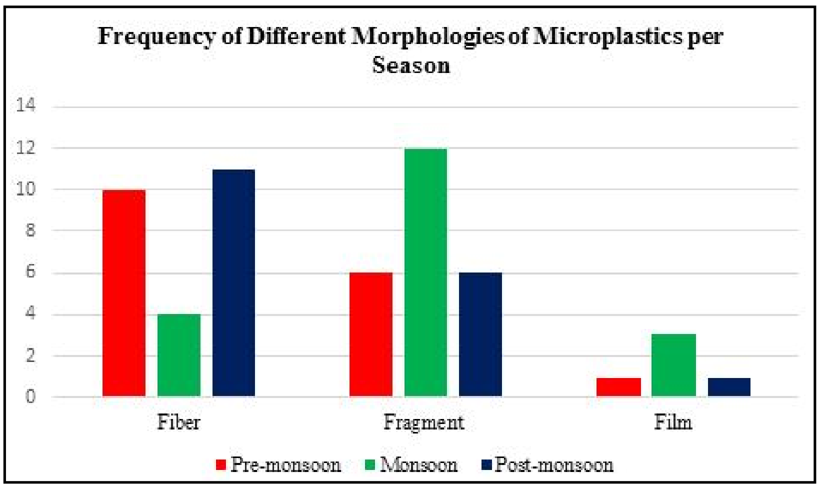

Figure 6. Frequency of Different morphologies of Microplastics per Season in Doma gut.

This change could be attributed to the increased water flow and changes in habitat structure due to the heavy rains, leading to more fragmentation of available food sources or habitat structures (Figure 6).

Comparative analysis of Microplastic presence across seasons :

During the Pre-Monsoon season, the lowest number of microplastics was recorded, suggesting relatively lower levels of plastic pollution or reduced ingestion rates by Doma fish before the onset of the monsoon. In the Monsoon season, there was a noticeable increase in the number of microplastics, which can be attributed to increased runoff and water flow that likely brings more plastic debris into Mahim beach from surrounding areas. The Post-Monsoon season saw the highest number of microplastics recorded, indicating that the accumulation of debris and increased fragmentation of larger plastic items during the monsoon likely contributed to the higher counts observed post-monsoon. In Worli jetty, the Monsoon season brings a significant increase in microplastic presence, particularly in the form of fragments and black-colored particles. This is likely due to the combined effects of increased runoff, river discharge, and turbulent water conditions that promote the fragmentation of larger plastic debris. The Pre-Monsoon and Post-Monsoon seasons exhibit similar patterns in both color and morphology distributions, indicating stable sources of microplastics that are likely consistent throughout the year, primarily from local urban activities and wastewater discharges (Figure 7).

The data provided, which includes measurements of various colors and morphological types at two locations (Mahim Bay and Worli Jetty) across three seasons (Pre-monsoon, Monsoon, and Post-monsoon), was analyzed using ANOVA to understand the effects of these factors and their interactions. The results of the ANOVA revealed that the location and season, when considered independently, do not have a statistically significant impact on the measurements. Specifically, the p-values for location and season were 0.145 and 0.652 respectively, indicating a lack of significance at the 0.05 level. However, the color of the samples demonstrated a highly significant effect, with a ($p=0.004$)), suggesting that color variations are a major determinant of the observed values. Furthermore, significant interactions were found between location and color ($p = 0.002$), and between season and color ($p \approx 0$), highlighting that the effect of

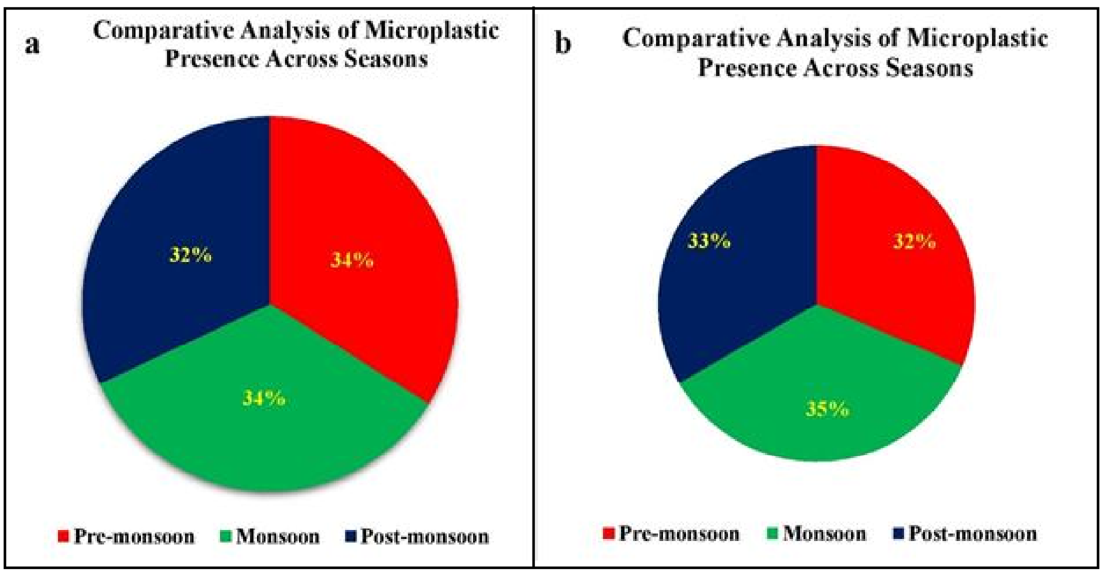

Figure 7. Comparative anaylisis of microplastics across seasons. (a) Mahim Beach (Spot A), (b) Worli Koliwada Jetty (Spot B).

color on the measurements is influenced by both the location and the season. Overall, the analysis underscores the dominant role of color in influencing the measurements, along with notable interaction effects involving location and season, but it also points to the need for more comprehensive data with repeated measures to fully explore variability and other statistical properties.

Polymer analysis :

In case of Mahim Beach, PE and Nylon are most prevalent during the Monsoon season (42.9%), indicating a possible influx or higher degradation of these materials during the rainy season. Nylon shows a higher presence during the Monsoon season (23.8%) compared to the Pre-Monsoon (17.6%) and Post-Monsoon (22.2%) seasons. PET and PP show varied presence across seasons with a higher count in the Pre-Monsoon (52.9%) and Post-Monsoon (50.0%) seasons compared to Monsoon (33.3%). In Worli jetty, PE and Nylon are most prevalent during the Monsoon (58.8%) and Post-Monsoon (62.5%) seasons, indicating a possible influx or higher degradation of these materials during and after the rainy season. Nylon is consistently present in the Pre-Monsoon (11.8%) and Monsoon (11.8%) seasons but disappears in the Post-Monsoon period. PET and PP show varied presence across seasons with a higher count in the Pre-Monsoon season (47.0%) compared to Monsoon (29.4%) and Post-Monsoon (37.5%) (Figure 8).

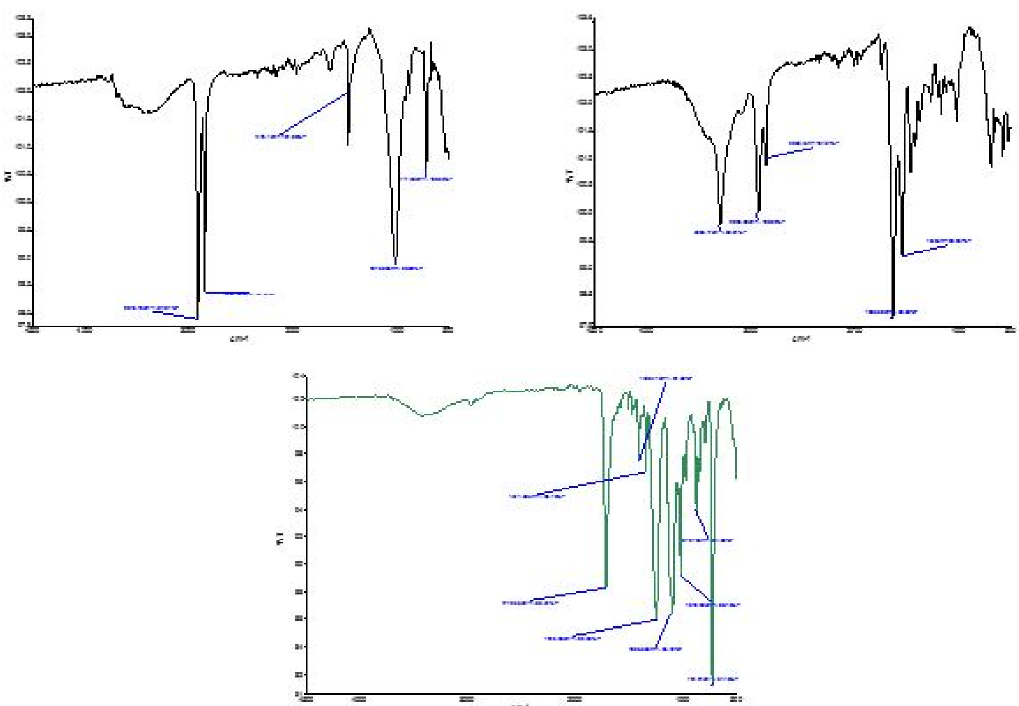

Fig. 8. FTIR spectra of microplastic samples: a. PE (Polyethylene), b. Nylon, c. PET (Polyethylene Terephthalate).

The present study provides a comprehensive analysis of the microplastic contamination in the gut of *Johnius dussumieri* (Doma fish) from Mahim Beach and Worli Jetty across different seasons in Mahim Bay, Mumbai. The results highlight distinct patterns in color and morphology distribution of microplastics, revealing seasonal variations influenced by environmental changes.

At Mahim Beach, the most common colors of microplastics during the Pre-Monsoon season were Transparent and Black, with Blue and Red also present. The Monsoon season saw a dominance of Black and Transparent microplastics, with a noticeable decrease in Blue and Red, indicating a shift in plastic pollution types. Post-Monsoon, Black microplastics remained prevalent, followed by Orange and Transparent. This seasonal shift suggests that different environmental factors, such as water flow and runoff, influence the types of microplastics ingested by fish[46]. In contrast, at Worli Jetty, Black, Blue, and Transparent microplastics were predominant during the Pre-Monsoon season. The Monsoon season showed an increase in Black-colored microplastic particles, possibly due to increased turbidity or environmental changes affecting fish coloration[36]. The Post-Monsoon period reverted to patterns similar to the Pre-Monsoon season, indicating stable sources of microplastics throughout the year.

In terms of morphology, Mahim Beach showed a higher prevalence of fibers during the Pre-Monsoon season, likely from fishing nets, ropes, or textiles[26]. The Monsoon season experienced a shift towards more fragments, likely due to increased water flow and degradation of larger plastic items[35]. This trend continued into the Post-Monsoon season. Worli Jetty displayed consistent dominance of fibers during the Pre-Monsoon and Post-Monsoon seasons, suggesting a stable physical environment and food sources. However, during the Monsoon season, fragments became dominant, likely due to increased fragmentation from heavy rains and turbulent water conditions[27].

Comparing the two locations, the Monsoon season at both Mahim Beach and Worli Jetty saw a significant increase in microplastic presence, particularly fragments and black-colored particles. This suggests that increased runoff and river discharge during monsoon contribute to higher plastic debris inflow and fragmentation[45]. Pre-Monsoon and Post-Monsoon seasons exhibited stable patterns in both color and morphology distributions, indicating consistent sources of microplastics primarily from urban activities and wastewater discharges[18].

The ANOVA results revealed that while the location and season independently do not significantly impact microplastic measurements, color variations play a major role. Significant interactions between location and color, and season and color, suggest that the effect of color on microplastic measurements is influenced by both location and season. This underscores the importance of considering color in future studies and highlights the need for more comprehensive data with repeated measures.

Polymer analysis at Mahim Beach indicated that PE and Nylon were most prevalent during the Monsoon season, suggesting higher degradation or influx during this period.

Nylon showed a higher presence during Monsoon compared to Pre-Monsoon and Post-Monsoon seasons. PET and PP were more prevalent in the Pre-Monsoon and Post-Monsoon seasons compared to Monsoon. At Worli Jetty, PE and Nylon were most prevalent during the Monsoon and Post-Monsoon seasons. Nylon was consistently present during Pre-Monsoon and Monsoon but disappeared in Post-Monsoon. PET and PP showed higher presence in Pre-Monsoon compared to Monsoon and Post-monsoon.

Recent studies on microplastic pollution in marine environments corroborate these findings. For instance, research by Gupta *et al.,*[12] found similar seasonal variations in microplastic pollution in coastal areas, with increased levels during and after the monsoon season due to runoff and river discharge. Frere *et al.,*[10] reported that color and morphology distributions of microplastics were influenced by local environmental conditions and sources of pollution, consistent with the patterns observed in this study. Moreover, several highlighted the significance of polymer types, noting that PE and Nylon were commonly found in marine organisms, especially during periods of high rainfall, aligning with the findings at Mahim Beach and Worli Jetty[8,14,15,20].

This present study provides crucial insights into the seasonal and spatial variations of microplastic contamination in the gut of *Johnius dussumieri* (Doma fish) at Mahim Beach and Worli Jetty. The results highlight the need for improved waste management, public awareness campaigns, policy interventions, and ongoing monitoring to mitigate the impact of microplastic pollution on marine ecosystems. Future research should focus on long-term monitoring and the impact of microplastics on marine life and ecosystem health, incorporating repeated measures for a more detailed understanding of temporal and spatial variability.

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