



# Occurrence and Distribution of Plastispheres in Coastal Sediments and Waters along the Maharashtra Coast, India

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## Abstract

Microplastics can promote microbial colonisation and biofilm growth, thus being referred to as “plastispheres”. The global plastic pollution surge is likely to adversely impact ecology and human health by providing a novel habitat for microbial communities. Even though microplastics in marine environments have been the subject of in-depth research, plastispheres have recently received attention. Thus, the current study investigates the prevalence and distribution of plastispheres along the Maharashtra coast of India, considering their plausible implications for ecology and human health. Microplastics were isolated from sediment and water samples obtained from 10 sampling sites. Subsequently, these microplastic particles were subjected to ATR-FTIR and scanning electron microscopy (SEM) analyses to ascertain their chemical composition, surface topography, and presence of attached biofilms. The predominant polymers composing the microplastic particles were polypropylene (42.8%), polyethylene (28.6%), polystyrene (14.3%), and polyvinyl chloride (14.3%). SEM analysis revealed the presence of topographical structures and degradation effects, facilitating microbial attachment on the microplastic surface. About 50% of the microplastic particles tested positive for biofilms, with over 66% of those collected from Girgaon and Malvan beaches exhibiting biofilm presence. These positively screened particles also displayed comparatively rough surface structures, likely enhancing microbial colonisation. Microplastic ageing and polymer type could positively affect microbial colonisation. Diatoms and fungal hyphae exhibit varied interactions with microplastic polymers. Notably, microplastics host various reproductive stages of fungi, as evidenced by filamentous networks, mycelia, and conidiophores.

**Keywords** Marine microplastics · Microorganisms · Diatoms · Fungi · Polymers

## Introduction

High and low-density polyethylene (HDPE and LDPE), polypropylene (PP), polyvinyl chloride (PVC), and polystyrene (PS) are among the widely manufactured thermoplastics (Sánchez 2020; Zhang et al. 2021). These versatile thermoplastics are used in a wide range of daily items, playing a significant role in the notable rise of worldwide plastic production, which presently amounts to 368 million metric tons annually (Sooriyakumar et al. 2022). However, the surge in plastic production and extensive utilisation has led to a parallel escalation in releasing plastic waste into the environment (Geyer et al. 2017). Microplastics (plastic less than 5 mm) pollution is an emerging environmental concern (Thompson et al. 2004). Microplastics are classified as either primary or secondary. Primary microplastics originate from sources with an initial size of less than 5 mm, while secondary microplastics result from the breakdown

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of larger plastic fragments (Dong et al. 2021). These tiny plastic particles have become ubiquitous in terrestrial, freshwater, estuarine, marine, polar, and remote regions (Dong et al. 2021). Given their small size, various aquatic organisms, mainly marine fauna, readily ingest microplastics, leading to their potential accumulation and dispersion throughout the food chain (Roman et al. 2021). Numerous studies have extensively documented the adverse impacts of microplastics on a diverse array of organisms, spanning from zooplankton to molluscs, fish, seabirds, turtles, and mammals (Zhang et al. 2021). Moreover, the hydrophobic nature and the high surface area-to-volume ratio of microplastics facilitate the accumulation of various contaminants, including heavy metals, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, perfluorinated alkyl substances, polybrominated diphenyl ethers, and pharmaceuticals and personal care products (PPCPs) (Bakir et al. 2014a; Caruso 2019; Atugoda et al. 2021; Khalid et al. 2021). The potential of microplastics to act as carriers for a range of contaminants could pose additional threats to ecosystems, wildlife, and potentially human health (Bakir et al. 2014b; Atugoda et al. 2021; Khalid et al. 2021).

Besides serving as vectors for various pollutants, the interaction between microplastics and microorganisms has recently become a topic of great interest (Dong et al. 2021; Stenger et al. 2021; Sooriyakumar et al. 2022). Microorganisms can attach to the surface of microplastics and form biofilms within a relatively short time (Harrison et al. 2014; Khatoon et al. 2018). For instance, studies have shown that bacterial communities quickly colonised LDPE when exposed to coastal sediments, demonstrating the speed of this process within just a week (Harrison et al. 2014). Various factors, including surface texture, hydrophobicity, and the presence of chemical additives, have been identified as influencing the formation of biofilms on the surface of microplastics (Tu et al. 2020; Wang et al. 2021a, b; Sooriyakumar et al. 2022). According to Sooriyakumar et al. (2022), the surface characteristics of microplastics inherently promote microbial colonisation. Microplastics featuring irregular or rough surfaces serve as attachment points for microorganisms, creating microenvironments conducive to microbial colonisation and the development of biofilms. Similarly, the hydrophobic nature and smaller particle size of microplastics, which offer a larger surface area relative to their volume (Atugoda et al. 2021), provide additional sites for microbial attachment.

Biofilms encompass a variety of microorganisms existing in symbiotic collaboration (Sooriyakumar et al. 2022). Among the microorganisms affiliated with microplastics, autotrophs like photosynthetic bacteria and algae can independently produce their own sustenance. Conversely, heterotrophs depend on the surplus food generated by

autotrophs during their coexistence (Bolan et al. 2020). Consequently, microplastics offer a distinctive habitat for microorganisms and have been denoted as “plastispheres” (Zettler et al. 2013). Plastispheres signify a novel ecological niche that can have significant environmental implications. As the research on microplastics and their interactions with microorganisms grows, our understanding of the ecological consequences and potential impacts on marine ecosystems will become more comprehensive. Biofilm formation can modify the physical and chemical attributes of microplastics, influencing their degradation and dispersion in the water column (sinking and buoyancy rate), their capacity to adsorb and transport various contaminants, and ultimately the trophic transfer and environmental release of adsorbed chemicals (Rummel et al. 2017; Stabnikova et al. 2021; Stenger et al. 2021; Vaseashta et al. 2021; Zhang et al. 2021). It has been established that a variety of microbial communities, such as toxic, pathogenic, invasive, or plastic-degrading species, can be found in biofilms on microplastics (Zettler et al. 2013; McCormick et al. 2014; Oberbeckmann et al. 2014; Curren and Leong 2019; Li et al. 2019; Zhang et al. 2021). These potentially harmful microorganisms might be extensively disseminated in seawater, shielded by biofilms, endangering human health (Metcalf et al. 2022a). A plethora of investigations have been carried out regarding microplastics in marine environments, addressing diverse topics (Ajith et al. 2020; Gola et al. 2021; Ahmed et al. 2021; Perumal et al. 2022; Biswas and Pal 2023), including their function as transporters for various contaminants (Bakir et al. 2014a; Caruso 2019; Atugoda et al. 2021; Khalid et al. 2021; Kumkar et al. 2023). However, recent focus has shifted towards a more specific examination of biofilms associated with microplastics (Kumar et al. 2022a; Kaur et al. 2022). Furthermore, previous research has indicated that obtaining a more profound understanding of the processes involved in biofilm formation on microplastic surfaces necessitates more detailed insights into the plastisphere compared to naturally occurring substrate-associated aggregates, such as microbial communities on cellulose, wood, and glass (Sooriyakumar et al. 2022).

The projected amount of plastic debris in the Earth's oceans is expected to reach 5.25 trillion particles, with microplastics comprising 92%. Approximately 80% of these plastic particles are linked to terrestrial sources (Coyle et al. 2020; Cincinelli et al. 2021; Gola et al. 2021). Notably, the benthic region of the Indian Ocean is reported to have the highest prevalence of microplastic contamination, quantified at 4 billion fibres per square kilometre (Eriksen et al. 2014; Woodall et al. 2014). Thorough examinations of microplastic occurrence within sedimentary substrates have been extensively documented across various coastal regions of India, including Goa (Veerasingam et al. 2016),

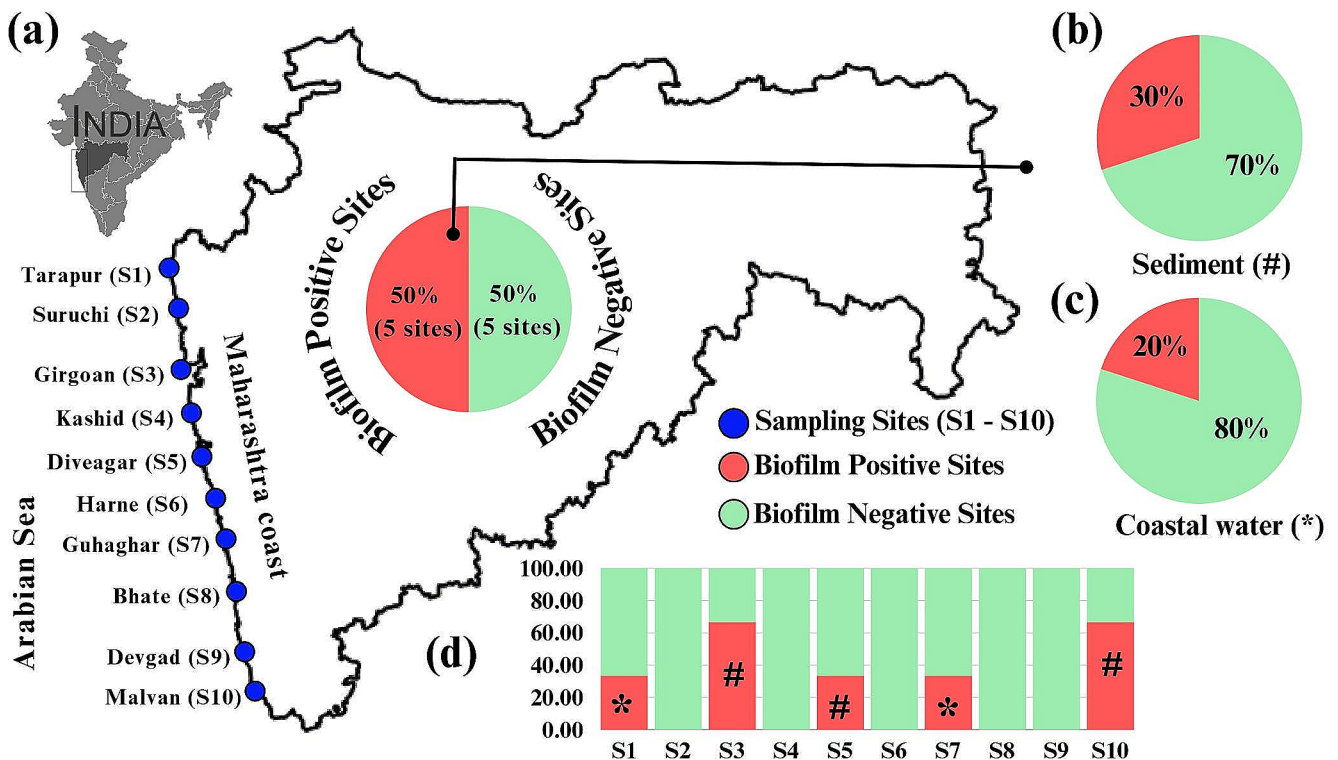
Tamil Nadu (Karthik et al. 2018), Karnataka (Tiwari et al. 2019), Kerala (Robin et al. 2020), Odisha (Patchaiyappan et al. 2021), Andhra Pradesh (Sambandam et al. 2022), West Bengal (Kumar et al. 2022b), the Andaman and Nicobar Islands (Goswami et al. 2020; Patchaiyappan et al. 2021), and Maharashtra (Kumkar et al. 2023; Tiwari et al. 2019). However, there is currently a research gap concerning biofilms' presence and prevalence on microplastics along the Maharashtra coast. Moreover, we speculate that significant differences in biofilm density on microplastics obtained from sediment and water samples along the Maharashtra coast are likely due to the region's diverse demographic zones, human activities, and land use patterns. Additionally, the diversity in microplastic origins offers the potential to gain insights into the relationship between microbial diversity residing on the surfaces of different microplastic polymers and the geographical locations from which they are sourced. To address these gaps, our study pursues the following objectives: (1) Collection and examination of microplastics obtained from coastal sediment and water along the Maharashtra coast to discern their surface morphology and disintegration patterns, (2) To identify the microbial communities associated with the microplastics, (3) Characterisation of the microplastics and investigation into the interplay between the diversity of microbial life inhabiting

on the surfaces of microplastic polymer types and the specific regions of their origin.

## Materials and Methods

### Study Locations

Maharashtra, ranked as the second most populous state and covering the third-largest geographical area in India, is bounded by the Arabian Sea on one side and the Western Ghats Mountain ranges on the other. The state encompasses five coastal districts: Thane, Raigad, Mumbai, Ratnagiri, and Sindhudurg. Plastic pollution from anthropogenic activities poses a significant challenge along the Maharashtra coast, with major contributors including densely populated regions, urban development, industrial zones, fishing ports, and coastal tourism (Kumkar et al. 2023). In our investigation, we deliberately chose ten distinct sample sites labelled S1 to S10, strategically positioned across the five coastal districts mentioned above, thus providing a representative overview of the entire Maharashtra coastline (Fig. 1a).



**Fig. 1** (a) Geographical distribution of the Maharashtra coastline showing collection sites ( $n=10$ ); pie chart within the map of Maharashtra state indicates overall biofilm-positive and negative sites; (b and c) Percent distribution of biofilm-positive sites in sediment and coastal

water, respectively; (d) Site-specific distribution of biofilm-positive microplastics (“#” and “\*” indicates biofilm found on microplastics isolated from coastal sediment and water samples, respectively)

## Sampling, Microplastic Isolation and Characterisation

In August 2021, we gathered beach sediment and surface water samples from ten locations along the Maharashtra coast, following the methodology outlined by Karthik et al. (2018) and Robin et al. (2020). A slight alteration was made to the procedure, considering our particular emphasis on investigating biofilms on microplastic particles. This modification was implemented to avoid the potential detachment of biofilms from microplastics during sample processing and extraction, which chemical interactions could influence. Stainless steel scoops were employed at each assigned sampling location to collect the uppermost 5 cm of beach sediment. Sediment samples were acquired from three quadrats (30 cm x 30 cm) on each beach, spaced 100 m apart. The sediment was placed in stainless-steel containers and sieved through a 5-mm mesh to remove particles larger than 5 mm. Likewise, 100 L of water were gathered from a depth of 0 to 25 cm below the surface for water samples, utilising a 5 L stainless-steel sampling container. The obtained water was subsequently strained through a stainless-steel sieve with a mesh size of 100  $\mu\text{m}$ .

The sieves underwent thorough inspection, and microplastic particles ranging from 3 to 5 mm in size were manually separated from the sediment and water samples using sterile forceps. These isolated particles were then individually placed into glass vials for subsequent analysis. The focus on choosing larger microplastic particles was intentional in clearly separating them from the samples. This helps to minimise the chance of unintentionally including microplastics from outside sources. In an aseptic laboratory environment, microplastic particles from each sample location were pooled together. Six particles were randomly chosen from this combined microplastic pool for each sampling location—three from water samples and three from sediment samples. To maintain an unbiased selection of microplastic particles, an anonymous individual, unaware of the sample sites or any sampling data, made the particle selections. The glass vials containing the microplastic particles were tightly sealed and covered with aluminium foil to prevent contamination from external sources. The task of impartially selecting microplastic particles was meticulously carried out in a strictly aseptic environment.

The selected microplastic particles were thoroughly examined for their colour (red, green, blue, white, yellow, and black) and morphological characteristics using the Olympus SZ61 stereo zoom microscope. To identify the polymeric composition of the microplastics and determine their potential source, we employed Attenuated Total Reflectance Fourier-transform Infrared Spectroscopy (ATR-FTIR) (Ballent et al. 2016). Following ATR-FTIR analysis

using the Thermo Scientific Nicolet™ iS20, the spectrum data of the microplastic particles were compared to the OMNiC reference library.

## Detection of Biofilms on Microplastics

We employed a high-resolution imaging method to comprehensively understand microplastic surface characteristics, biofilm formation, and changes induced by degradation. The goal was to explore microbial communities and uncover the importance of surface texture and topography in biofilm development. Scanning Electron Microscopy (SEM) was chosen for its effectiveness in revealing surface texture, topographical features, and attached materials on microplastic surfaces, including microorganisms like bacteria, fungi, and algae (Kumkar et al. 2021; Verma et al. 2022). This technique plays a crucial role in unveiling the complexities of microplastic disintegration due to weathering and ageing and understanding its potential role in carrying other contaminant pollutants. In our study, six microplastic particles, including three from sediment and three from water samples at each designated station, underwent preparation for SEM analysis. This preparation involved sputter-coating the particles with a thin layer of gold and imaging using a Scanning Electron Microscope (Tescan Mira3, Tescan Orsay Holding, Brno, Czech Republic).

## Data and Image Analysis

All values that are given as %, mean  $\pm$  standard error ( $M \pm SE$ ), or otherwise specified. PAST freeware Version 4.03 (Hammer et al. 2001) was used for the data analysis.

## Results and Discussion

The present research contributes to our comprehension of the prevalence and distribution of biofilm formation on microplastics along the Maharashtra Coast, shedding light on the interactions between microplastics and microbes. These microbial communities, consisting of autotrophs, photosynthetic algae, fungi, and bacteria, form biofilms and exhibit rapid growth on the solid surfaces of microplastics (Bolan et al. 2020; Sooriyakumar et al. 2022). Upon scrutinising microplastic samples from the ten sampling sites, our investigation unveiled the presence of biofilms on microplastic particles collected from half of these sites (50%) (Fig. 1a). Among the samples positive for biofilms, 30% were derived from sediment while 20% were obtained from coastal water samples (Fig. 1b and c). Microplastic particles from sampling sites S1, S3, S5, S7, and S10 were identified as biofilm-positive (Fig. 1d). Among the designated

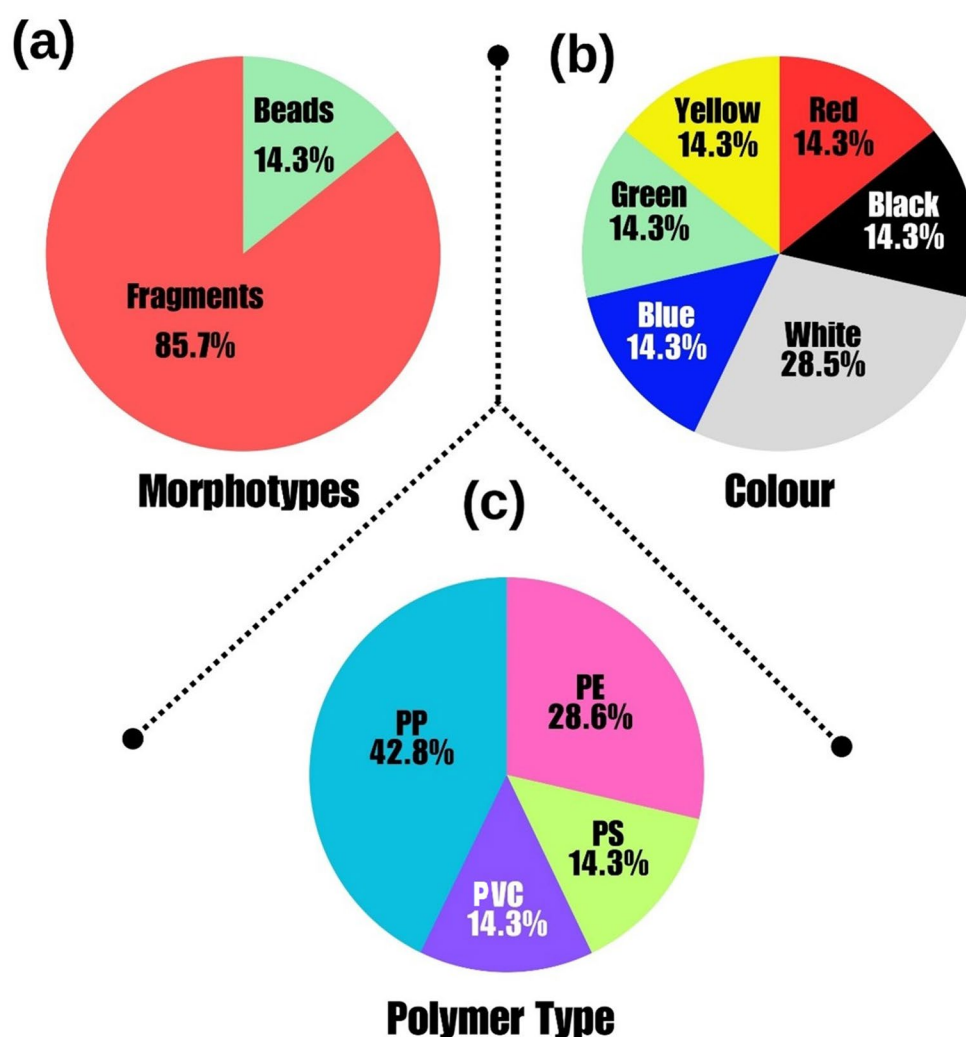


sampling stations, the Girgaon (S3) and Malvan (S10) locations displayed the highest percentage (66.66%) of biofilm positive microplastic (Fig. 1d). In contrast, the Tarapur (S1), Diveagar (S5), and Guhagar (S7) stations had 33.33% of microplastic particles exhibiting biofilm (Fig. 1d). The formation of biofilms and the degree of microbial colonisation can be significantly influenced by various factors, including surface roughness, polymer composition, hydrophilic or hydrophobic characteristics, and other relevant attributes (Sooriyakumar et al. 2022). While microplastics themselves lack direct porosity, their surfaces can develop pits, fissures, and cavities through weathering, abrasion, and photo-oxidation processes (Atugoda et al. 2021; Kumkar et al. 2021, 2023). The presence of such morphological features, including flakes, eroded surfaces, trenches, and cavities, not only facilitates the adsorption of pollutants like heavy metals (Turner and Holmes 2011; Li et al. 2018; Shruti et al. 2019; Atugoda et al. 2021; Khalid et al. 2021; Kumkar et al. 2021, 2023) but also encourages the formation of biofilms (Tu et al. 2020; Wang et al. 2021a, b; Sooriyakumar et al. 2022). Using detailed SEM analysis, Tiwari et al. (2019) demonstrated that microplastics collected from Girgaon exhibit rougher surfaces than those from other places. Our present data align with this past trend, revealing a noticeable pattern of increased biofilm colonisation on microplastic particles with rough surfaces. We observed more microplastic particles with positive biofilm presence in samples collected from Girgaon and Malvan than in other locations. This is likely associated with the rougher surfaces of the microplastics obtained from these specific areas. This holds particular significance as both microplastics and the pollutants they absorb can accumulate in substantial quantities in the environment, potentially exerting adverse effects on ecosystems and food chains. Verdú et al. (2023) showed that biofilm growth considerably affects the vector transport of personal care products such as triclosan-adhered polyethylene microplastics into *Daphna magna*. Furthermore, Guan et al. (2020) conclusively proved that biofilm formation increased microplastics' function in the transport of trace metals, such as nickel (Ni), copper (Cu), zinc (Zn), and cadmium (Cd) in the aquatic environment. In a recent study by Kumkar et al. (2023), various emerging pollutants were identified in the coastal waters of Maharashtra. These pollutants included heavy metals such as vanadium (V), copper (Cu), arsenic (As), nickel (Ni), cobalt (Co), chromium (Cr), cadmium (Cd), and lead (Pb). Additionally, pharmaceuticals and personal care products such as metoprolol, tramadol, venlafaxine, triclosan, bisphenol A, and bisphenol S were detected, along with plasticisers like di-n-butyl phthalate (DBP) and bis(2-ethylhexyl) phthalate (B<sub>2</sub>EHP or DEHP). Moreover, earlier investigations have showed weathered microplastic particles' capability to carry these pollutants into fish

(Kumkar et al. 2021, 2023; Verma et al. 2022). Considering that fish and fish-related products constitute a primary food source for the population residing in the coastal regions of Maharashtra, the presence of diverse pollutants along the Maharashtra Coast (Kumkar et al. 2023), the transport capacity of microplastics for these pollutants (Li et al. 2018; Kumkar et al. 2021, 2023), and the potential enhancement of microplastics uptake by marine organisms through biofilms (Fabra et al. 2021), pose a substantial threat to aquatic biota and human health.

Among the five distinct morphological categories considered (Supplement 1a), only microplastic fragments and beads exhibited positive biofilm presence (Fig. 2a). In this context, microplastic fragments were notably prevalent, constituting 85.7% of instances with associated biofilms, while beads accounted for 14.3%. Regarding colour, white microplastics showed the highest occurrence of biofilm, making up 28.5% of the total instances, followed by other colour categories, each representing 14.3% (Fig. 2b). Notably, white-coloured microplastics have often been observed in the digestive systems of marine fish (Tanaka and Takada 2016; Pan et al. 2021). Previous research has investigated the impact of microplastic colour and biofilm growth on the ingestion and susceptibility of species to such particles (Peters and Bratton 2016; Ory et al. 2017; Naidoo et al. 2020; Kumkar et al. 2021). This study analysed the polymeric composition of 60 microplastic particles using ATR-FTIR. Spectral analysis (Supplement 1b) revealed the following polymers: polypropylene (PP), polyethylene (PE), polystyrene (PS), and polyvinyl chloride (PVC). The per cent distribution of biofilm-positive microplastic polymers along the Maharashtra coast is as follows: PP (42.8%), PE (28.6%), PS (14.3%), and PVC (14.3%), respectively (Fig. 2c). Over 70% of the polymers identified in microplastic particles consisted of PE and PP. This finding is reasonable, considering that the study sites were either urban (Urban area) or suburban to rural (Tourism) areas, where disposable items like food wrappers, straws, water and beverage bottles, wire insulation, plastic bags, and sachets for personal care products (shampoo, conditioners, and scrub) are commonly utilised. It is crucial to highlight that PP, PE, PS, and PVC have demonstrated a higher affinity for a range of environmental contaminants, including heavy metals and hydrophilic and/or hydrophobic chemicals (Amelia et al. 2021). Specifically, PE exhibits the highest affinity for heavy metals, while PS shows the highest affinity for hydrophilic and hydrophobic chemicals (Amelia et al. 2021). In this context, the presence of biofilm on white microplastics in the study area, coupled with the prevalence of polymer types exhibiting a high affinity for pollutants, presents a dual threat to marine life, raising concerns.

**Fig. 2** Categorisation of microplastics isolated from coastal sediment and water sample across Maharashtra state according to (a) Morphotype; (b) Colour, and (c) Polymer type

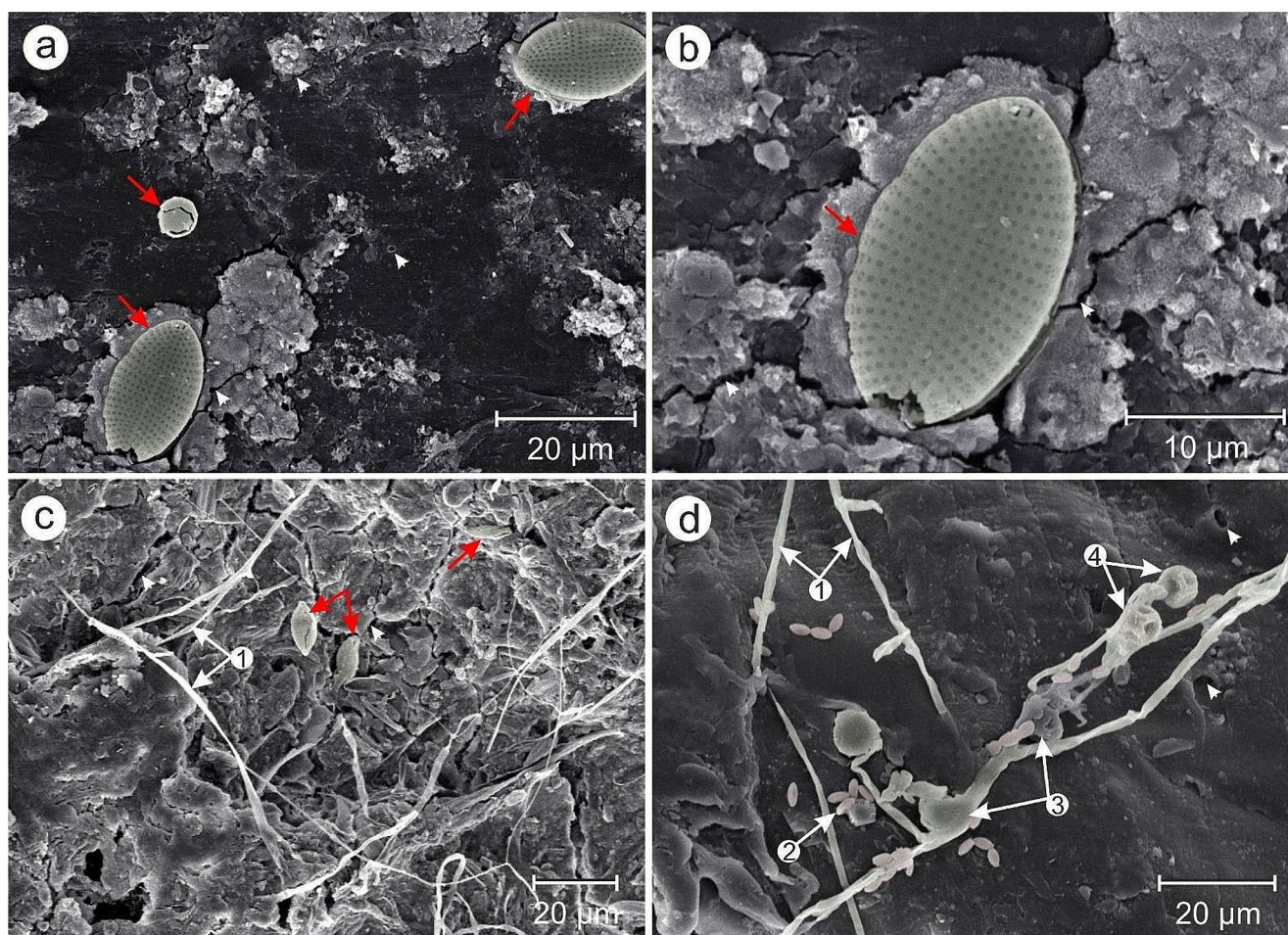


Plastispheres are recognised for fostering the growth of biofilms, hosting diverse microbial communities (Oberbeckmann et al. 2015; Frère et al. 2018; Debroy et al. 2022; Miao et al. 2021). It is crucial to emphasise the progression from biofilm formation to subsequent biodegradation processes, leading to the deterioration of the polymer's physical structure (Debroy et al. 2022). In our study, all plastispheres exhibited rough surfaces characterised by cracks, fissures, and trenches (Fig. 3a–d). This highlights the complex interplay among microplastics, biofilms, and polymer integrity, contributing to our understanding of their ecological implications. According to Eich et al. (2015), diatoms constitute a significant element of marine biofilms and play a crucial role in their formation and activity. SEM micrographs offer tangible evidence of the substantial colonisation of plastic surfaces by diatoms (Fig. 3a and b) and fungal colonisation (Fig. 3c and d) in the majority of the examined samples. Diatoms were prevalent on microplastic particles obtained from coastal waters of Maharashtra, while fungi (fungal hyphae or spores) were observed to have colonised 60% of

the microplastic particles from sediment samples. Similar findings were reported by Eich et al. (2015), where floating plastic exhibited an increased abundance of diatoms. Hence, it is evident that microplastics can act as selective artificial microhabitats, attracting distinct microbial communities.

Though fungal pathogens represent one of the most diverse microbial groups and exhibit a propensity to adhere to plastics, colonising and persisting on plastic pollutants in the environment and posing a potential pathogenic threat, their significance has only recently gained attention from the scientific community (Gkoutselis et al. 2021; Akinbobola et al. 2024). For instance, A recent investigation by Akinbobola et al. (2024) revealed that biofilms linked with plastic could function as a unique reservoir facilitating the environmental persistence of the multi-drug resistant fungal pathogen *Candida auris* for up to 30 days, whether in freshwater or marine water. Additionally, *C. auris* could transfer from plastic beads to beach sand while retaining its pathogenic properties. In the current investigation, the presence of a substantial layer of extracellular polymeric substances (EPS)





**Fig. 3** Surface characteristics and microbial colonisation of microplastic particles observed using SEM: **(a and b)** Microplastic displaying a rough surface with evident cracks, crevices, and holes (white arrowheads), hosting diatom colonisation (red arrow); **(c and d)** Micro-

plastic featuring fungal colonisation, showcasing intricate mycelial networks comprising hyphal filaments (1), clusters of conidia (2), compact mycelia (3), and conidiophore structures (4)

forming a biofilm is apparent on the plastisphere, along with distinct filamentous fungal structures such as vegetative and reproductive hyphae (Fig. 3c and d). As noted by Priyadarshane and Das (2023), EPS consists of proteins, nucleic acids, and carbohydrates that are recognised for promoting microbial growth and keeping them clustered in the biofilm. Abundant conidia, the asexual fungal spores, are observed surrounding the fungal hyphae (Fig. 3d). Additionally, there were compact mycelia (Fig. 3d) and fungal hyphae distributed across the surface or forming filamentous networks. The presence of conidiogenous hyphae (conidiophore) was also noteworthy, indicating efficient fungal growth and reproduction within the plastisphere (Fig. 3d). Our results support an earlier study conducted on soil samples obtained from disposal areas within the city confines of Siaya, Western Kenya (Gkoutselis et al. 2021). These sites receive a significant influx of plastic waste and sewage water from both terrestrial and river sources. While the specific identification of the fungus was not possible in our study, it is

reasonable to assume the potential presence of opportunistic human pathogenic fungi in these environments. Therefore, we suggest that future studies should focus on isolating and characterising the microbial community associated with plastispheres, particularly multi-drug resistant pathogens capable of enduring transitions across diverse environmental matrices, thereby possessing the potential for widespread dissemination within the landscape (Junaid et al. 2022a, b; Metcalf et al. 2022b; Khare et al. 2024). This would assist in reducing the possible risk imposed by these biofilms-associated microorganisms on human health.

Earlier studies have indicated that the microbial colonisation of microplastics is influenced by the type of polymer (Oberbeckmann et al. 2015; Frère et al. 2018). For example, marine bacteria exhibit a preference for polystyrene (PS) polymer, while algal microbes tend to favor polyvinyl chloride (PVC) surfaces (Eich et al. 2015; Miao et al. 2021), and diatoms are more prevalent on PS foam (Carson et al. 2013). In a previous investigation, Frère et al. (2018) found that

microbial communities on polyethylene (PE) were more diverse than those on PS and polypropylene (PP). However, our observations revealed more variability, such as the colonisation of fungal hyphae and diatoms on the surface of PP, while PE and PS showed predominant colonisation by fungal hyphae and diatoms, respectively (Fig. 2a and d). However, more investigation is required to fully comprehend the processes driving the preferential colonisation of microorganisms on a certain kind of microplastic polymer.

## Conclusions and Future Prospective

The results of the current study indicate that microplastics create distinct microenvironments that support a diverse range of microorganisms in the marine ecosystem, including diatoms and fungal species. The ageing of microplastics enhances microbial colonisation, and the type of microplastic polymer influences microbial colonisation patterns. Diatoms and fungal hyphae display diverse interactions with microplastic polymers. Notably, microplastics are hosts for various fungi reproductive stages, as evidenced by filamentous networks, mycelia, and conidiophores. However, the presence of potentially harmful bacteria and fungi within these biofilms necessitates further investigation. The prevalence of microplastics as microbial hosts may facilitate disease transmission, posing increased risks to human health and wildlife. Our study highlights the intricate relationship between microplastics and marine microorganisms, emphasising potential implications for ecosystems, human health, and animal welfare. Further research is imperative to fully understand these interactions and develop strategies to mitigate their adverse effects. Future investigations should prioritise three key areas: (1) employing molecular techniques like metagenomics to identify the microbes residing on microplastics; (2) assessing the ecological and epidemiological impacts of the plastisphere, and (3) investigating the influence of microplastic polymer type and morphology on biofilm formation and uptake by marine organisms.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s41208-024-00710-5>.

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**Data Availability** No datasets were generated or analysed during the current study.

## Declarations

**Ethical Approval** Not applicable.

**Conflict of Interest** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Competing Interests** The authors declare no competing interests.

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