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Assessing Microplastic Contamination in Gurupura Estuarine Sediments, Mangalore, India

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Abstract:
This study aims to shed light on the ability of intertidal ecosystems within estuaries to cope with microplastic pollution. Microplastics identified in this research were categorized based on their source (primary and secondary microplastics) and size, with particles smaller than 1000 µm comprising the majority (79%). Additionally, colour and shape characteristics were assessed, with coloured plastic (89%) and fibre shapes (99%) being predominant. Polymer types detected included Polyamide (61%), polyethylene (27%), polypropylene (11%), and polystyrene (1%). Of note, in 11 samples, secondary microplastics were more frequently recovered, indicating the potential degradation of initial microplastics via photochemical and biological processes. The most commonly identified microplastics, as determined by FTIR analysis, were polyamide, polyethylene, polystyrene, and polypropylene. These findings provide valuable insights for future studies aiming to monitor microplastic abundance along the Gurupura estuary shoreline. To mitigate the overabundance of microplastics in estuarine sediments, effective waste management strategies, legislative measures, and increased awareness of the ecological impacts of microplastics are crucial.

Keywords: *Microplastics (MP's), FTIR, degradation, Gurupura estuary, South-west coast.*

INTRODUCTION

The first time that the scientific community was made aware of the issue of ocean plastic pollution was in the 1970s (Carpenter et al., 1972; Colton and Knapp, 1974; Coe and Rogers, 1996). The majority of plastic waste, including beach trash, is produced on land. Fishing-related debris makes up almost 18% of the marine plastic waste found in the ocean ecosystem. Along with other products made from land-based materials, the aquaculture industry also the potential to discharge plastic into the ocean (Hinojosa and Thiel, 2009). Macro or mesoplastic microplastic were defined as those with a size between 0.5 and 5 mm (Andrady, 2011; Cole et al., 2011). However, different researchers have interpreted the terms "microplastics" and "microlitter" in different ways. Microplastics were characterised by (Gregory and Andrady 2003) as particles having a diameter of a few micrometres to 500 micrometres, whilst microlitter was defined as virtually undetectable particles that are retained by a 67 micrometre sieve (0.06-0.5 mm in diameter).Due to their extended residence times, propensity for biota consumption, and release of harmful components during decomposition, microplastics pose a concern to the aquatic environment (Andrady, 2011). Mixed forms of semidiurnal tides are present in the Netravati-Gurupura estuary (Reddy et al., 1979). According to Subramanian et al. (1987) and the Karnataka Irrigation Department (1986), the Netravati and Gurupura Rivers yearly discharge 12,015 x 106 m^3 and 2,822 x 106 m^3 of fresh water and 14 x 105 and 1 x 105 tonnes of silt into the Arabian Sea. According to Murthy et al. (1988), the drainage region has 3,954 mm of annual rainfall on average, with the southwest monsoon accounting for about 87% of that total. As a result, tides govern river mouth currents during the rest of the year and fresh water discharge during the southwest monsoon (Reddy et al., 1979). Because of this, the southwest monsoon is characterised by ebb flow, whereas the winter and summer are characterised by flood flow. Objective is to assess the microplastic contamination in the Gurupura River sediments.

Investigation zone

Dakshina Kannada is a maritime district located in the south-western part of Karnataka state adjoining the Arabian Sea. The geographical area is 4770 sq. km the study area lies in between 12°56'12" - 12° 57' 59" N and 74° 47' 57" - 74°, 48' 09" E which has a tropical climate and the maximum temperature recorded so far is 36° C. The average annual rainfall is 3954 mm out of which 87% is received during the southwest monsoon (Murthy et al., 1988).

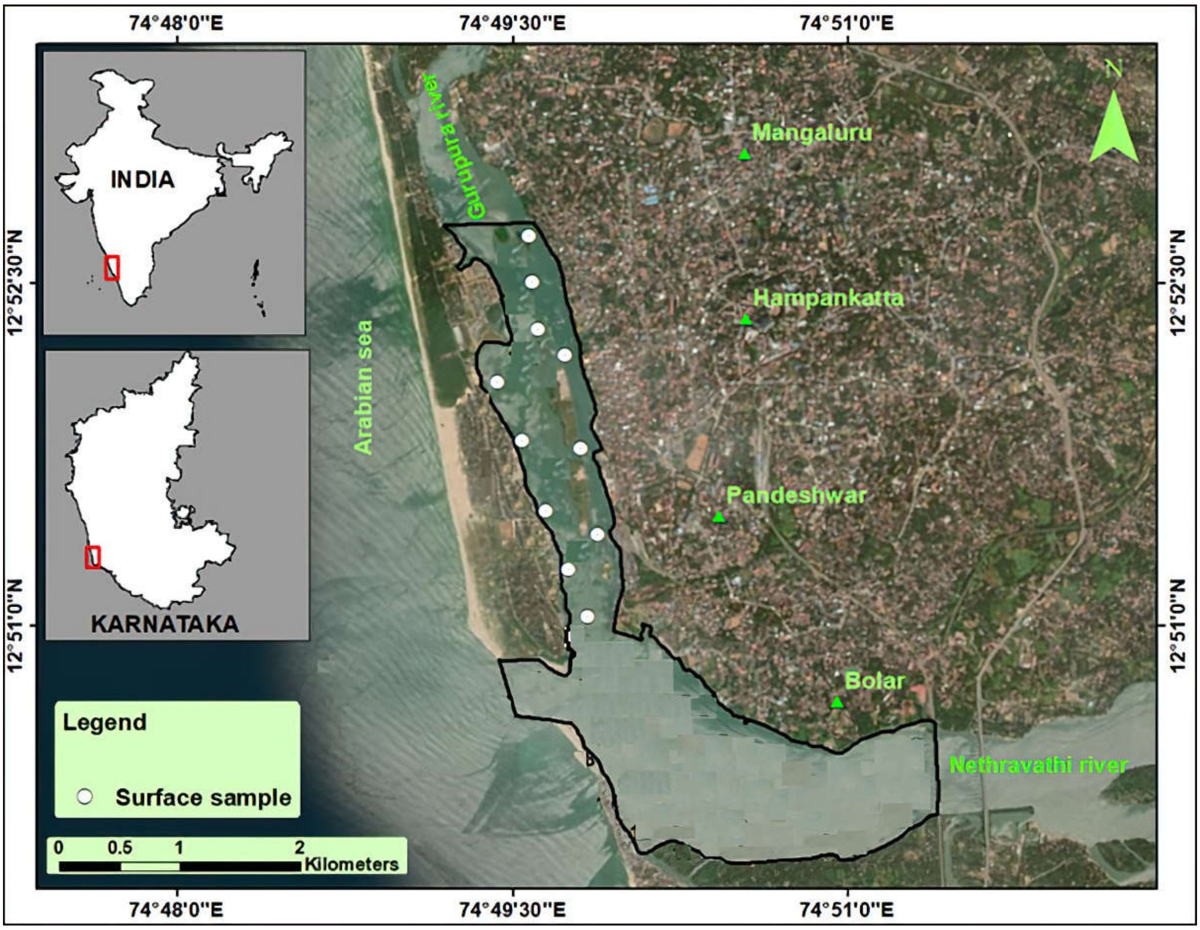

Figure 1: Sampling Locations across the Gurupura River Estuary: A Geospatial Overview

MATERIALS AND METHODS

A Van Veen grab sampler and the grid sampling method were used in collectionof11 sediment samples with 400 to 500m intervals. The wet samples were sieved using a 5 mm screen to remove large debris while retaining particles <5 mm. The sediment was dried at 50°C in ceramic bowls. The oven dried samples were homogenised and passed through a 5 mm testing sieve to remove large debris and organic plant remains (Sruthy and Ramasamy, 2017). According to National Oceanic and Atmospheric Administration (NOAA) criteria, microplastic was obtained from sieved sediment samples (Masura et al., 2015).30g of dried sediment was treated with a 30% H_2O_2solutionfollowed by 2N HCl to remove the organic content and calcareous component from the surface sediments. Later, the density separation method was employed: The pre-treated estuary sediments and 50cc of zinc chloride solution (density: 1.58g/cm^3) were thoroughly blended. Using a vacuum pump assembly and 0.45 m of Whatman® nitro-cellulose membrane filter paper, the mixture was filtered. The filtering procedure was carried out three times in order to improve the outcomes of the extraction. Using an attenuated total reflectance diamond crystal attachment and Fourier-transform infrared spectroscopy (FTIR) technology, the different polymer compositions of the microplastics were distinguished. The recovered microplastic was identified using an online digital camera system (Model: Leica DMC 4500) and an optical stereo zoom microscope in polarising mode based on the colour, shape, and composition of the materials. The distribution of microplastics in terms of colour, shape, size, and composition was displayed using pie chart. All containers and pieces of equipment used for microplastics extraction was meticulously cleaned with distilled water before use in order to prevent contamination. Similarly, Kimberly Clark cellulose wipe was used to clean the Petri dishes that were used to preserve the samples. In order to screen for contamination during analysis, the extraction procedure for a sample was performed without a sediment sample.

RESULTS AND DISCUSSION

Colour classification of microplastics

The microplstic appealing colour, diminutive size, and high buoyancy, fish are able to consume them (Chatterjee and Sharma, 2019). MPs of various colours display in the silt as a result of the frequent usage of colored plastic objects including clothes, packaging, and fishing gear. Zhang et al. (2015); Wang et al. (2017). While it is acknowledged that colours may undergo alterations during transportation through surface water due to weathering (Kalogerakis et al., 2017; Wu et al., 2018), such changes are not consistently observed. The colour classification of microplastic was: colored plastic (89%) and white plastic (11%). The transparent variety out numbers the white-colored variety in white plastics and the majority of the fragments were blue and white in colour (Tables 1)

Shape of microplastics

Fibres, films, pieces, and pellets are the four primary types of plastics (Doyle et al., 2011; Hidalgo-Ruiz et al., 2012 .Household waste from using personal care products and washing clothes is a significant contributor to fibre pollution in the environment. Peng et al. 2017Larger plastic items degrade in rivers due to mechanical and UV ageing. Fibres are likely created by fishing gear and textiles. They are frequently dumped into drainage canals of rivers. (Table 1) display the shapes of the Microplastic. The shapes of MPs are classified as fibre, pellet, fragment, and film.

Size classification of microplastics

Visual counting under an optical microscope is the common technique for measuring microplastics, although it is time-consuming and prone to error UV radiation intensity, environmental factors, and plastics durability all affect the size and distribution of MPs (Thompson et al., 2004; Barnes et al., 2009).The size classification of MPs suggest that the majority of particles fall under <1000 µm (79%), followed by >1000 µm (21%) in surface sediments. (Figure 4 and Table 2)

Composition of microplastics

The 11 sample investigated curve of the MPs composition closely matched a spectral library for a readily accessible instrument in the range of 92.6% to 97.5% (Figure 2). According to the FTIR data, polyamide, polyethylene, polystyrene, and polypropylene are the common polymers among the types of microplastic found in estuaries sediments. The polymer types in decreasing order are Polyamide (61%) and polyethylene (27%), which predominated in the sediments, followed by polypropylene (11%), and polystyrene (1%). Polyamides are in both natural and manufactured forms. Naturally occurring polyamides include proteins found in materials like wool and silk. Synthetic polyamides may be produced using step-growth polymerization or solid-phase synthesis, and these polyamides can subsequently be used to make materials such sodium polyaspartate, nylon, and aramids. Although it may be produced using renewable resources, ethylene is frequently purchased using petroleum or natural gas.

These sources can also be used to produce ethylene, which is the building block for polyethylene. Polystyrene has been found in sludge, water, soil, and air. Polystyrene and other goods like toys, CDs and cup covers are produced using polystyrene. Sources of polypropylene include thin-wall containers (such as yoghurt cups, disposable hot beverage cups, etc.), caps and closures for bottles, crates, and pallets, just-in-time storage solutions, bottles and jars for packing condiments, detergent, and toiletries. Rigid packaging is made of polypropylene. (Figure 5 and Table 2)

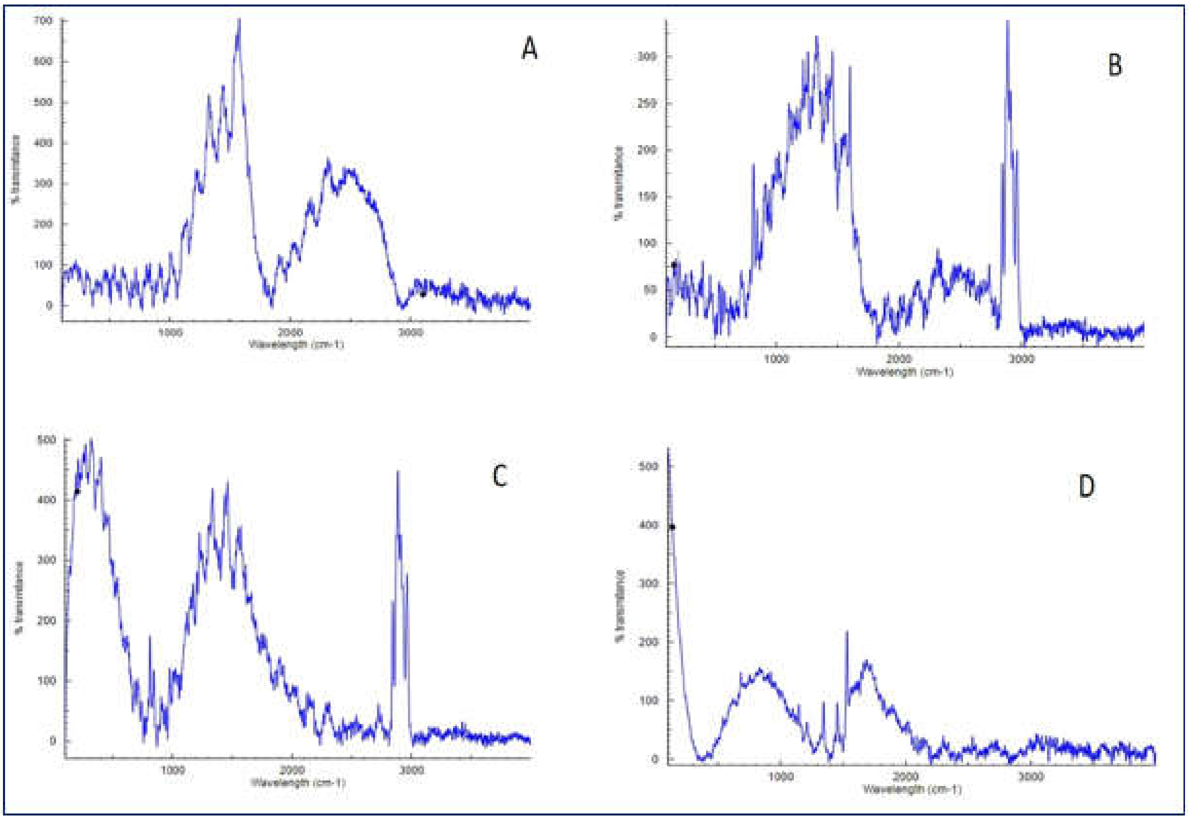

Figure 2: FTIR result the microplastics (A- polyamide, B- polyethylene; C- polypropylene, D- polystyrene

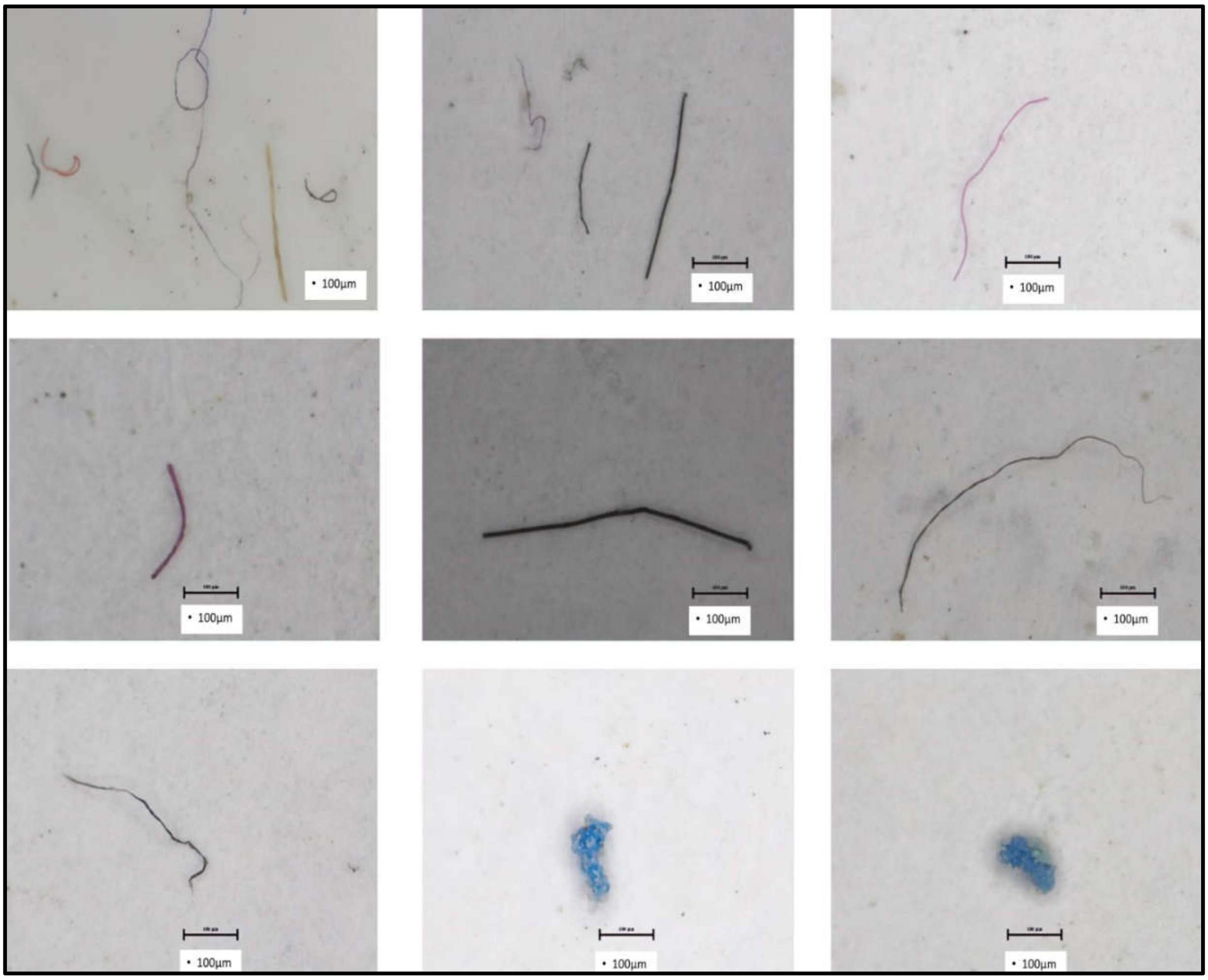

Figure 3: Fibre, Filament, Fragment and beads in the Gurupura River estuary sediments

Table 1: Shape and colour of Microplastics in surface sediments

Shape of MPS	**Fibre**							**Filament**	**Fragment**					**Beads**	**Total**
Colour of (Mps) / Sample. no	**Transparent**	**White**	**Blue**	**Red**	**Green**	**Black**	**Pink**	**White**	**White**	**Blue**	**Orange**	**Pink**	**Black**	**Black**	
1	2	1	5	6	1	4	0	0	0	0	0	0	0	0	**19**
2	0	1	5	3	1	0	0	0	0	2	0	0	0	0	**12**
3	1	2	9	3	0	1	0	0	0	0	0	0	0	0	**16**
4	0	4	1	4	0	0	0	0	0	0	0	0	0	0	**9**
5	0	9	2	6	1	5	1	2	1	0	0	0	0	0	**27**
6	0	5	3	4	0	0	0	0	0	0	0	0	0	0	**12**
7	0	4	9	5	0	0	0	0	0	0	0	0	0	0	**18**
8	2	5	4	3	1	1	1	2	0	0	0	0	0	2	**21**
9	0	13	5	5	1	0	0	0	0	0	0	0	0	0	**24**
10	1	4	8	5	1	1	0	0	2	0	0	0	0	0	**22**
11	0	1	5	2	1	1	1	0	0	0	0	0	0	0	**11**
Total	**6**	**49**	**56**	**46**	**7**	**13**	**3**	**4**	**3**	**2**	**0**	**0**	**0**	**2**	**191**

Table 2: Size and composition types of MPs in surface sediments

S. No	**< 1000 µm**	**> 1000 µm**	**(PA) polyamide**	**(PP) polypropylene**	**(PE) polyethylene**	**(PP) polypropylene**	**Total**
1	15	4	13	1	5	0	19
2	9	3	8	1	3	0	12
3	12	4	11	0	5	0	16
4	8	1	7	0	2	0	9
5	22	5	15	2	9	1	27
6	8	4	8	0	3	1	12
7	13	5	8	2	7	1	18
8	17	4	11	2	7	1	21
9	19	5	12	1	11	0	24
10	18	4	15	0	7	0	22
11	8	3	6	1	4	0	11
Total	**149**	**42**	**114**	**10**	**63**	**4**	**191**

Table. 3 A comparative investigation on the distribution of microplastics in different estuaries around the world

S. No	Study Estuaries	Location	Microplastics in sediments	References
1	Vembanad Lake	Kerala	252.8 (particles m^{-2})	Sruthy and Ramasamy 2017
2	Cochin Estuary	Kerala	1340±575.22 (particles/ d.w. Kg)	Suresh et al., 2020
3	Kayamkulam Estuary	Kerala	430.15 (particles/ d.w. Kg)	Radhakrishnan et al., 2021
4	Uppanar Estuary	Tamil Nadu	30.2 (particles/ d.w. Kg)	Begum et al., 2020
5	Coleroon Estuary	Tamil Nadu	11.7 (particles/ d.w. Kg)	Begum et al., 2020
6	Vellar Estuary	Tamil Nadu	24.8-43.4 (particles/ d.w. Kg)	Nithin et al., 2022
7	Adyar Estuary	Tamil Nadu	20 particles/50 g d.w.	Dhineka et al., 2022
8	Cooum Estuary	Tamil Nadu	14 particles/50 g d.w.	Dhineka et al., 2022
9	Mandovi-Zuari Estuaries	Goa	4873 particles/kg	Gupta et al., 2021
10	Sal Estuary	Goa	3950 particles/kg	Saha et al., 2021
11	Ganga Estuary	West Bengal	210.25 particles/kg	Sarkar et al., 2019
12	**Gurupura Estuary**	**Karnataka**	**510.36 particles/kg**	**Present study**

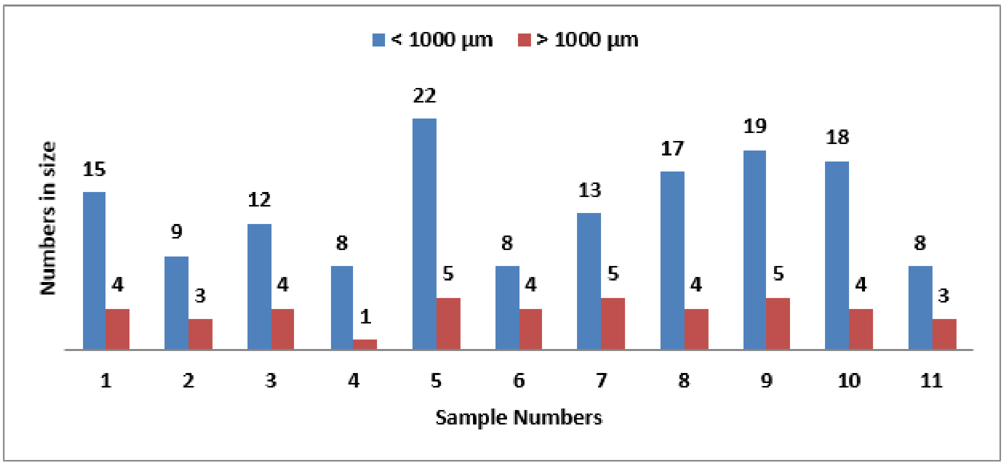

Figure 4: Size of MPs

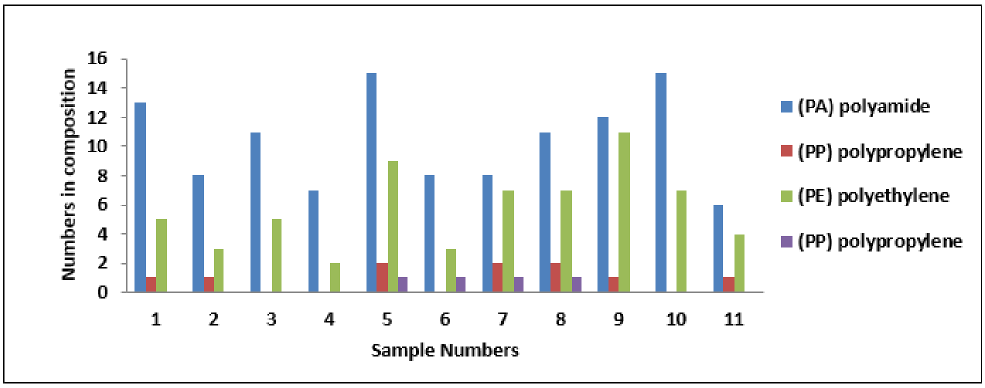

Figure 5: Composition of MPs

THE COMPARATIVE FINDINGS

The distribution of microplastics in estuarine surface sediments was shown and compared with other estuaries In India (Table.3). The Mandovi-Zuari Estuaries and Sal Estuary, Goa; the Cochin Estuary, Kerala, The dispersion of microplastics in the Vembanad estuary, on the southwest coast of India, has been documented by Sruthy and Ramasamy (2017). According to this study, low-density polyethylene is the polymer type that makes up the majority of the microplastic. The causes of microplastic in Vembanad Lake are fragmentation of larger plastic trash and improper disposal of plastic garbage.

This study documents the spatial changes in the quantity, colour, shape, size, and composition of microplastics in the Gurupur estuary, southwest coast of India. The mean abundance of the microplastic distribution was 510 particles/kg. The proximity of metropolitan areas and the sampling location's distance from the coast both contributed to the presence of microplastic in sediments. The FTIR investigations result that among the several forms of microplastics in estuary surface sediments, polyamide, polyethylene, polystyrene, and polypropylene were the predominant polymers. The appropriate management of solid waste, effects of microplastics on the ecosystem mitigate the hazards.

Source of microplastics

The primary types of microplastics are fibres shed from clothing fishing nets and tiny commercially generated particles, such as those found in cosmetics. Secondary MPs are produced as a result of the breakdown of bigger plastic items like water bottles. Exposure to outside influences, especially UV radiation, is the main contributor to this deterioration. The fact that all of the samples in this study secondary which are in multiple stages of degradation, including photo-, chemical-, and biological degradation, to become the deteriorated remnants of primary microplastics.

CONCLUSION

The majority of microplastics (MPs) found in the Gurupura Estuary exhibit white and blue hues. Fragmentation emerges as the second most prevalent shape classification following fibres, indicating potential decomposition of fishing nets during transit through the estuary, influenced by its hydrodynamics. Size-wise, smaller microplastic (<1000 µm) dominate compared to larger counterparts, attributed to their enhanced accumulation capacity within sandy substrates' interstitial spaces, contrasting with the inefficiency of larger microplastics in such accommodation. Polyamide and polyethylene emerge as the most abundant polymer types, followed by polystyrene and polypropylene. Samples 5 and 9 exhibit higher microplastic counts, with 24 to 27 microplastic identified per 30 grams of sediment, potentially linked to fishing and industrial activities. The presence of microplastic in sediments is influenced by proximity to urban areas and the distance of the sampling site from the shoreline. Addressing this issue necessitates proper solid waste management, enforcement mitigate the ecological impacts of microplastics.

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