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FTIR Spectroscopic Characterization and Identification of Microplastics in Water Samples from Ashtamudi Lake, Kollam, Kerala

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Abstract

Microplastics (MPs), defined as plastic particles under 5 mm, have garnered significant attention over the past 45 years, particularly in marine environments (Bergmann et al., 2015; Carpenter et al., 1972). Recently, research has expanded to freshwater systems, revealing their pervasive nature across aquatic, terrestrial, and atmospheric environments (Dris et al., 2015; Wagner and Lambert, 2018).MPs enter ecosystems either as primary MPs or as secondary MPs from the degradation of larger plastics. Major sources include plastic waste from households and industries, which can enter waterways directly or indirectly. This accumulation leads to detrimental effects on aquatic life (Merlin Issac & Kandasubramanian, 2021). Notably, fluvial systems are crucial pathways for transporting MPs from terrestrial sources to oceans, with studies indicating that rivers in Asia, particularly the Ganges, contribute significantly to ocean plastic pollution (Lebreton et al., 2017; Napper et al., 2021).

Research indicates a wide range of MP concentrations in European rivers, from 0.03 to 187,000 particles per cubic meter, with diverse forms such as fibers, fragments, and spheres being identified (Heß et al., 2018; Leslie et al., 2017). In India, inadequate waste management and high population density contribute to elevated MP levels in freshwater systems, with the Ganges potentially releasing billions of MPs daily into the Indian Ocean (Napper et al., 2021).MPs pose risks not only to aquatic organisms through ingestion but also raise concerns about human health via the food web (Arthur et al., 2008; Andrady, 2011). Their physical characteristics can influence their behavior in aquatic environments, with studies exploring the analogy of plastic as sediment, indicating that MPs may behave similarly to natural sediment particles (Enders et al., 2019; Kane and Clare, 2019).Despite growing awareness, research on MPs in freshwater environments remains limited compared to marine studies. Understanding the fate of MPs, alongside their ecological impacts, is critical for effective management and mitigation strategies to combat plastic pollution in all ecosystems.

INTRODUCTION

Microplastics (MPs) have been studied for more than 45 years, with a particular emphasis on the marine environment (Bergmann *et al.*, 2015; Carpenter *et al.*, 1972; Cole *et al.*, 2011). However, only recently has research begun to concentrate on freshwater environments (Dris *et al.*, 2015; Wagner and Lambert, 2018). Anthropogenic contaminants known as microplastics (MPs), which are plastic particles with a diameter of 5 mm, are pervasive and have expanded into the aquatic, terrestrial, and atmospheric environments. Increased productivity and slow biotic decomposition of plastic led to its accumulation in the environment leading to adverse effects in aquatics (Merlin Issac & Kandasubramanian, 2021). MP is released into the environment through a variety of sources and entry points, either as primary MP that is already less than 5 mm in size or as secondary MP that breaks down into smaller particles of plastic. Plastic wastes from households, industries, etc. act as a source that may enter into the marine system directly or by other water bodies, thereby raising its amount and affecting the life of aquatics (Nizzetto *et al.,* 2016).

Fluvial systems are thought to be a significant pathway for the movement of MPs from terrestrial sources into the seas. Lebreton *et al.,* 2017 evaluated the inflow of plastics into the oceans by rivers using numerical simulations. They came to the conclusion that rivers in Asia account for a sizable portion of the plastic released into rivers. Recent papers have documented a wide range of MP concentrations in European river water, from 0.03 (Mani *et al.,* 2019) to 187,000 particles (p) m3 (Leslie *et al.,* 2017). Additionally, MPs in river water produced a wide variety of forms, such as spheres, fibers, pieces, and foils, all of which had different relative abundances. Heß*et al.,* (2018) primarily identified fibers and fragments in the water phase in the Rhine and the Danube, whereas Mani *et al.,* (2015, 2019) and Lechner *et al.,* (2014) primarily discovered MP spheres. Polyethylene (PE), Polypropylene (PP), and Polystyrene (PS) were the most prevalent MP polymer types in the river water (Heß*et al.,* 2018; Mani *et al.,* 2015, 2019; Schmidt *et al.,* 2018).

The durability of the substance, low recycling rates, subpar waste management, and maritime use were listed as the primary causes of the accumulation of plastics in the environment. Therefore, the simulation was based on rates of improper waste management, population density, monthly catchment runoff, and the presence of manmade barriers like dams. They did not, however, sample the environment as part of their research.

Lebreton *et al.,*2017 state that the Ganges River in India is the second most polluted river in the world and that it releases up to 1.05 -105 tons of plastic into the Indian Ocean per year. According to samples taken along the Ganges River by Napper *et al.,* 2021, the Ganges could daily release up to 1-3 billion MPs into the Indian Ocean. India, the second-most populous nation in the world with a current population of 1.35 billion, has poor waste management and wastewater treatment, which results in a high MP generation rate. When considering the potential for pollution, so-called megacities, which have more than 10 million residents occupying a relatively compact area and are undergoing rapid economic expansion (Napper *et al.,* 2021). Only 5% of municipal solid waste and municipal waste water were treated in 2007; the remainder was immediately released into water bodies, bringing pollutants including heavy metals, in addition to informal settlements, which are typically not connected to the sewage systems. Due to this, research on the levels of heavy metals in Indian rivers have been conducted more frequently recently since the focus was on MP in maritime environments, there aren't many studies on environmental MP concentrations in Indian watercourses to date. It is reasonable to presume that solid waste degrades to MP once released into the environment and enters freshwater systems, and that the effluents released both contain MP. These earlier findings clearly show that MP is a widespread contaminant in freshwater systems throughout India.

Global attention has been drawn to the issue of plastic pollution in the oceans (UNEP and GRID-Arendal, 2016; Borrelle *et al.,* 2017). According to Geyer *et al.,* (2017), plastic has been discovered in every aspect of the marine ecosystem, from seafood to the most remote places on the planet, such as the bottom of the deepest ocean trenches (Fischer *et al.,* 2015; Peng *et al.,* 2018). Plastic garbage is dumped into the ocean; 80% of it comes from the land, primarily through rivers, and 20% comes from the water (mainly lost fishing gear; Ritchie and Roser, 2020). All of it eventually ends up in marine sediments, which serve as many contaminants' ultimate sink (Woodall *et al.*, 2014).

Microplastic, also known as minuscule plastic particles with a diameter of less than 5 mm, has been found in various ocean locations throughout the world. On an individual level, such as through eating, they are known to affect the biota, but it is unclear how they would affect the population as a whole. Through the introduction of hard-substrate habitat to environments where it is normally rare, microplastic-induced modification of pelagic ecosystems may occur. A significant link between *Halobates sericeus* and microplastic, as well as an overall increase in *H. sericeus* egg densities, were seen in the NPSG (North Pacific Subtropical Gyre) due to high microplastic concentrations. The transfer of energy between assemblages that are substrate- associated and pelagic may be facilitated by predation on *H. sericeus* eggs and recently hatched young. To comprehend the ecological effects of oceanic microplastic contamination, it may be helpful to understand the dynamics of species connected with hard substrates. (Goldstein *et al.,* 2012).

According to Allen's definition, plastic particles are solid, mobile forms of matter and are thus a part of the field of "physical sedimentology" (1985). It seems sense to examine what can be learnt about the destiny of plastic in the marine environment from the study of sedimentology in order to influence management decisions. According to Kane and Clare (2019), it is possible that the fate of solid plastic particles in the environment will be similar to the fate of silt particles with roughly identical physical characteristics. Additionally, as plastic has just recently been spread into the marine environment in considerable amounts, this represents an instantaneous event (in geologic time) and offers a chance to test sedimentology theories.

To use the "plastic as sediment" analogy, it is essential to understand hydraulic equivalence (Enders *et al.*, 2019; Kane and Clare, 2019). The conventional models for frequently encountered depositional environments can be used to forecast the likely destiny of plastic in the marine environment where hydraulic equivalency can be determined to exist between certain plastic and sediment types. This idea serves as the foundation for both the current investigation and numerical (hydrodynamic) simulations of plastic destiny in the marine environment (Eg. Hardesty *et al.*, 2017; Koelmans *et al.*, 2017; Atwood *et al.*, 2019; Van Wijnen *et al.,*2019). A family of petroleum- derived organic polymers known as plastic includes polyvinyl chloride (PVC), nylon, polyethylene (PE), polystyrene (PS), and polypropylene (PP) (Vert *et al.*, 2012). PP, PE, low-density polyethylene (LDPE), and polyacrylates are typical plastic polymers (Imhof *et al.*, 2013; Frias *et al.*, 2014; Hidalgo-Ruz *et al.*, 2012).

Over the past 50 years, plastic production and use have continually expanded, with worldwide production exceeding 300 million tonnes in 2014 (Plastics Europe, 2015). These usage patterns indicate that the production of plastics and the amount of plastics (including microplastics) in aquatic habitats are expected to rise over time (Andrady, 2011; Galgani *et al.*, 2010). Although the size of a particle considered to be "microplastic" is not universally agreed upon in the literature, many studies adopt a cut off of 0.5 or 1 mm to distinguish between macro or mesoplastic and microplastic particles (Andrady, 2011; Cole *et al.*, 2011). Studies tended to focus on plastic particles between 1 and 5 mm before around 2010, and information about smaller particle sizes was rare before that time (Claessens *et al.*, 2011).

Due to their well-documented abundance in marine ecosystems, prolonged residence durations, and propensity to be consumed by biota, microplastics may present a concern to aquatic environments (Arthur *et al.,* 2008a; Galgani *et al.*, 2010; Andrady, 2011). The small size of microplastics results in their uptake by a wide range of aquatic species disturbing their physiological functions, which then go through the food web creating adverse health issues in humans.

Few researches have examined the existence, fate, and impacts of microplastics in freshwater habitat, despite an increasing number of studies and reviews on plastic pollution in the marine environment. According to the concept of hydraulic equivalence, a plastic particle of a certain size, shape, and density will react in the environment similarly to a naturally occurring sediment particle of a known size, shape, and density. A quartz sphere is the benchmark used in sedimentology to determine density and shape Leeder, 1982). Quartz has a density of 2.65 g/cm3.

In contrast, plastic particles have a density of roughly 0.9 to 1.4 g/cm3. In reality, most naturally occurring minerals have densities between 1.7 and 3.0 g/cm3 that are higher than plastic. Additionally, the majority of natural grains do not have perfect spheres and instead come in a variety of forms, just like plastic particles.

However, naturally occurring organic waste, such as wood, leaves, and marine algal detritus, typically has densities that are equivalent to plastic, ranging between 0.9 and 1.3 g/cm3. In addition, despite having different densities, sand, silt, and clay-sized particles can theoretically have hydraulic equivalence with larger-sized plastic particles (Enders *et al.*,2019;). Additionally, some studies have found a correlation between plastic particle size and wave/current energy (Ling *et al.*, 2017; Enders *et al.*, 2019). Since they are primarily controlled by the same physical principles, it is reasonable to assume that the fate of plastic in the marine environment will be comparable to the fate of naturally occurring organic matter as well as silt- and clay-sized mineral grains (Enders *et al.*, 2019).

REVIEW OF LITERATURE

Microplastics have been investigated for over 45 years especially in the marine environment (Bergmann *et al.*, 2015), but only in recent years research has also started to focus on freshwater environments (Dris *et al.*, 2015). With regard to European rivers, previous studies have investigated microplastics in the catchments of the river Rhine (Heß *et al.*, 2018). Plastic is a general term that refers to a family of organic polymers derived from petroleum sources, including polyvinylchloride (PVC), nylon, polyethylene (PE), polystyrene (PS), and polypropylene (PP) (Vert *et al.*, 2012). Common plastic polymers include PP, PE, low-density polyethylene (LDPE), and polyacrylates (Imhof *et al.*, 2013). Plastic production and use has increased steadily over the past 50 years, with global production reaching over 300 million tons in 2014 (Plastics Europe, 2015). These usage patterns suggest that plastic production and quantities of plastics (including microplastics) in aquatic environments will likely continue to increase over time (Andrady, 2011). The defined size of a particle constituting a “microplastic” varies, but an upper limit of 5 mm is generally agreed upon in the literature, and many researchers use 0.5 or 1 mm as the cut-off between macro or mesoplastic and microplastic (Andrady, 2011; Cole *et al.*, 2011). Prior to about 2010, studies typically investigated plastic particles ranging from 1 to 5 mm, and data relevant to smaller particle sizes are scarce prior to that time (Claessens *et al.*, 2011).

Microplastics may pose a risk to aquatic environments due to their documented ubiquity in marine ecosystems, long residence times, and propensity to be ingested by biota (Arthur *et al.*, 2008a; Galgani *et al.*, 2010; Andrady, 2011). While studies and reviews on plastic pollution in the marine environment are increasingly common, to date, few studies have assessed the presence, fate, and effects of microplastics in freshwater environments. Even fewer studies have been completed in Canada; despite the fact that 7% of the world’s renewable freshwater is contained within these water bodies (Environment Canada, 2012). While the presence, sources, fate, and effects of microplastics have not been well characterized in freshwater systems, evidence from the marine environment suggests that microplastics could be considered contaminants of emerging concern (Wagner *et al.*, 2014; Eerkes-Medrano *et al.*, 2015). Microplastics fall into two categories: they are either produced intentionally (e.g., microbeads, plastic production pellets) and called "primary microplastics" or are degraded from larger plastic to smaller pieces (e.g., fibers) and are called "secondary microplastics" (Cole *et al.*, 2011; Gilman, 2013).

Microplastics may pose a risk to aquatic environments due to their documented ubiquity in marine ecosystems, long residence times, and propensity to be ingested by biota (Arthur *et al.*, 2008a; Galgani *et al.*, 2010; Andrady, 2011). In recent decades, increased and uncontrolled plastic manufacture has resulted in significant contamination in the environment. According to Plastics- Europe (2018), global plastic output in 2017 exceeded 348 million tons, and it is estimated that by 2050, global plastic production might reach 33 billion tons (Cincinelli *et al.*, 2019). China consumes the most plastic (30%) in the world (NBoSo, 2017). According to Ramos et al., (2015), polyethene plastic film (PE) residues were identified in around 10% of agricultural land. Klemes *et al.*, (2020) reported that from January 20 to March 31, 2020; 207 kilotons of residual medical waste were collected in China. Plastic syringes, plastic drips, plastic gloves, and plastic bags are among the medical waste (Tang, 2020, Klemes *et al.*, 2020). Previous research has shown that plastic mulch is a productive agricultural strategy (Kader *et al.*, 2017, Zhao *et al.*, 2016), but it also causes a high concentration of waste plastic fragments in the soil environment (Kader *et al.*, 2017).

The lack of effective waste plastic processing has resulted in several environmental issues, including the accumulation of plastic fragments in the world's oceans (Klingelhöfer *et al.*, 2020), and soil environment (Ateiam *et al.*, 2020). Different mechanisms in the soil environment break down waste plastic residues from plastic mulching procedures in agriculture that are left over after usage, eventually becoming microplastics (MPs) with a size of 5 mm (Thompson, 2006, Ryan *et al.*, 2009). By the action of physical forces, remaining waste plastic materials from mulching operations are gradually transforming into smaller and smaller residues, eventually transforming into microplastics (Steinmetz *et al.*, 2016, Horton *et al.*, 2017a, Huang *et al.*, 2020, Yu *et al.*, 2021). Microplastics are formed as a result of physical, chemical, and biological processes such as ultraviolet rays, water or air erosion, and the work of earthworms (Wright and Kelly, 2017). In addition, the remaining polymers undergo photo-oxidative degradation, which causes them to break down into even smaller particles (Gasperi *et al.*, 2018). MPs pollution has become a global concern, despite the fact that soil pollution caused by plastic has been mostly disregarded. Aerial deposition, sewage sludge techniques, compost and plastic film mulching, and tyre abrasion have all been mentioned in the literature as MPs sources (Sarker *et al.*, 2020, Selonen *et al.*, 2021). The presence of MPs from various sources has a significant impact on the soil environment (Koutnik *et al.*, 2021). The main sources of MPs in the soil are mulching and sludge operations (He et al., 2018, Petroody *et al.*, 2021). It is estimated that around 44,000–300,000 and 63,000–430,000 tons of MPs are applied annually to North American and European cropland, respectively, through sewage sludge (Gionfra, 2018). Sewage irrigation is another source of MPs in the soil, with a higher abundance of MPs (5190 pieces kg 1) in sewage irrigated agricultural areas than in non- sewage irrigated agricultural fields (2030 pieces) (Nizzetto *et al.*, 2016, Van den Berg *et al.*, 2020).

It's critical to situate plastic pollution in the context of natural sediment transport mechanisms right away. Humans currently produce approximately 360 million tons/year of plastics (Plastics Europe, 2019) and it is estimated that ~8–14 million tons/year enters the ocean (about 3 percent of all production); some is lost or deliberately thrown overboard from ships, but most enters the marine environment from the land via rivers (Jambeck*et al.*,2015). 8 million tons per year compares to the 12.5 billion tons of sediment transported to the coastal marine environment by rivers each year (Syvitski*et al.*, 2005). As a result, the annual mass of sediments entering the oceans is 1500 times more than the mass of MP particles. The total amount of waste reaching the oceans from all rivers is estimated to be roughly 200 million tons per year (Hedges *et al.*, 1997), which is 25 times the quantity of plastic (i.e., plastic currently equals approximately 4 percent of POM entering the oceans). Given their similar densities, the contrast of MP and organic matter in terms of sediment particle behaviour is very intriguing. Organic matter is dissolved organic matter (DOM; particles less than 0.05 m) and particulate organic matter (POM; particles greater than 0.05 m) that enters the marine environment through rivers. Organic matter reaching the ocean in total amounts to around 400 million tons per year, or about 1% of total carbon stored through terrestrial primary production. Organic matter in its many forms, dissolved and particulate, has very distinct fates in the marine environment and plays very different roles in the Earth's carbon cycle (Hedges et al., 1997; Blair and Aller, 2011; Kandasamy and Nath, 2016).

In a study of bottom sediments in Swedish industrial harbors, Noren (2007) discovered that the majority of the particles were milk-white to clear spheres with a diameter of 0.5 to 1 mm.

According to Black *et al*., 2018 MP samples obtained in shallow water near storm water outflows into Puget Sound, USA, revealed that the MP was primarily made up of fibers.

Haave *et al.*, (2019) did not specifically state that the polyurethane acrylic resin that dominated MP in 500 m sampled adjacent to sewage outfalls near Bergen, Norway, occurred in the form of "fragments". Singdahl-Larsen (2019) discovered that fibers were the dominating form of MP in the upper sediment layers, but that other forms (films and fragments) prevailed deeper down in the cores in older sediments in a study of sediments and core samples taken in the Oslo fjord. Black *et al.*, (2018) wet-sieved their sediment samples at 1 mm and 335 m, then visually selected MPs from the sieved sediment.

Hu *et al.*, 2020 studied surface water and sediment in Dongting Lake (China) 0.62–4.31 items/m2 were collected from Sediment and 21–52 items/100 g from water. 50–91% fibres, 5.67– 33.33% beads, 2.63–20.00% fragments. Napper *et al.*, 2021 studied microplastics in Ganges River (India). 120 water samples were studied in two seasons, pre-monsoon and post-monsoon. He identified 91% fiber, and the rest 9% fragment.

The aim of this study was to provide the first investigation on the abundance, polymer type and characteristics of microplastics in water along the different sites of Ashtamudi Lake, Kollam, Kerala.

OBJECTIVES

- To assess the microplastic contamination in Ashtamudi Lake.
- To identify the type of microplastics obtained using FTIR spectroscopy.

METHODOLOGY

SAMPLE SITE

The Ashtamudi is one of the largest wetland ecosystems in Kerala. This estuarine system lies in Kollam district and is the second largest wet land of the state. Ashtamudi Lake has been designated as RAMSAR SITE in November 2002. The lake is under pollution stress on many pockets that are more localized to urbanization of Kollam town. Several major and minor drainage channels loaded with waste products from municipal and industrial sources join the lake at the southern end.

SITE SELECTION:

Figure 1 shows the diagrammatic representation of the sites selected for the present study in Ashtamudi Lake.

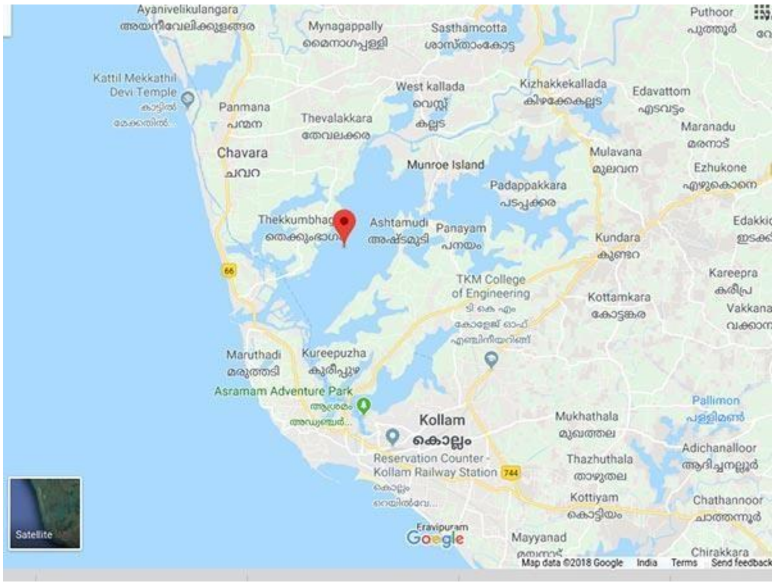


Fig 1: Diagrammatic representation of the study site

(Site 1: Asramam, Site 2:Mundro island, Site 3: Dalavapuram, Site 4: Sambranikkodi, Site 5: Kadavoor)

Samples were collected from five different sites (Figure1) along the Ashtamudi lake - Asramam (8.8963^0 N, 76.5907^{0}E) (Figure 1), Munroe island (8.9952^{0}N, 76.6105^{0}E), (Figure 2) Dalavapuram (Figure 3), Sambranikkodi (8.9487^0 N, 76.55030 E), Kadavoor (8.9205°N, 76.5940^{0}E) (Figure 4) Kollam, Kerala, India.

Figures 2-5 show the photographs of specific sites selected for the study. 5 sites in the estuary were selected purposively for the present study

Site 1: ASRAMAM

SITE 2: MUNROE ISLAND

SITE 3: DALAVAPURAM

Site 4: SAMBRANIKKODI

Site 5: KADAVOOR

STUDY PERIOD:
The water, samples were collected during the pre- monsoon season precisely during March 2022 to May 2022.

Sample collection:
Plastic bottles were totally avoided for collection and storage of the samples. Bottle sampling method was performed in flowing water using clean glass bottles (1L) at a depth of 1- 2cm below the water surface. Water samplings were done during morning hours between 7 AM and 9 AM. Multiple samples were collected by following standard sampling procedures of APHA (2012). The collected samples were transferred to glass bottles. The closed and labelled containers were transported to the laboratory for further examination.

WATER ANALYSIS
Wet Sieving
The sample was poured through a stainless steel fine mesh sieve. Sample bottle was rinsed with squirt bottle filled with distilled water to transfer all residual solids to the sieves. This also removes salts from the field sample. The rinsing was repeated thrice. Later the sieve was also thoroughly rinsed using distilled water.
Transfer of Sieved Solids
A clean and dry 500 ml beaker was weighed to the nearest 0.1 mg. Solids collected in the 0.3-mm sieve was transferred into the tared beaker using a spatula and by minimal rinsing with distilled water from a squirt bottle. Ensured all solids are transferred into the beaker. The beaker was placed in an oven at 90^{o}C for 24 hours or longer to sample dryness.
Wet Peroxide Oxidation (WPO)
20 ml of aqueous 0.05M Fe(II) solution was added to the beaker containing the 0.3 mm size fraction of collected solids. 20 ml of 30% hydrogen peroxide was added and heated to 75^{o}C on a hotplate. As soon as gas bubbles were observed at the surface, beaker was removed from the hotplate and placed in the fume hood until the boiling subsided. Again heated to 75^{o}C for an additional 30 minutes. If natural organic material is visible, add another 20 ml of 30% hydrogen peroxide. Repeated until no natural

organic material was visible.

Density Separation

Approximately 5 g of salt (NaCl) per 50 ml of sample was added to increase the density of the aqueous solution (~5 M NaCl). Heated the mixture to 75ºC until the salt dissolved and then transferred the WPO solution to the density separator. Then the WPO beaker were rinsed with distilled water to transfer all remaining solids to the density separator. Covered loosely with aluminum foil. The solids were allowed to settle overnight. Visually inspected the settled solids for any microplastics. When present, drained the settled solids from the separator and removed the microplastics using forceps. Drained settled solids from the separator. Collected floating solids in a clean 0.3-mm custom sieve. Rinsed the density separator several times with distilled water to transfer all solids to the 0.3-mm sieve. Allowed the sieve to air dry while loosely covered with aluminum foil for 24 hours.

Identification of microplastic

The filters were observed under a stereo microscope connected to a digital camera. A visual assessment was applied to identify the morphotypes of microplastics according to the physical characteristics of the particles as per Hidalgo-Ruz *et al*., 2012.

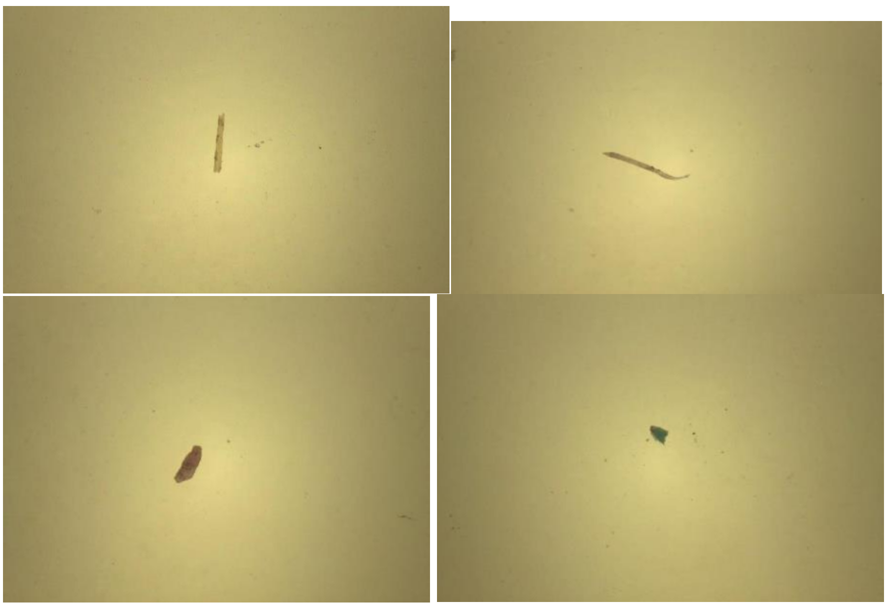
Polymer identification

Most abundant type of microplastic in the collections was selected and required quantities were taken to test the polymer types using FTIR spectroscopy.

RESULTS

A total of 803 microplastic (Figure. 1) items were obtained in the study. 208 from Sambranikodi, 180 from Kadavoor, 225 from Asramam, 56 from Munroe island, 134 from Dalavapuram. Four different morphotypes of microplastics – fibres (35.24%), fragments (26.9%) sheets (13.2%) and pellets (24.6%), were observed in various samples collected from Ashtamudi Lake. (Table 2). Microplastics of six different colours –Blue (36.9%) Red (9.7%) Yellow (2.9%) Black (16.06%) Colourless (16.7%), Green (17.7%). (Table 3) Polystyrene (22.5%), Polypropylene, (38.8%), nitrile (9.3%), polyethylene (29.7%) (Table 4) were the plastics obtained.

PLATE 1



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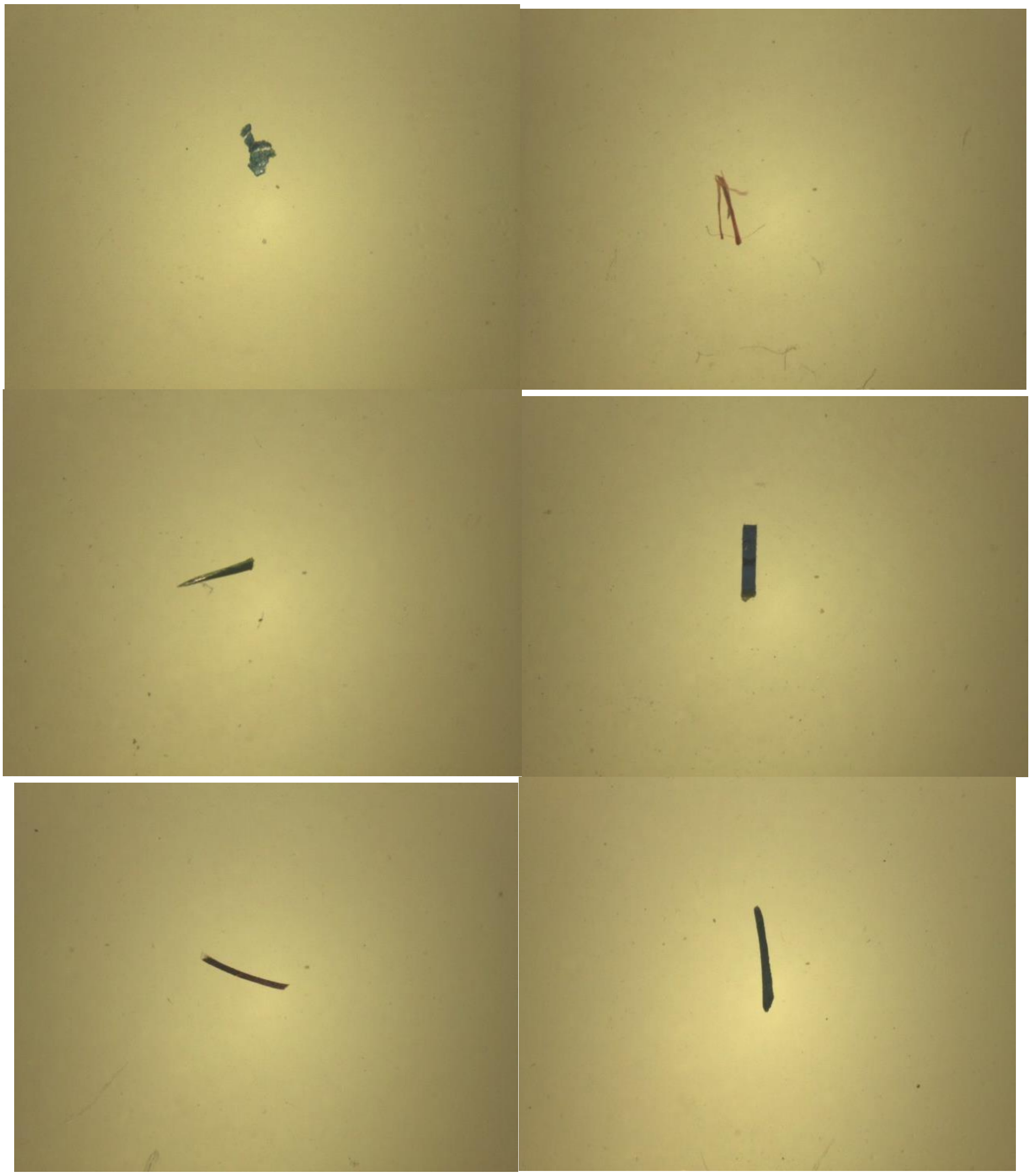

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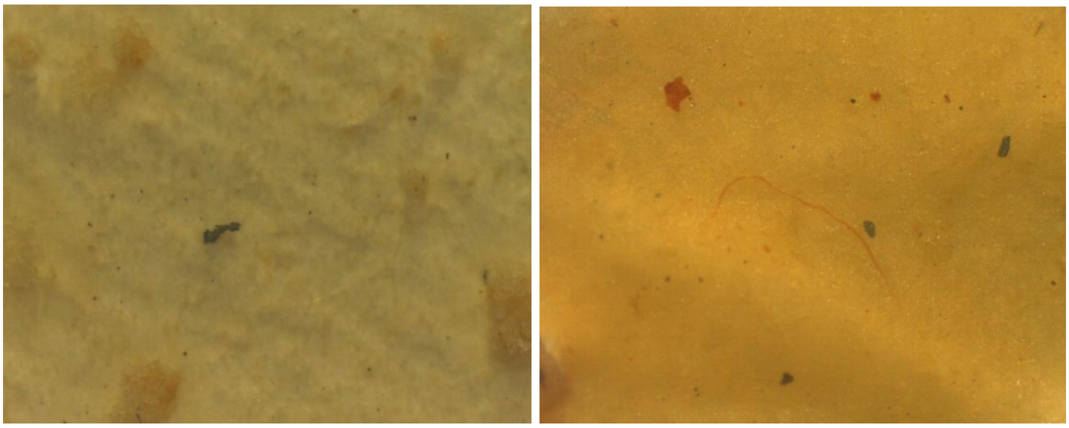

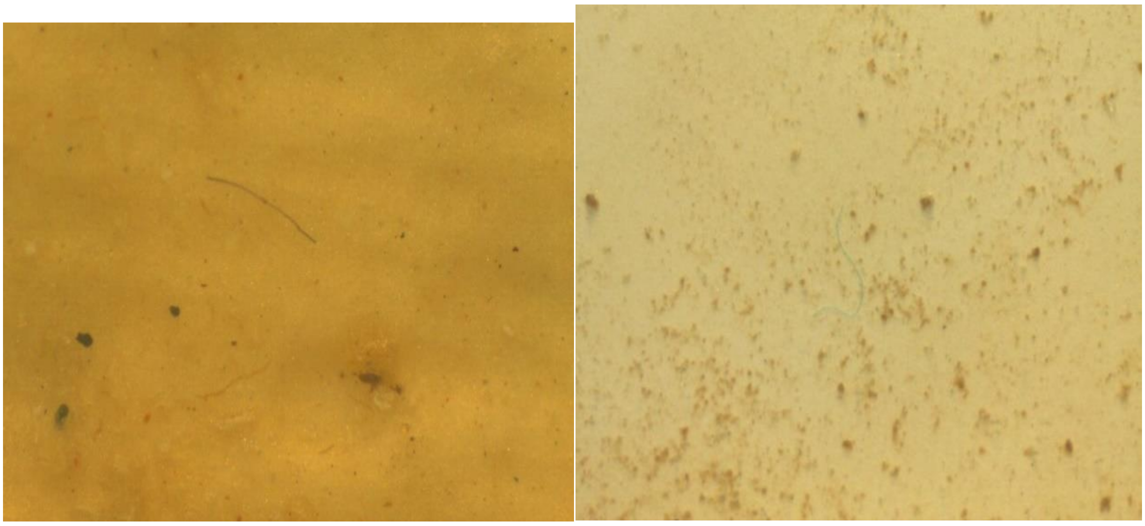

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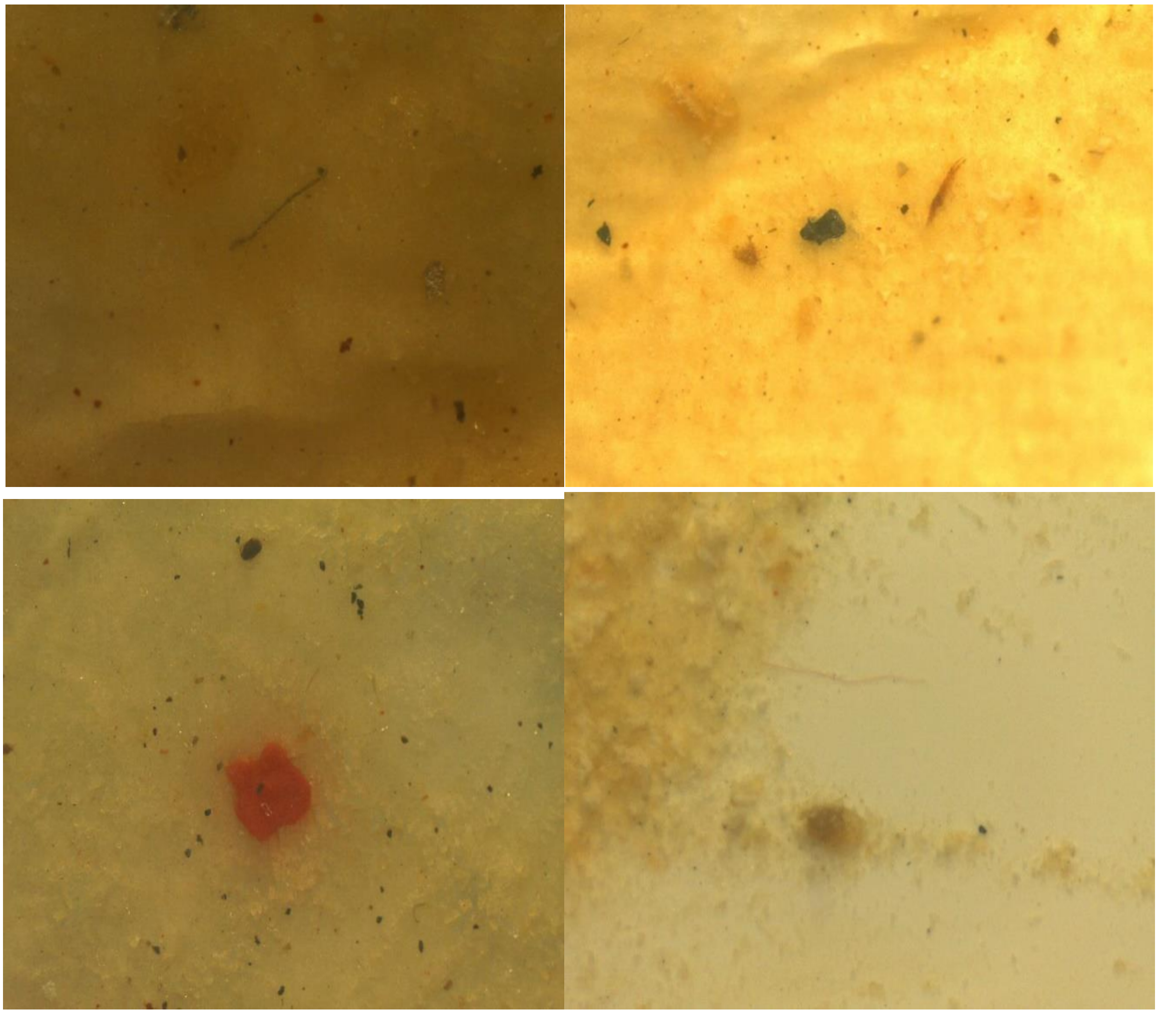

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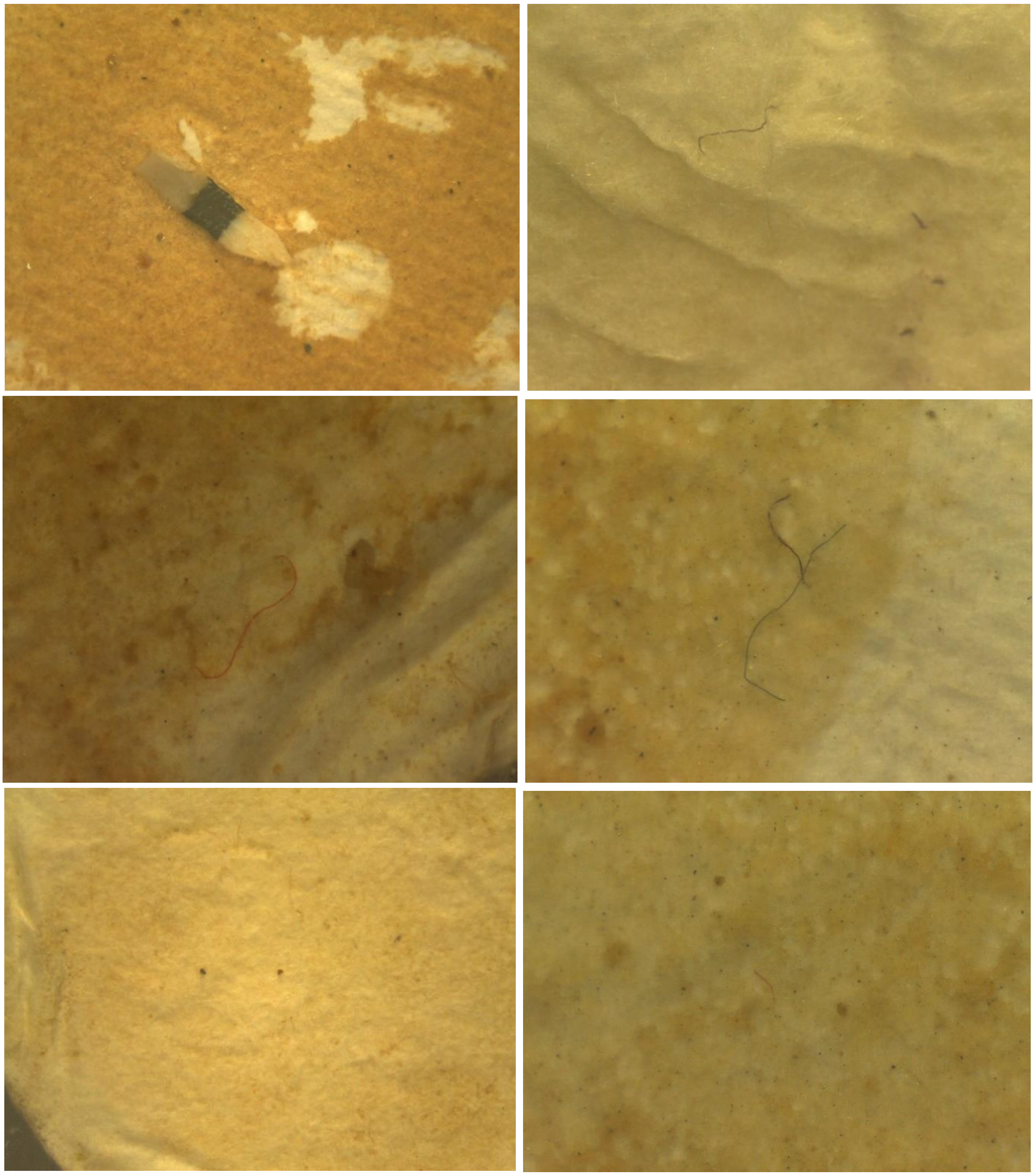
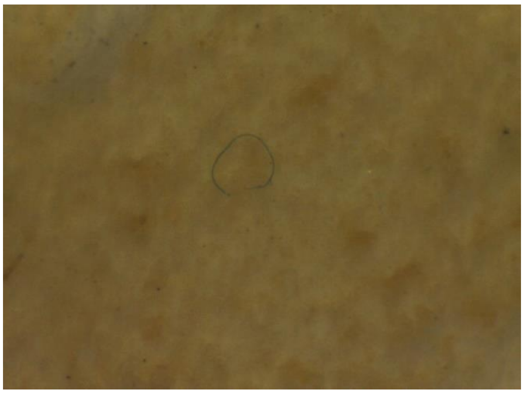
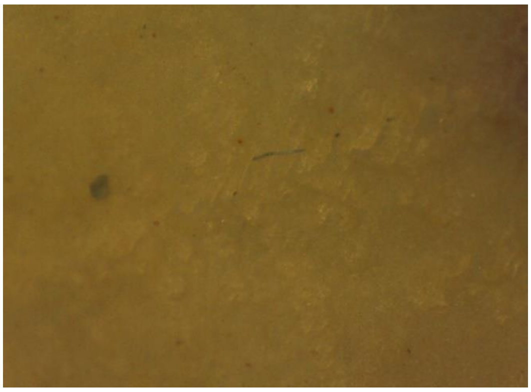


PLATE 6





Sampling Location	Station	No. of item	Mean	SD
Sambranikodi	1	75	69.3333333	14.36430762
	2	53		
	3	80		
Kadavoor	1	76	60	14.4222051
	2	56		
	3	48		
Asramam	1	68	75	10.44030651
	2	70		
	3	87		
Munroe Islands	1	12	18.6666667	8.326663998
	2	28		
	3	16		
Dalavapuram	1	54	44.6666667	12.09683154
	2	49		
	3	31		

Table 1: The sampling sites and number of plastic item collected.

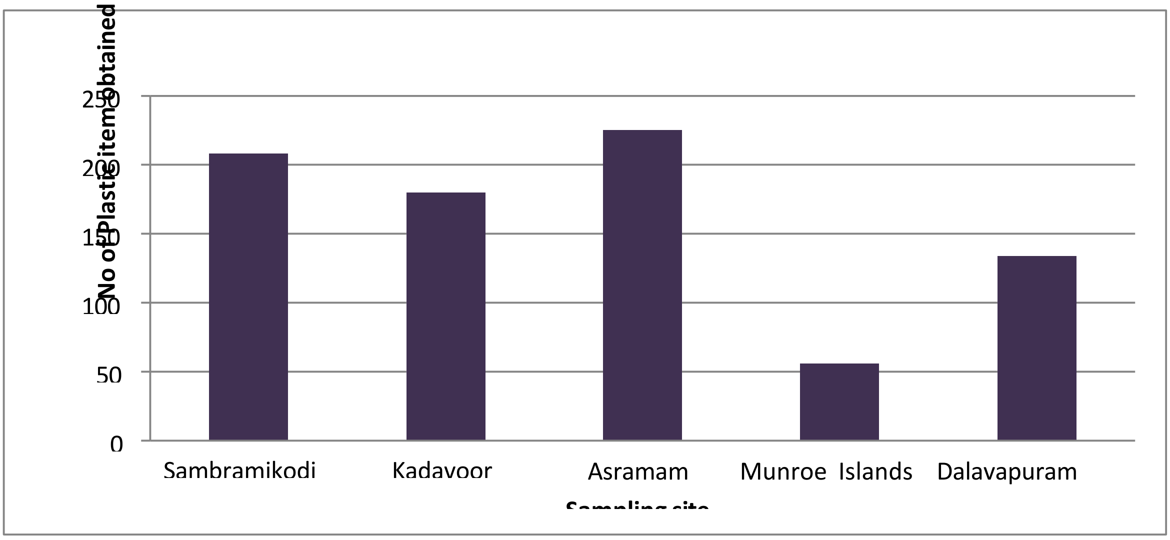


Figure 2: Bar diagram showing the occurrence of microplastics in different sampling site

Table 2 showing percentage of various colours of microplastics obtained

Colour of Plastic	No of item obtained	Percentage (%)
Green	142	17.6836862
Blue	297	36.9863014
Red	78	9.7135741
Yellow	23	2.86425903
Black	129	16.0647572
Colourless	134	16.6874222

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Table 3: Showing percentage of various polymers of microplastics obtained.

Type of Polymer	No of item	Percentage (%)
Polystyrene	181	22.5404732
Polypropylene	312	38.8542964
Nitril	75	9.33997509
Polyethylene	235	29.265

Table 4: Showing percentage of occurrence of microplastics based on size.

Size of Plastic	No of Items	g% əf a No of
Small Microplastic < 2	526	65.504358
mm Large microplastic		
(2-5 mm) Mesoplastic>	29	3.6114570

248 30.8841843

Table 5 showing the percentage of types of microplastics obtained.

Type	No of items	Percentage (%)
Fibre	283	35.24283935
Fragment	216	26.89912827
Sheet	106	13.20049813
Pellet	198	24.65753425

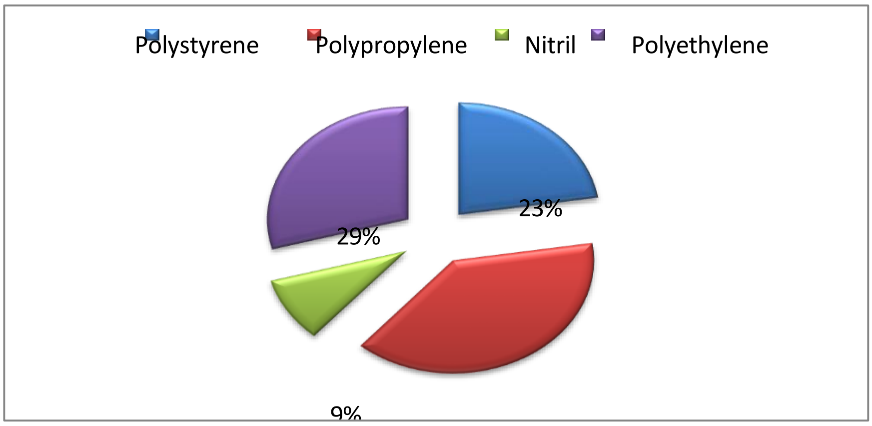

Figure 3: Pie diagram showing the percentage of different type of polymers obtained from the sampling site

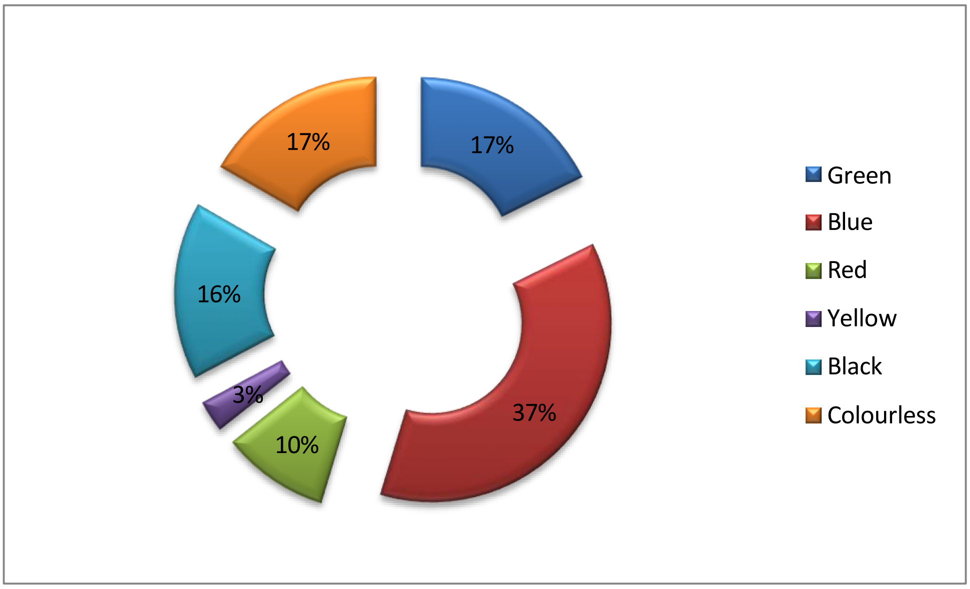

Figure 4: Illustration showing the different colour of plastic item obtained from sampling site in percentage (%)

All the suspected microplastics were validated using FT - IR analysis. The polymer types identified using FTIR, include Polyethylene, Polystyrene, Polypropylene and Nitrile. From the total particles analysed, 312 were polypropylene and the most abundant one. FTIR spectra of the four microplastics are represented in Figures 2 and 3 respectively.

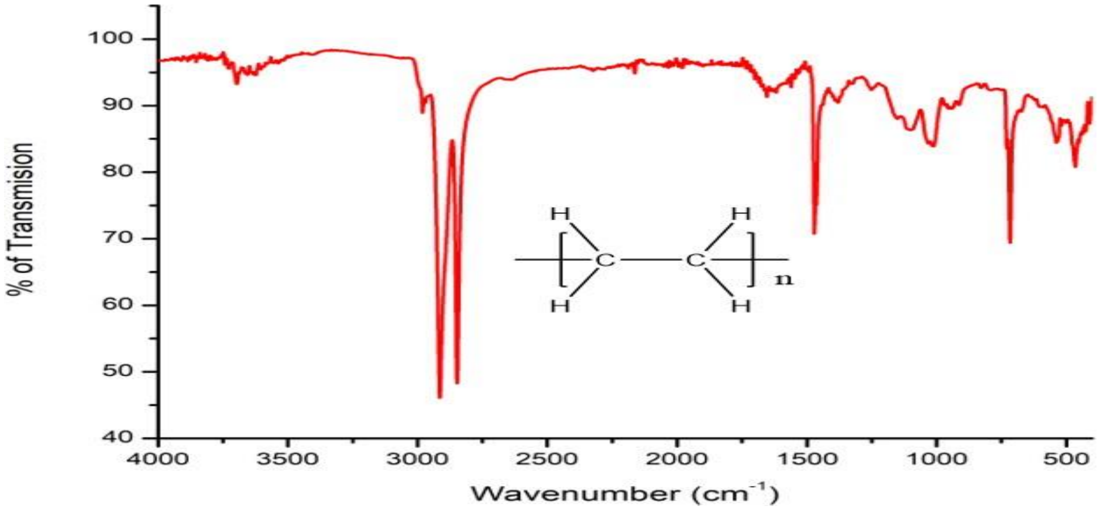

Figure 5: The FT IR spectra of Polyethylene – characteristic peak located at 2914 cm^{-1}, 2847 cm^{-1}, 1471 cm^{-1} and 717 cm^{-1}

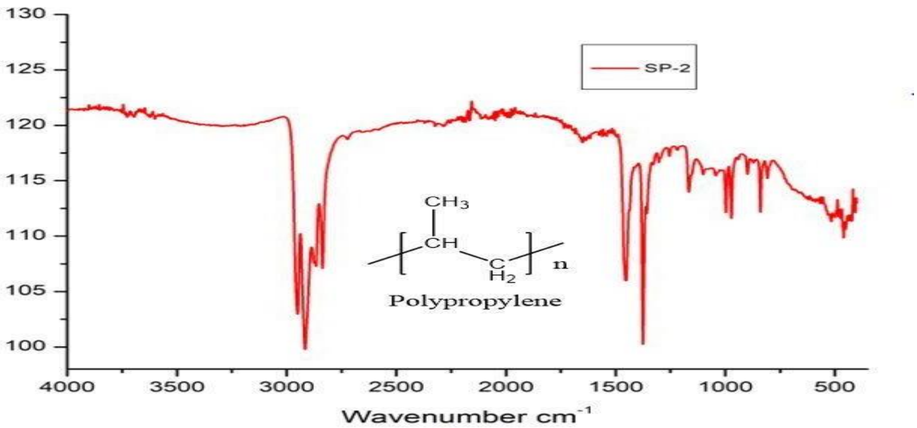

Figure 6: The FT IR spectra of Polypropylene- characteristic peak at 2950cm^{-}1, 2916cm^{-1}, 2867cm^{-1} 1375cm^{-1} and 1452 cm^{-}

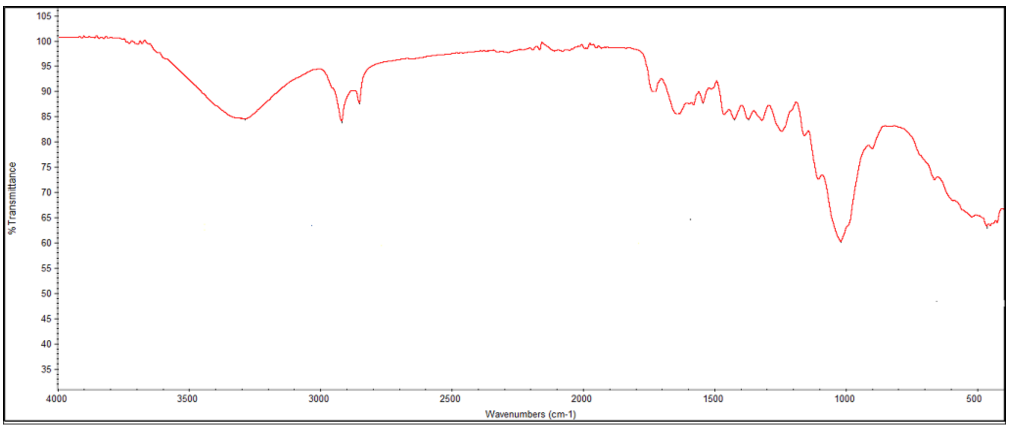

Figure 7: FT IR spectra of Nitrile with characteristic peaks at 2919cm^{-1}, 2851cm^{-1}, 2237cm^{-1}, 1602cm^{-1}, 1176cm^{-1}, 967cm^{-1}

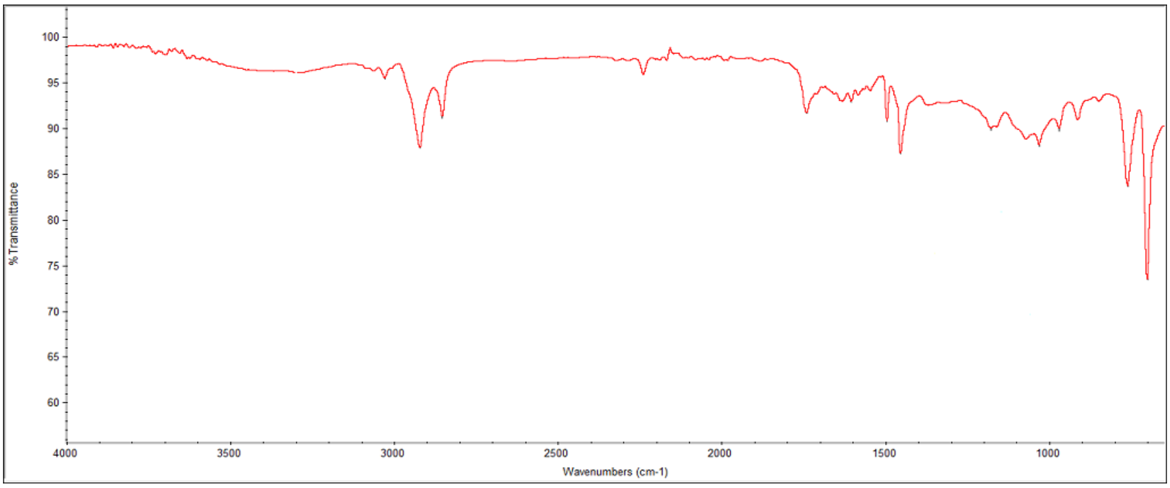

Figure 8: FT IR spectra of POLYSTYRENE with characteristic peaks at 3026cm^{-1}, 2851cm^{-1}, 1602cm^{-1}, 1493cm^{-1}, 1028cm^{-1}, 698.34cm^{-1}

DISCUSSION

Microplastics of different polymers were identified from various sites of Ashtamudi Lake in Kollam district. The polymer types identified using FTIR, include Polyethylene, Polystyrene, Polypropylene and Nitrile. From the total particles analysed, 312 were polypropylene and the most abundant one. Fibres (35.24%), fragments (26.9%) sheets (13.2%) and pellets (24.6%), were observed in various samples collected from Ashtamudi Lake. Six different colours of microplastics were identified, Blue(36.9%) Red (9.7%) Yellow (2.9%) Black (16.06%) Colourless (16.7%), Green (17.7%) together in the Asramam, Sambranikkodi, Munroe, Kadavoor and Dalavapuram.

Napper *et al.*, 2021 detected an average MP contamination of 0.038 particles/L, with 91% of those particles with different colours being fibres from the samples from the surface water of the Ganges River in Northern India and Bangladesh. Polystyrene (22.5%), Polypropylene, (38.8%), nitrile (9.3%), polyethylene (29.7%) were the plastics obtained from the study sites in Ashtamudi Lake in Kollam district. According to Vert *et al.*, 2012 polyvinylchloride (PVC), nylon, polyethylene (PE), polystyrene (PS), and polypropylene (PP) were commonly identified in riverine studies. In a study by Selvam *et al.*, 2020, Punnakayal estuary situated in the south-east coast of India was found to be contaminated with up to 19.9 MPs/l, indicating the capability of this estuary for MP channelization from inland sources to the Gulf of Mannar. In another study by Manickavasagam *et al.*, 2020, the transport of plastic debris from densely populated areas to seas via South Juhu creek was estimated. The study revealed that a major proportion of transported plastic debris comprised macroplastic and megaplastics, which undergoes fragmentation during their course and ultimately converts into MPs, which is an important issue to be addressed. Several studies, including the present study, found predominantly fibres, ranging from 37.9% (Konechnaya *et al.*, 2021), over 51.6% (Amrutha *et al.*, 2020 and 35.24% (this study) up to 91% (Napper *et al.*, 2021). Eriksen *et al.*, (2013) has been reported that freshwater systems can become contaminated by microplastics in one of three ways: effluent discharge from wastewater treatment plants, overflow of wastewater sewers during high rain events, and run-off from sludge applied to agricultural land.

SUMMARY AND CONCLUSION

- The present study identifies the presence, abundance, distribution and types of microplastics in

Ashtamudi Lake of Kollam in Kerala.

- Out of total 803 suspected microplastics, MP concentrations were high in Asramam (225).
- 208 from Sambranikodi, 180 from Kadavoor, 56 from Munroe island, 134 from Dalavapuram.
- Asramam is one of the prime centres of Kollam city, as it is one of the best tourist spot in Kollam and parks, hospitals, industries etc. are situated in the banks of Ashtamudi Lake. Hence the pollution level is considerably high. Compared to other sites Sambranikkodi is an emerging tourist spot and lots of human intervention is occurring leading to an increase in dumping of disposables and other wastes recently.
- Four different morphotypes of microplastics – fibres (35.24%), fragments (26.9%) sheets (13.2%) and pellets (24.6%), were observed in various samples collected from Ashtamudi Lake. (Table 2). Microplastics of six different colours –Blue (36.9%) Red (9.7%) Yellow (2.9%) Black (16.06%, Colourless (16.7%), Green (17.7%) (Table 3). Polypropylene (38.8%) and Polyethylene (29.7%) were the most abundant plastics obtained (Table 4). This indicates plastic pollution on and off land due to plastic carry bags, plastic bottles and packing materials which needs urgent management actions. Ashtamudi Lake is the source of livelihood for thousands of fishermen and is stated to be the second biggest fish-landing centre after the Vembanad estuary.
- So it is important to take more environmentally relevant approach to understand the fate, behaviour and impacts of microplastics as an environmental pollutant and decrease the risk of pollution.

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