An assessment of microplastic in the Himalayan River and Canal system between Rishikesh and Roorkee.

A

MAJOR PROJECT REPORT

Submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY
IN
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Under the supervision of

Prof. Dr. Ashish Kumar

(Professor and Head
Department of Civil Engineering)

By

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY
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HIMACHAL PRADESH, INDIA

May, 2024

STUDENT'S DECLARATION

We hereby declare that the work presented in the Project report entitled " **An assessment of microplastic in the Himalayan River and Canal system between Rishikesh and Roorkee** " Submitted for partial fulfilment of the requirements for the degree of Bachelor of Technology in Civil Engineering at the **Jaypee University of Information Technology, Waknaghat** is an authentic record of our work carried out under the supervision of **Prof. Dr. Ashish Kumar**. This work has not been submitted elsewhere for the reward of any other degree/diploma. We are fully responsible for the contents of our project report.

Signature of Student

Sharad Singh (201621)

Department of CE

JUIT, Waknaghat

CERTIFICATE

This is to certify that the work presented in the project report titled **" An assessment of microplastic in the Himalayan River and Canal system between Rishikesh and Roorkee"** submitted to the Department of Civil Engineering**, Jaypee University of Information Technology, Waknaghat** in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering is an authentic record of work carried out by **Sharad Singh (201621)** under the supervision of **Prof. Dr. Ashish Kumar**. To the best of our knowledge, the preceding statement is correct.

Date:

Signature of Supervisor
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ACKNOWLEDGEMENT

The success and final end of this project necessitated a great deal of direction and assistance from our supervisor, and we are extremely fortunate to have received it all as part of the project's completion. We owe everything we've accomplished to his oversight and help, and we'd like to express our gratitude.

I would like to express our sincere gratitude to ***Prof. Dr. Ashish Kumar*** for his valuable guidance and kind supervision throughout the project.

I would like to extend our sincere thanks to him. We are highly indebted to him for his guidance and constant support.

ABSTRACT

The pervasive presence of microplastics in aquatic environments has become a critical environmental issue globally. This thesis investigates the occurrence, distribution, and potential ecological impacts of microplastics in the river and canal systems of the Himalayan region. Through comprehensive field sampling and laboratory analyses, we quantify microplastic concentrations in the Himalayan River and Canal system between Rishikesh and Roorkee., ranging from glacial streams to lower-altitude canals. Employing advanced microscopy and spectroscopic techniques, we identify shapes, and sizes of microplastics present.

Our findings reveal significant spatial variability in microplastic contamination, with higher concentrations observed in densely populated and industrial areas, considering factors such as tourism, waste management practices, and hydrological dynamics.

This research underscores the urgent need for effective management strategies and policy interventions to mitigate microplastic pollution in this ecologically sensitive and socio-economically vital region. By enhancing our understanding of microplastic dynamics in the Himalayan river and canal systems, this thesis contributes to the broader efforts aimed at preserving freshwater ecosystems and ensuring sustainable water resource management in the face of growing environmental challenges

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CHAPTER 1
INTRODUCTION

Plastics are synthetic polymer compound mostly made from petrochemical sources, such compound has high molecular mass and plasticity and certain chemicals are added to increase the performance and efficiency of the products. Plastics size less than 5 mm are categorized as Microplastics and it is one of the greatest potential threat to marine environment for the whole world. There are two types of micro-plastics i.e. primary micro-plastics and secondary micro-plastics. Primary microplastics are the by-products of particulate emissions released from industrial production, the release of plastics dust from plastics products. Secondary microplastics are larger plastic particulate material. These micro-plastics eventually end up in water bodies travelling all the way from rivers to seas or oceans. Microplastic can also act as a pollutant transport medium for other toxic elements such as DDT and hexachlorobenzene and eventually end up within the body of a living organism who consume it.

Some of this environmental pollution is from littering, but much is the result of storms, water runoff, and winds that carry plastic—both intact objects and microplastics—into our oceans. Single-use plastics—plastic items meant to be used just once and then discarded, such as a straw—are the primary source of secondary plastics in the environment.

Microplastics have been detected in marine organisms from plankton to whales, in commercial seafood, and even in drinking water. Alarmingly, standard water treatment facilities cannot remove all traces of microplastics. To further complicate matters, microplastics in the ocean can bind with other harmful chemicals before being ingested by marine organisms.

In the past six decades, we have produced more than 8.4 billion tons of plastics. Most of it has now ended up in landfills or directly in our natural environment. In fact, only 9% of the plastic used today is recycled.

Up to 12 million tons of plastic enter our oceans every year. This corresponds to one garbage truck per minute. Plastic waste on the streets can also get into the ocean via drainage networks or rivers:

According to estimates, the world's major rivers transport up to 2.41 million tons of plastic into the sea each year, which corresponds to 100,000 garbage trucks.
Microplastics were first detected in large numbers in the world's oceans in 2004. That made one thing very clear: plastic in the environment does not just go away. And not "only" with plastic, but also with microplastics, we are dealing with an environmental problem of enormous and global proportions (Thompson et al., 2004).

The Central Pollution Control Board (CPCB) Report (2019-20) had stated that 3.5 million metric tonnes of plastic waste are generated in India annually.

Speaking about a 2021 United Nations paper and several media reports, 77 countries in the world had passed full or partial ban on plastic bags.

Around 34.7 lakh tonnes per annum (TPA) of plastic wastes was generated by India during 2019-20, Minister of State in the Ministry of Environment, Forest and Climate Change, Ashwini Kumar Choubey told the Lok Sabha.
From 1950 to 2015, around 8.3 billion metric tonnes (BMTs) of plastic had been produced globally, and of this, 80 per cent - 6.3 BMTs - was accounted as plastic waste.
Plastic pollution soared from two million tonnes in 1950, to 348 million tonnes in 2017, becoming a global industry valued at $522.6 billion, said United Nations Environment Programme (UNEP). It is expected to double in capacity, by 2040.

Government notifies the Plastic Waste Management Amendment Rules, 2021, prohibiting identified single use plastic items by 2022.

Thickness of plastic carry bags increased from 50 to 75 microns from 30th September, 2021 and to 120 microns with effect from the 31st December, 2022.

Guidelines for Extended Producer Responsibility given legal force;

The manufacture, import, stocking, distribution, sale and use of following single-use plastic, including polystyrene and expanded polystyrene, commodities shall be prohibited with effect from the 1st July, 2022:-

- Ear buds with plastic sticks, plastic sticks for balloons, plastic flags, candy sticks, ice-cream sticks, polystyrene [Thermocol] for decoration;

- Plates, cups, glasses, cutlery such as forks, spoons, knives, straw, trays, wrapping or packing films around sweet boxes, invitation cards, and cigarette packets, plastic or PVC banners less than 100 micron, stirrers.

In order to stop littering due to light weight plastic carry bags, with effect from 30th September, 2021, the thickness of plastic carry bags has been increased from fifty microns to seventy five microns and to one hundred and twenty microns with effect from the 31st December, 2022. This will also allow reuse of plastic carry due to increase in thickness (CPCB).

Objective

The objective of the test will be to identify shapes, and sizes of microplastics present. We will be achieving our objective through comprehensive field sampling and laboratory analyses, we quantify microplastic concentrations in the Himalayan River and Canal system between Rishikesh and Roorkee., ranging from glacial streams to lower-altitude canals. Employing advanced microscopy and spectroscopic techniques.

CHAPTER 2

LITERATURE REVIEW

2. Introduction

The following are the findings of the papers that are already in the field of microplastic in water bodies in India. In the following chapter I have made a summary of the literature papers relevant to the scope of this paper and make a contemporary interpretation of the same.

2.1 **Abundance, characteristics and seasonal variation of microplastics in Indian white shrimps (Fenneropenaeus indicus) from coastal waters off Cochin, Kerala, India**

This study investigated the presence and seasonal variation of microplastics in a commercially important marine shrimp species, Fenneropenaeus indicus, from the coastal waters of Cochin, India. The soft tissues of 330 shrimps were examined over a period of 12 months, from March 2018 to February 2019. A total of 128 microplastics were detected, of which 83% were fibres. An average (mean ± SD) of 0.39 ± 0.6 microplastics/shrimp (0.04 ± 0.07 microplastics/g wet weight) was obtained from the shrimps sampled. Microplastic contamination was significantly higher in July-August (Monsoon season) compared with other months *(Daniel et. al.).*

2.2 **An assessment of microplastics in the ecosystem and selected commercially important fishes off Kochi, south eastern Arabian Sea, India**

Spatial and temporal variation in microplastic abundance was observed with higher abundance in surface water indicating threats to pelagic ecosystem. The relative concentration of microplastic was highest during monsoon season. The major microplastics were fragments of 1-5 mm in white and blue colours. Gut content analysis of 16 species (653 individuals) comprising pelagic (8 species) and demersal (8 species) indicated occurrence (4.6%) of microplastics (fragment>filament>pellet) of size 0.27mm to 3.2 mm in Sardinella longiceps, S. gibbosa, Stolephorus indicus Rastrelliger kanagurta and Cyanoglossus macrostomus *(Keziya et al)*

2.3 **An assessment of microplastics in the ecosystem and selected commercially important fishes off Kochi, south eastern Arabian Sea, India**

This study examined the presence of microplastics in the edible (muscle and skin) and inedible (gill and viscera) tissues of nine commercially important pelagic fish species from Kerala, India. A total of 163 particles consisting mainly of fragments (58%) were isolated. Out of 270 fishes analysed (n = 30 per species), 41.1% of the fishes had microplastics in their inedible tissues while only 7% of fishes had microplastics in their edible tissues. The quantity of microplastics in inedible tissue was significantly larger in filter feeders than, that in visual predators ($p < 0.05$). The average abundance of microplastics in edible tissues was 0.07 ± 0.26

items/fish (i.e., 0.005 ± 0.02 items/g) and was 0.53 ± 0.77 items/fish (i.e., 0.054 ± 0.098 items/g) in inedible tissues (*Daniel et. al.)*
.

2.4 **Microplastics in the environment and in commercially significant fishes of mud banks, an ephemeral ecosystem formed along the southwest coast of India**

Sampling conducted over three periods, Pre-mud bank (Pre-MB), Mud bank (MB), and Post mud bank (Post-MB) extending over three depths (2 m, 5 m and 18 m), along the semi-circular patch of mudbanks revealed marked spatio-temporal variability in microplastic distribution. In both surface water and sediments, microplastic concentration was comparatively high during MB than in Pre-MB and Post-MB periods. Spatially, during MB, the microplastic concentration was high at 5 m where the dampening of waves occurred concomitant to the thick fluid mud formation. In contrast, during Post-MB, with the subsequent dissipation of MB's and less wave dampening, the microplastics aggregated at 5 m were transported to both inshore (2 m) and offshore (18 m), thus raising their concentration at these depths. Likewise, the microplastic ingestion was more in fishes caught during MB (41%) than Post-MB (30%) and Pre-MB (29%) periods indicating increased uptake corresponding to the higher incidences in their ambient environment. Microplastic ingestion was more among pelagic planktivores, S. gibbosa (38%), A. chacunda (20%) and R. kanagurta (13%) compared to the demersal fishes. White coloured fragments of size 1-5 mm of polypropylene were the dominant microplastic in the surface waters, sediment and fishes analysed. The present study indicates the critical role of wind speed, rainfall, wave patterns, and the fluid muddy environment in regulating the microplastics distribution in a transient ecosystem formed along the southwest coast of India *(Keziya et al)*
.

2.5 **Microplastics pollution in the Brahmaputra River and the Indus River of the Indian Himalaya**

In this study, microplastics pollution in river shore sediment of the Indian Himalaya, including the Brahmaputra River and the Indus River was discussed. Sampling campaigns were performed in years 2018 and 2019. Sample pretreatment was performed using $Na_2WO_4 \cdot 2H_2O$ for density separation and H_2O_2 for oxidation of organic material. Microplastics analysis was performed by using FTIR microscope. The smaller size of microplastics 20–150 μm were more abundant (531–3485 MP/kg in the Brahmaputra River and 525–1752 MP/kg in the Indus River) than microplastics in size range between 150 μm and 5 mm (20–240 MP/kg in the Brahmaputra River and 60–340 MP/kg in the Indus River). Microplastics were found in sediments of all sampling sites. Fragmented, secondary microplastics were dominant in the river shore sediment of the Indian Himalaya *(Tsering et. al.).*

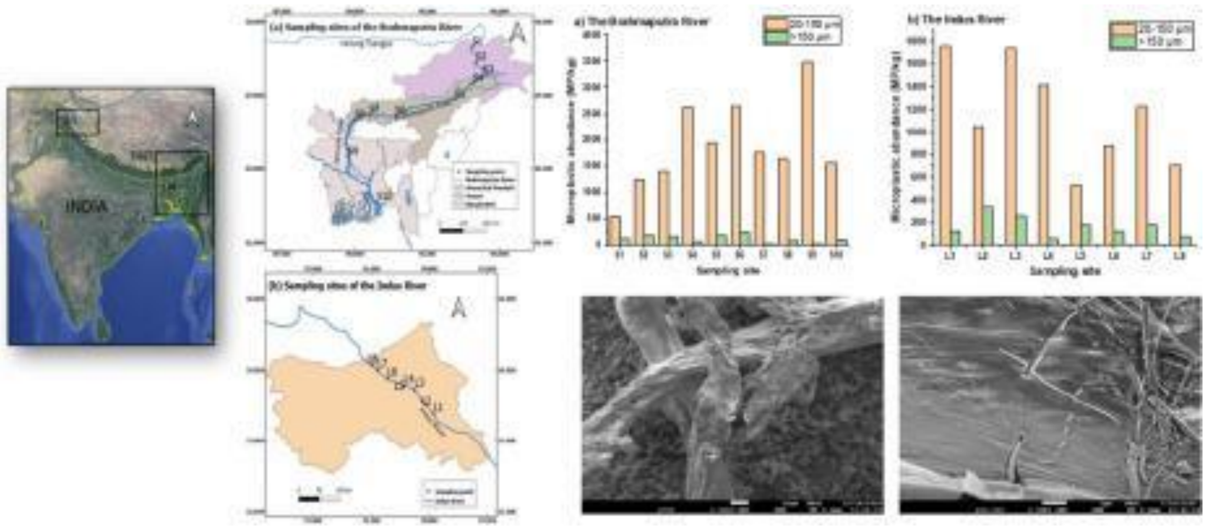


Fig 1: Microplastic in river shore

2.6 **Distribution and characterization of microplastics in beach sand from three different Indian coastal environments**

The occurrence of microplastic particles were evaluated on beaches along the Indian coast from three different locations Girgaon Mumbai (Arabian sea coast), Tuticorin, and Dhanushkodi (Bay of Bengal coast). Density separation method was adopted for isolation of microplastics from sand. Isolated microplastics were characterized using three different analytical techniques e.g. fluorescence microscopy (after staining with Nile Red), FTIR and SEM-EDS techniques. Microplastic concentrations in beach sands were from 45 ± 12 # MP kg^{-1} to 220 ± 50 # MP kg^{-1} of dry sand. The order of abundance of plastic type was polyethylene (43%) > polyethylene terephthalate (17.3%) ≈ polystyrene(17%) > polypropylene (12.3%) > Others (11%) > polyvinylchloride (1.33%), and very similar profile was observed for all monitored locations. SEM images show microplastics surfaces with characteristic cracks, suggests their polymer aging, mechanical and oxidative weathering, which was found highest for the microplastics collected from Mumbai (*Tiwari et. al.)*

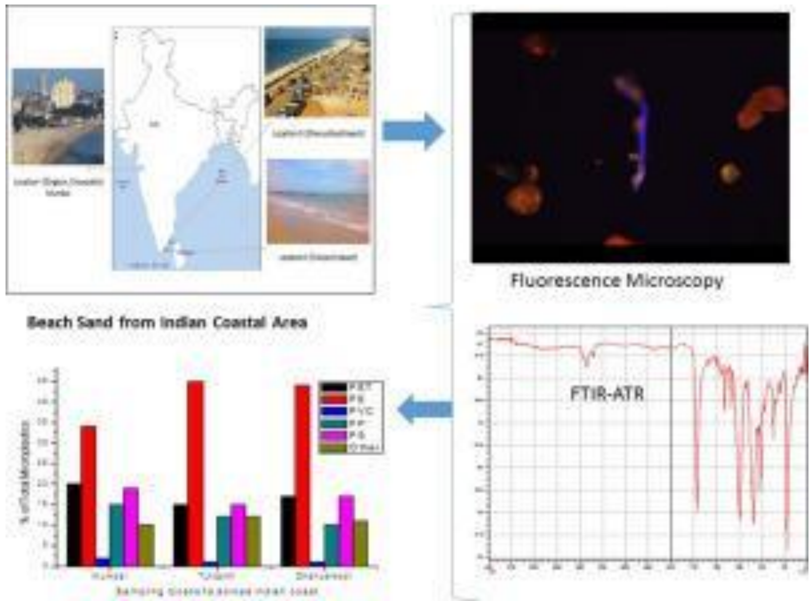


Fig 2: Microplastic on beach shores

2.7 Plastics and microplastics: A threat to environment

Plastics are synthetic polymer compound mostly made from petrochemical sources, such compound has high molecular mass and plasticity and certain chemicals are added to increase the performance and efficiency of the products. Plastics size less than 5 mm are categorized as Microplastics and it is one of the greatest potential threat to marine environment for the whole world. There are two types of micro-plastics i.e. primary micro-plastics and secondary micro-plastics. Primary microplastics are the by-products of particulate emissions released from industrial production, the release of plastics dust from plastics products. Secondary microplastics are larger plastic particulate material. These micro-plastics eventually end up in water bodies travelling all the way from rivers to seas or oceans. Microplastic can also act as a pollutant transport medium for other toxic elements such as DDT and hexachlorobenzene and eventually end up within the body of a living organism who consume it. The Government Agencies and Non-government organization of different nations have adopted many policies and laws to curb the harmful effects of plastics and microplastics. A concrete and comprehensive plan should be adopted for zero tolerance against plastics waste and peoples participation is a must to achieve the full success *(Laskar et.al.).*

2.8 Contamination of Indian sea salts with microplastics and a potential prevention strategy

This study reports the contamination of Indian sea salts with different microplastic particles, as a consequence of using contaminated sea water. Samples from all eight brands of investigated sea salts were found contaminated, and concentrations of these particles ranged from 103 ± 39 to 56 ± 49 particles kg^{-1} of salt. Both fibres and fragments were observed with large variation in size.

Eighty percent of the extracted fibres and the fragments were smaller than 2000 μm and 500 μm respectively. Extracted particles were mostly polyesters, polyethylene terephthalate (PET), polyamide, polyethylene, and polystyrene. Their total mass concentration was also estimated as 63.76 $\mu g\ kg^{-1}$ of salt. These results are significant, since India is a leading producer and exporter of sea salts. A simple sand filtration of artificially contaminated sea water could effectively (> 85% removal by weight and > 90% removal by number) remove these microplastics and has the potential for preventing the transfer of microplastics into the salt from contaminated sea waters *(Seth et. al).*

2.9 Microplastics in different environmental compartments in India: Analytical methods, distribution, associated contaminants and research needs

This study aims at reviewing the scientific literature related to microplastic (MP) pollution in various environmental matrices in India and highlighting the research gaps for future research priorities. Currently used methods for sampling, extraction, identification, characterization and quantification of MPs were assessed, and sources, distribution, transport pathways, fate, impacts, chemical risks and MP-biota interactions in the marine and freshwater ecosystems of India were examined. Studies on the spatial and temporal transport pathways of MPs are very scarce, especially w.r.t. river discharge, anthropogenic activities, beach morphology, bottom topography, biofouling and hydrodynamics. Though some amount of baseline data of MPs at select regions along the Indian coast have been generated, the extent of MP pollution in air, major rivers and nearshore continental shelf is still poorly understood. Moreover, this study highlights an urgent need for the harmonized and standardized sampling and analytical methods for MP research, that can enable us to study the spatial and temporal comparisons around the world meaningful *(Veerasingam et. al.)*

Findings of the paper

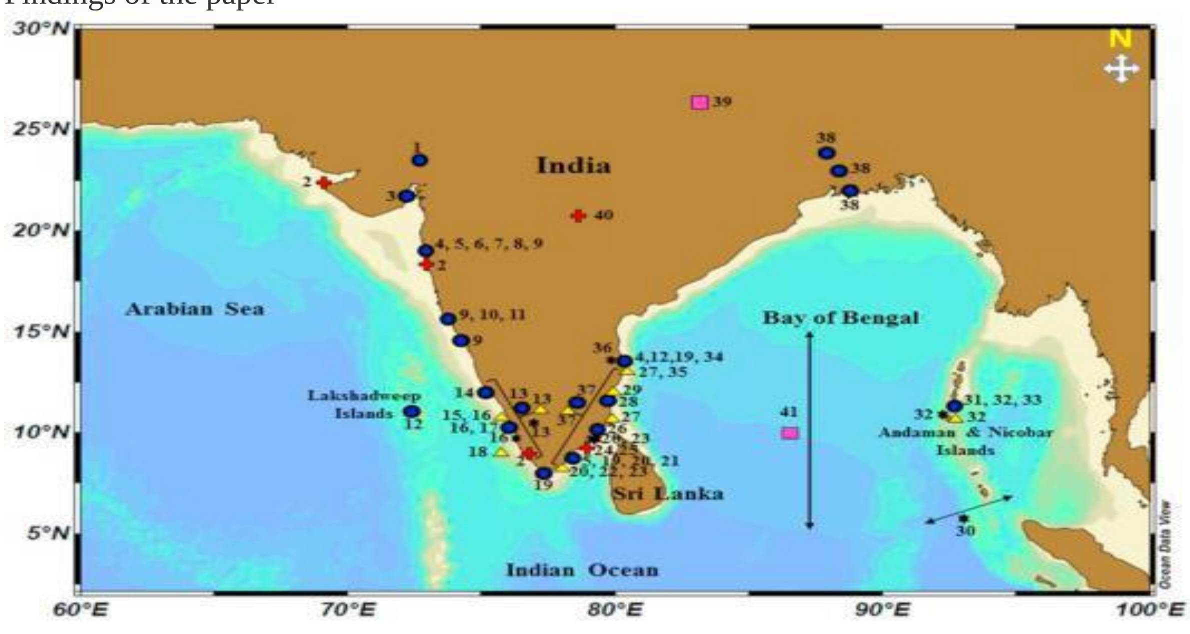


Fig 3: Map showing the concentration of Microplastic

Map showing the microplastic concentrations in different environmental matrices reported along the Indian coast. Sediment (●), water (●), biota (▲), salt (✚) and dust (■). Table no. 1 expands on the studies relevant to Microplastics on various environmental matrices along the east coast of India. Through this table we are able to quantify the consumption of microplastic through fisheries and sediments.

Table 1. Microplastic studies in various environmental matrices along the east coast of India.

S. No	Location	Sample type	Size	Shape	Polymer type	Abundance
1	Ganga river	Sediment	<5 mm	Fibers, films, and foams	PET, PE, PP, PS	107.57 to 409.86 items/kg
2	Chennai	Sediment	2–5 mm	Pellets	PE and PP	304 (before flood), 896 (after flood)
3	Chennai and Sundarbans	Sediment	NA	Pellets	PE and PP	NA
4	Tamil Nadu coast	Sediment	300 µm to 5 mm	Fragments, fibers, and foams	PE, PP, PS	1323 ± 1228 mg/m^2(High tide); 178 ± 261 mg/m^2(Low tide)
5	Chennai, Tuticorin, Tiruchenthur, Manapad, and Kanyakumari	Sediment	0.5–3 mm	Fibers, Fragments, and foams	Polyethylene (PE), Polypropylene (PP), Nylon (NY), polystyrene (PS) and polyester (PES)	439 ± 172 to 119 ± 72 items/kg in high tide; 179 ± 68 to 33 ± 30 items/kg in low tide
6	Chennai	Sediment	2–5 mm	Pellets	NA	201 numbers
7	Puducherry	Sediment	300 µm to 5 mm	Fragments, fibers, films, foams and pellets	PP, HDPE, LDPE, PS, polyurethane (PU)	72.03 ± 19.16 items/100 g
8	Rameswaram, Gulf of Mannar	Sediment	1.01–4.75 mm	Irregular shapes, Fibers, and Pellets	PP, PE, PS, NY, PVC	403 items
9	Dhanushkodi and Tuticorin	Sediment	36 µm to 3 mm	Fibers, Granules and films	PE, PET (Polyethylene terephthalate), PS, PP, PVC (polyvinylchloride)	45 ± 12 to 181 ± 60 items/kg

S. No	Location	Sample type	Size	Shape	Polymer type	Abundance
10	Tuticorin, Gulf of Mannar	Sediment	0.5–3 mm	Fibers, fragment, and films	PE, PP, PES, polyamide (PA) and paint	8.22 ± 0.92 to 17.28 ± 2.53 items/kg
11	Tuticorin	Sediment	0.05–5 mm	Fibre, film, fragment, and foam	NY, PE, PP, PS, PET, PVC	25 ± 1.58 to 83 ± 49 items/m^2
12	Andaman	Sediment	100 μm–1000 μm	Fragments, fibres, and spherules	PP, PVC	414.35 ± 87.4 items/kg
13	Port Blair Bay, Andaman Island	Sediment	<5 mm	Fibre, fragment, pellet	NY, PU, PVC	45.17 ± 25.23 items/kg
14	Andaman and Nicobar Archipelago	Sediment	<5 mm	Irregular, Filament, film, pellet	PE, PP	73 to 151 items
15	Chennai	Water	<5 mm	Fragment, fibre	PET, PA	2 to 11 items/L
16	Port Blair Bay, Andaman Island	Water	<5 mm	Fibre, fragment, pellet	NY, PU, PVC	0.93 ± 0.59 items/m^3
17	Bay of Bengal	Water	0.355–4.75 mm	Fragments, fibers, foams, films, pellets	NA	16107 ± 47077.63 items/km^2
18	Tuticorin, Gulf of Mannar	Water	0.5–1 mm	Fibers, fragments and films	PE and PP	12.14 ± 3.11 to 31.05 ± 2.12 items/L
19	Tuticorin	Water	150 μm to 5 mm	Fibre, fragment, film, foam	PE, PES, PS, PA, PP	3.1 ± 2.3 to 23.7 ± 4.2 items/L
20	Port Blair Bay, Andaman Island	Zooplankton	<5 mm	Fibre, fragment, pellet	NY, PU, PVC	MP occurrence found in 27 out of 30 zooplankton samples (i.e. 90%)
21	Port Blair Bay, Andaman Island	Fishes	<5 mm	Fibre, fragment, pellet	NY, PU, PVC	MP occurrence found in 33 out of 72 fish samples (i.e. 45.83%)
22	Southeast coast of the	Fishes	<5 mm	Fibre, film, pellet	PE, PET, PA	20 items found in 17 fishes

S. No	Location	Sample type	Size	Shape	Polymer type	Abundance
	Bay of Bengal					
23	Fishing harbour, Chennai	Green Mussel	5–103 µm	Fibers and particles	PS	0.9 ± 0.3 items/10 g to 3.2 ± 3.2 items/10 g
24	Pondicherry	Bivalves	<100 µm	NA	PU, PVC, PES, and PET	0.18 ± 0.04 to 1.84 ± 0.61 items/g; 0.50 ± 0.11 to 4.8 ± 1.39 items/individual
25	Tuticorin, Gulf of Mannar	Oyster	0.25–5 mm	Fibers, fragments and films	PE and PP	5.21 ± 4.85 to 9.74 ± 8.92 items/individual
26	Tuticorin, Gulf of Mannar	Fish	0.5–1 mm	Fibers and fragments	PE and PP	Ingestion found in 12 fishes out of 40 fish samples
27	Tuticorin	Fishes	85 µm to 5 mm	Fibre, fragment, film, foam	PE, PS, PA	0.0002 ± 0.0001 to 0.2 ± 0.03 items/g; 0.11 ± 0.06 to 3.64 ± 1.7 items/individual
28	Tuticorin, Gulf of Mannar	Sea Salt	<2 mm	Fragments, Fibers, sheets	PP, PE, NY, Cellulose	NA
29	Tuticorin	Sea Salt	<5 mm	Fragments, fibre	PE, PP, PS, PA	35 ± 15 to 72 ± 40 items/kg
30	Tuticorin	Bore-well Salt	<5 mm	Fragments, fibre	PE, PP, PS, PA	2 ± 1 to 29 ± 11 items/kg
31	Patna	Indoor dust	<5 mm	NA	PET, PC	55–6800 µg (PET); <0.11–530 µg (PC)
32	East Indian Ocean	Atmospheric dust	58.591–988.37	Fibers, fragment	PET, PP, PAN-AA, PR	0.4 ± 0.6 items/100 m^3

Table no. 2 expands on the studies relevant to Microplastics on various environmental matrices along the west coast of India. Through this table we are able to quantify the consumption of microplastic through fisheries and sediment.

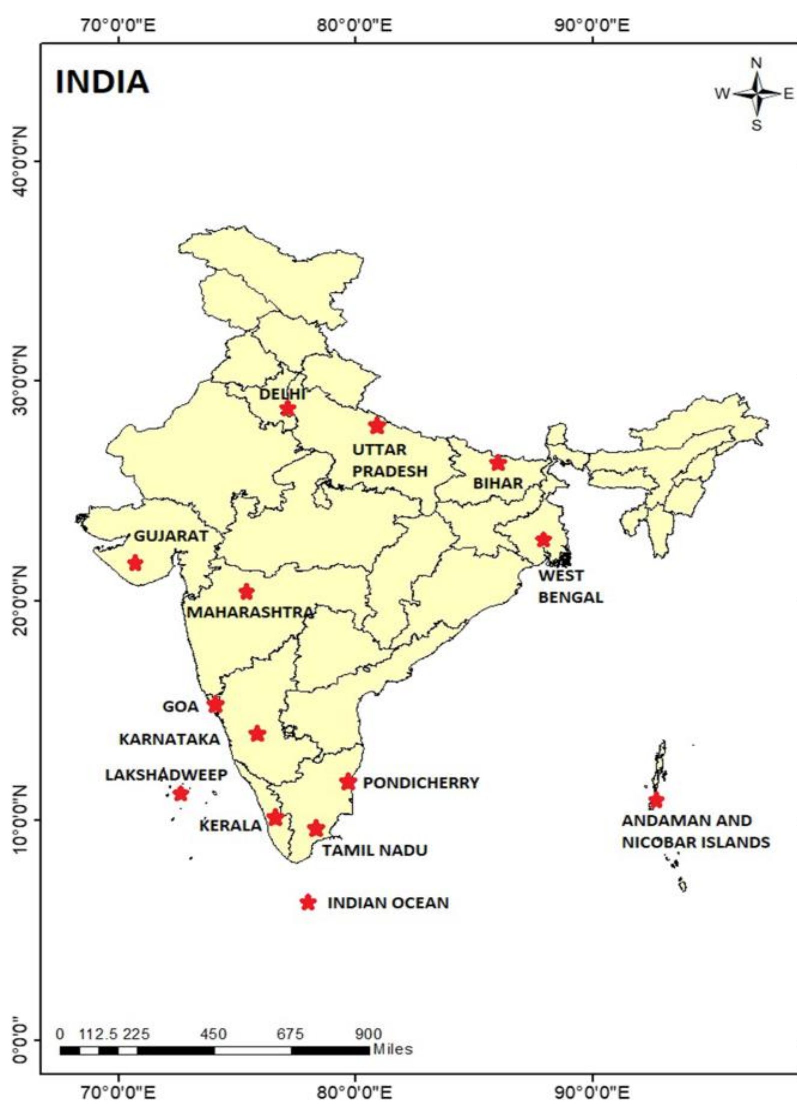
Table 2. Microplastic studies in various environmental matrices along the west coast of India.

S. No	Location	Sample type	Size	Shape	Polymer type	Abundance
1	Sabarmati river, Ahmedabad	Sediment	75 µm to 5 mm	Fibers	NA	47.1 mg (MP size from 75 µm to 212 µm) and 4 mg (212 µm to 4 mm)
2	Alang-Sosiya, Gujarat	Sediment	NA	Fragments, foams and fibers	PU, NY, PS, PES	81 mg items per kg sediment
3	Narmada estuary	Sediment	0.1 µm to 5 mm	Fragments	PC, PA, PVC	5.8 ± 0.4 to 11 ± 1.0 m^2/g
4	Mumbai	Sediment	NA	Pellets	PE and PP	NA
5	Mumbai	Sediment	36 µm to 3 mm	Fibers, Granules, and films	PE, PET (Polyethylene terephthalate), PS, PP, PVC (polyvinylchloride)	220 ± 50 items/kg
6	Mumbai	Sediment	≤5 mm	Fragments, fibers, foams, films and pellets	NA	194.33 ± 46.32items/m^2
7	Mumbai	Sediment	1–5 mm	Fragments, fibers, foams, films and pellets	NA	NA
8	Mumbai	Sediment	<5 mm	Pellets	NA	NA
9	Maharashtra, Goa, Karnataka	Sediment	1–5 mm	Fragments, fibres, films and pellets	PE, PP	43.6 ± 1.1 to 346 ± 2 items/m^2
10	Goa	Sediment	3–5 mm	Pellets	NA	50 to 300/m^2
11	Goa	Sediment	1–5 mm	Pellets	PE and PP	1655 (SW monsoon), 1345 (NE monsoon)
12	Tinnakkara Island, Lakshadweep	Sediment	2–5 mm	Pellets	NA	603

S.No	Location	Sample type	Size	Shape	Polymer type	Abundance
13	Kerala coast	Sediment	0.3–4.75 mm	Fragments, fibers, foams, films, and pellets	PE, PP, PA, PS, PET, PUR, Rayan (RY), cellulose	40.7 ± 33.2 items/m^2
14	Nattika beach, Kerala	Sediment	<5 mm	Fragments, fibres and films	PE, PP, PS	70.15 and 120.85 items/kg
15	Kochi, Kerala	Sediment	1–5 mm	Fragments, fibers, pellets, foams, filaments and films	NA	10–70%
16	Vembanad lake, Kerala	Sediment	<5 mm	Fragments, fibers, foams and films	PE, PP, PS	252.80 ± 25.76 items/m^2
17	Kerala coast	Water	0.3–4.75 mm	Fragments, fibers, foams and films	PE, PP, PS, RY, CE, PUR	1.25 ± 0.88 items/m^3
18	Kochi, Kerala	Water	1–5 mm	Fragments, fibers, pellets, foams, filaments and films	NA	10–80%
19	Kerala coast	Fishes	0.2–0.5 mm	Fibers, fragments and foams	PE, CE, RY, PP	Ingestion found in 15 fishes out of 70 fish samples
20	Kochi, Kerala	Fishes	0.27 mm–3.2 mm	Fragments, filaments, and pellets	PE, PP	Among the 653 samples, ingestion found in 4.6% of fishes
21	Cochin, Kerala	Shrimps	0.25–5 mm	Fibres, fragments and sheets	PE, PS, PP, PA	0.39 ± 0.6 items/individual
22	Kochi, Kerala	Benthic invertebrates	<20 µm	Fragments and fibers	PS	NA
23	Kerala, Maharashtra, and Gujarat	Salt	500–2000 µm	Fibers and fragments	PE, PET, PS, PES, PA	56 ± 49 to 103 ± 39 items/kg

This review article is an effort to present current understanding of MP pollution in aquatic systems, terrestrial systems, atmosphere and human consumables of India by reviewing available scientific literature. Along with this, the review also focuses on identification of the gap areas in current knowledge and highlights way forward for future research. This would further help in meeting the goals of this emergent pollutant management.

Plastics industry is a fast-growing industry in India, where Western India has been the largest consumer of plastics (47%) with major consumption in the states of Gujarat, Maharashtra, Madhya Pradesh, Daman and Diu, Chhattisgarh, and Dadra and Nagar Haveli *(Vaid et. al)*



MP studies conducted in different parts of India (highlighted with a red star).

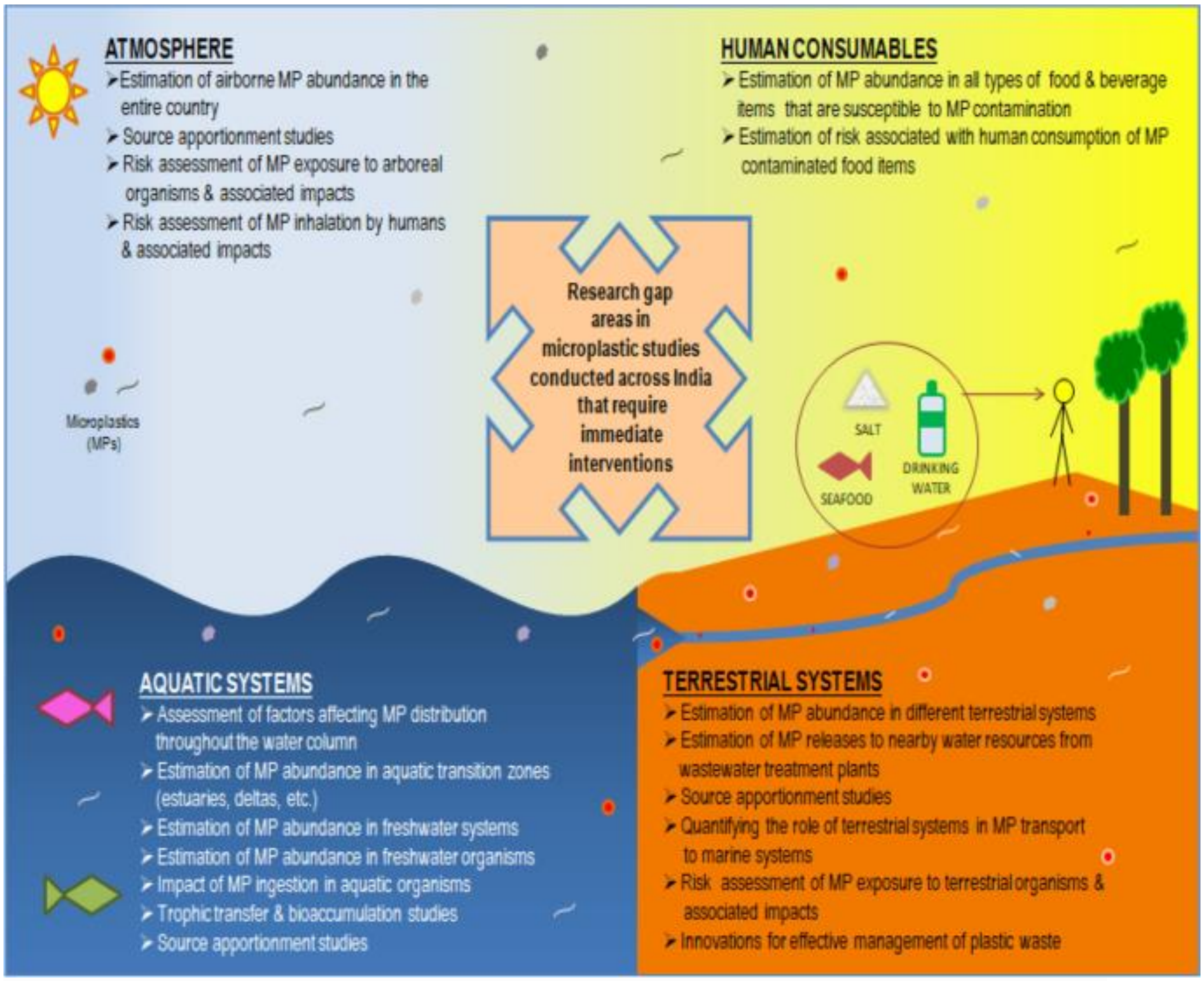


Fig 4: Gap areas in the microplastic research in Indian environments that need immediate attention

Research Gap

On reviewing the above mentioned research papers we find that there is neglible to no data on microplastic in the Himalayan river and canal system resulting in no impact study of seasonal variation in the content of microplastic. In the following chapters we will discuss the procedure through which we will be generating data on the content of microplastic and it's variation with the seasonal change.

Chapter 3

Materials and Method

From the above discussed research gap we have to conclusion of collecting 4 sample set for the month of October 2023, January 2024 and April 2024 i.e. 12 samples (O,J,AP-1; O,J,AP-2; O,J,AP-3 and O,J,AP-4) from different parts of the Ganga River and its associated canal system have been collected to see the effects. The following collected samples will be the source of our testing and findings on the impact of Microplastic and the variation in its content because of seasonal change. Employing advanced microscopy and spectroscopic techniques, we will be identify shapes, and sizes of microplastics present.

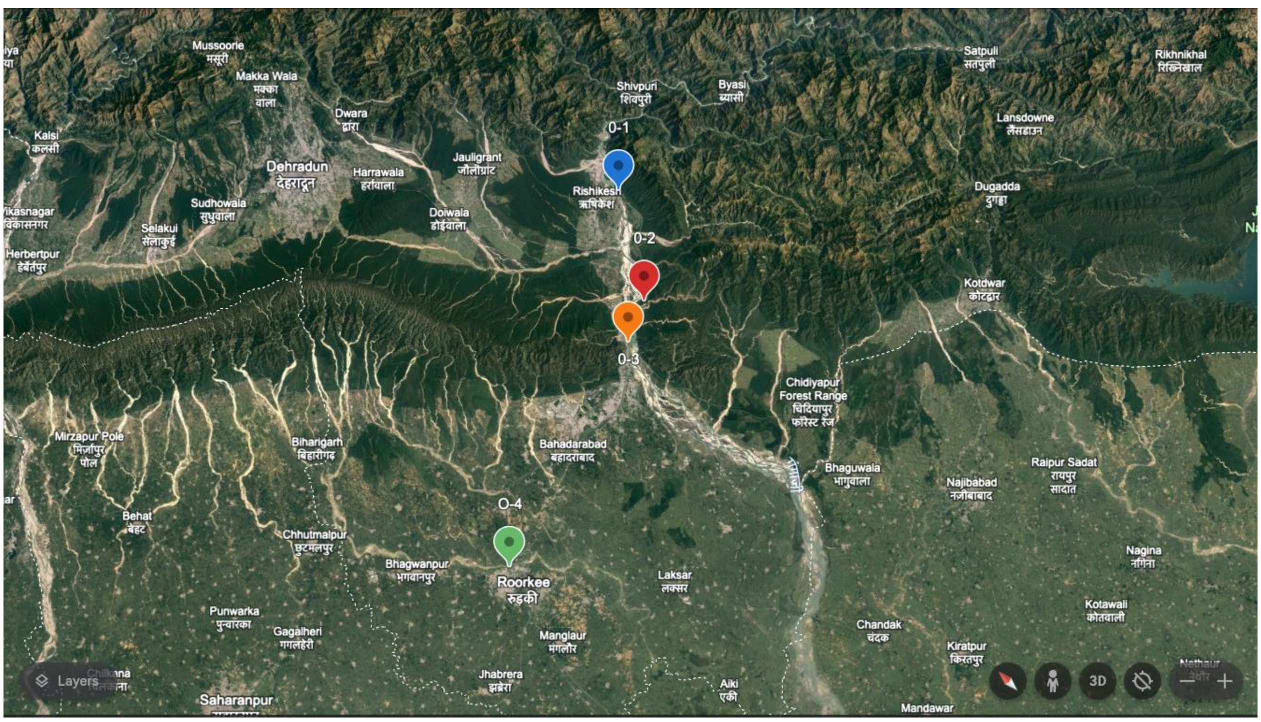


Fig 5: Site of the sample collection marked on a satellite map.

Table 4: location of the source site for samples.

Sample name	Longitude	Latitude
O,J,AP-1	30°4'26"N	78°17'24"E
O,J,AP-2	29°58'35"N	78°13'16"E
O,J,AP-3	29°57'26"N	78°10'27"E
O,J,AP-4	29°52'41"N	77°53'34"E

To achieve the objective following methodology will be followed:

1. Sample Collection: (Main Ganga River having larger catchment area before Pashulok Barrage (O,J,AP -1); Chilla Canal System just before intake (O,J,AP -2); Main Ganga River having less catchment area - Bheemgoda Barrage (O,J,AP -3; Upper Ganges Canal System – at Roorkee (O,J,AP -4) and the total test sample are for the months of– October, January and April)
2. Filtration of the 10-liter collected sample.
3. Study under Binocular Microscope
4. Characterization of plastics with SEM-ED

For this we have collected the following samples in the month of October 2023, January 2024, and April 2024.

The site photo of the location of our first sample is attached below. This is the source site with the most intervention of human with the river body before it enters into the canal system.

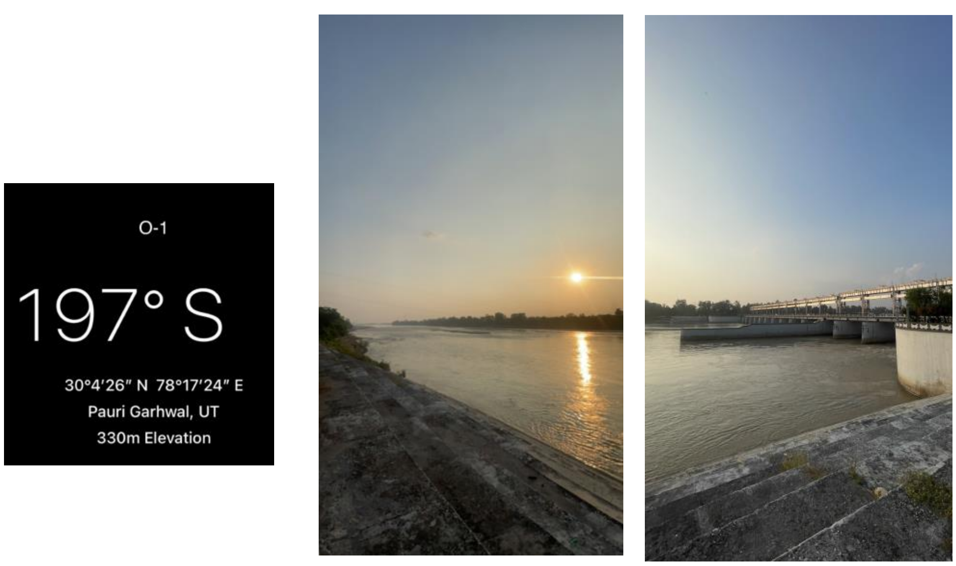
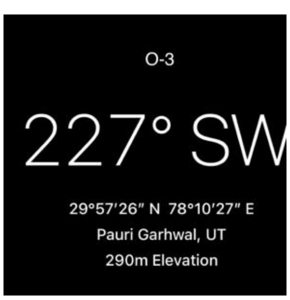


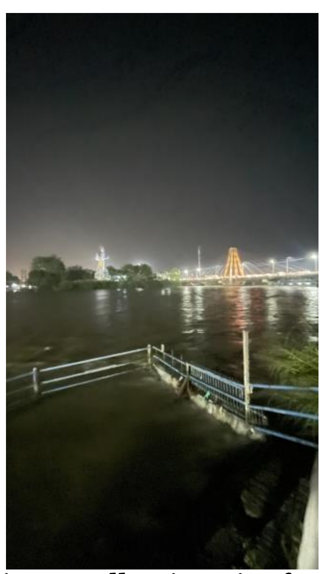
Fig 6: Collection site for sample 1

The second source site serves as a site with close to none human intervention in the same river body after it enters into the canal system and has been uninterrupted for 14kms.

Fig 7: Collection site for sample 2

Third source site serves as a location post the intervention of an hydro-power plant in the same river and canal system.





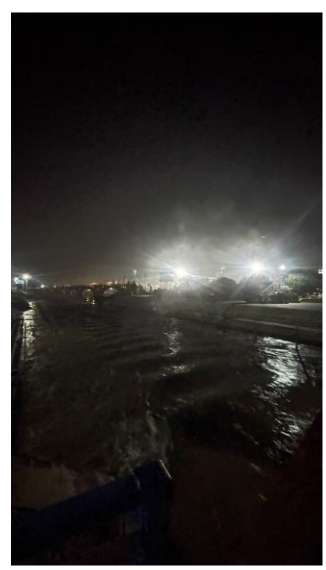


Fig 8: Collection site for sample 3

The fourth source site serves as a location with the most human intervention out of the four samples collected and which will also serve as a location with the most impact of season variation.

Fig 9: Collection site for sample 4

After Water collection the sample is ran through the Vacuum pump to obtain the filtrate which will be further studied to under a microscope. The process of vacuum pump filtration is very important to collect the floating as well as the sedimented particles in the sample.

Fig 10: Collected sample along with a Vacuum pump

The following photos show the process of vacuum pump filtration along with the filtrate of the floating as well sedimented particles in the sample.

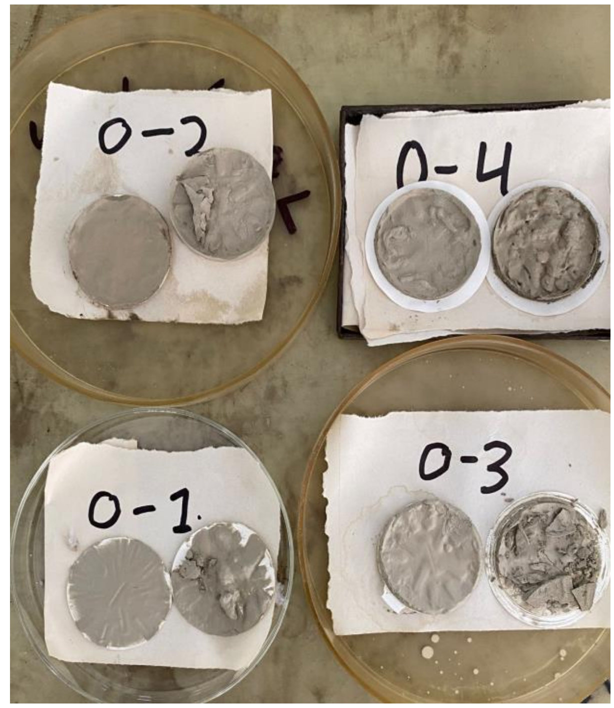


Fig 11(a): Process of Filtration. 11(b): Filtrate.

After the collection of filtrate in the sample it is prepared in a petri-dish to be viewed under a binocular microscope which will help visually differentiate microplastic in the range of 500 microns.

Fig 12(a): Binocular microscope Fig 12(b) Sample preparation in a petri-dish

After identify the microplastic under binocular microscope the next step consists of preparing stubs for further testing in SEM. The following pictures expand on the process of hand picking particles to be put on a stub to be viewed under a SEM machine.

Fig 13(a): Picking of microplastic. Fig 13(b) Preparation of SEM stubs.

After preparing the stubs they are further gold plated with 5 micron of gold in LUXOR gold sputtering device, LUXOR^{Au}, to be placed under the SEM. With the help of this process we get a clearer image in the SEM as it prevents charging of the surface, to promote the emission of secondary electrons so that the specimen conducts evenly, and to provide a homogeneous surface for analysis and imaging.

Fig 14(a): Stubs before gold.

Fig 14(a): Stubs after gold plating.

After completion of this process the stubs are placed inside a SEM machine. We are using Thermo Scientific Apreo S in this test. With the help of this we will be able to identify the size and texture of microplastic present in the sample in the range of 5 microns.

Fig 15(a): Stubs being placed in the SEM.

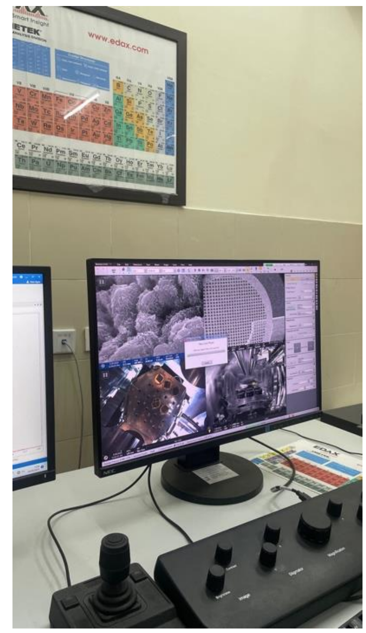


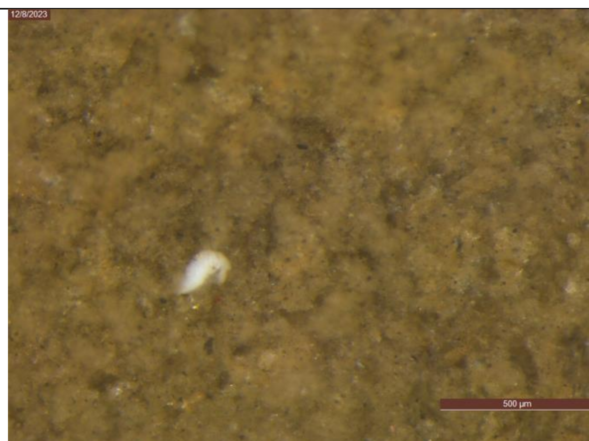
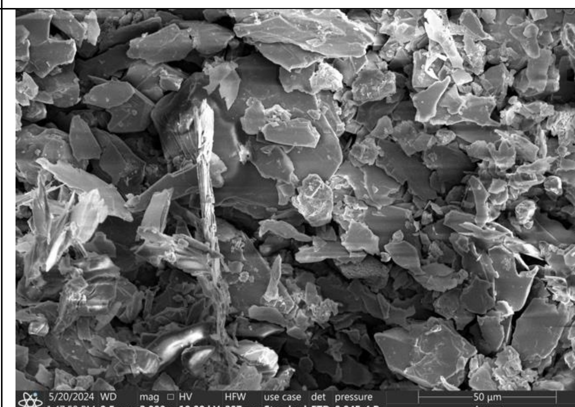
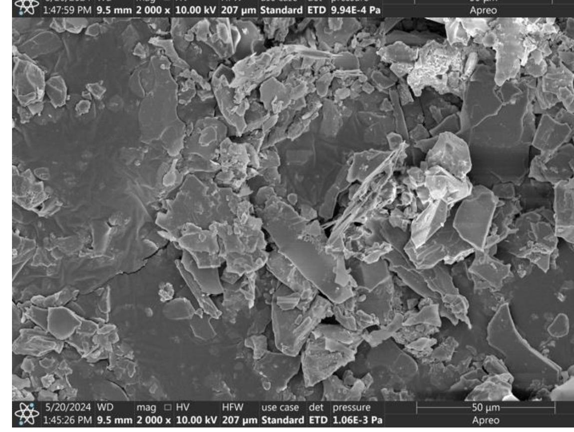
Fig1 5(b):Working of the SEM.

Chapter 4

Result and Discussion

From the above methodology we are able to make the following result comparison for the sample sets collected in the month of October 2023, January 2024 and May 2024, after using binocular microscope to identify shapes, and sizes of microplastics present in the range of 500 microns and SEM for particle sizes in the range of 5 microns.

Table 5. Results for the month of October

Sample Name	Under Binocular Microscope for the microplastic for the size of comparable to 500microns	Under SEM(Thermo Scientific Apreo S) for the microplastic size of comparable to 5 microns
O-1	 	 

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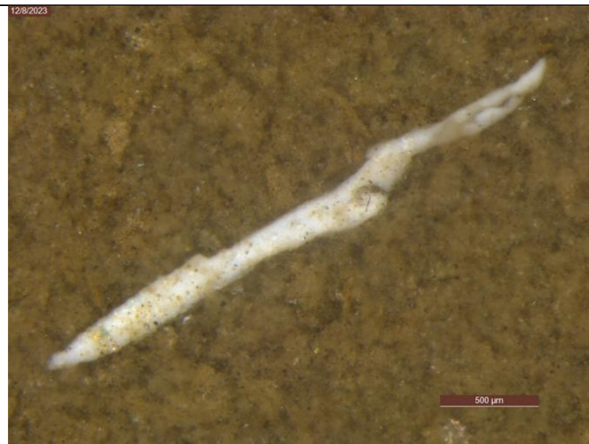

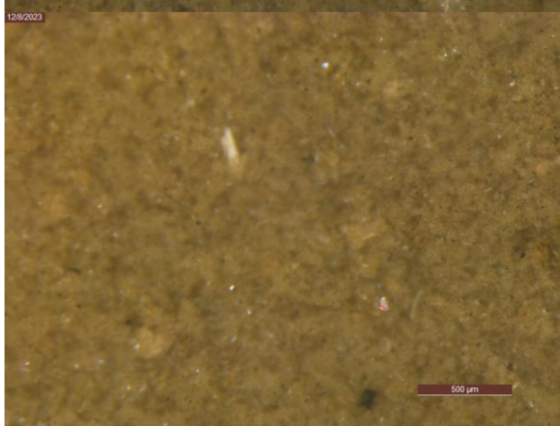

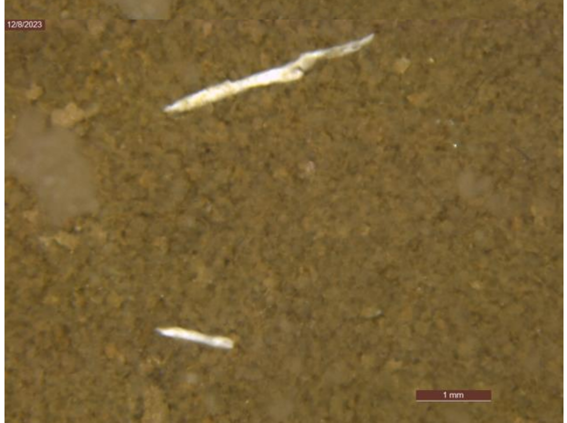

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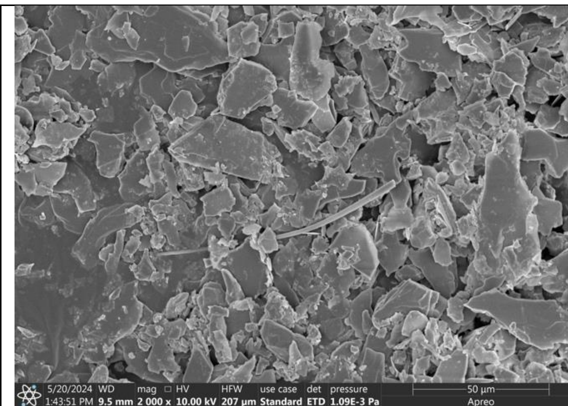

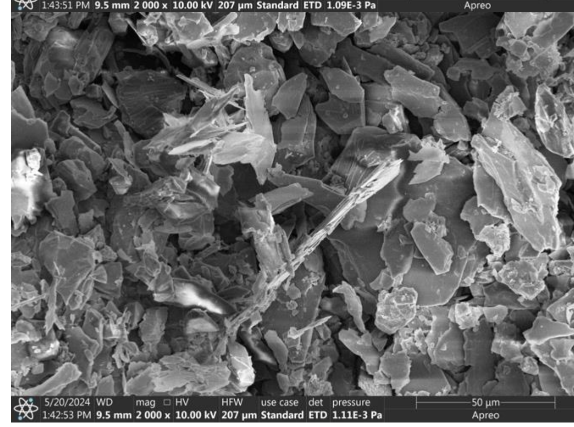

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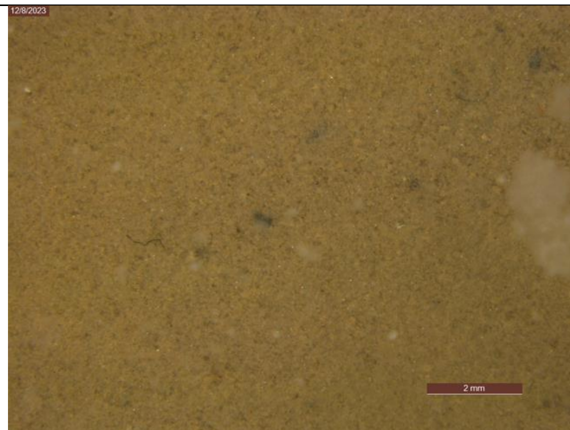
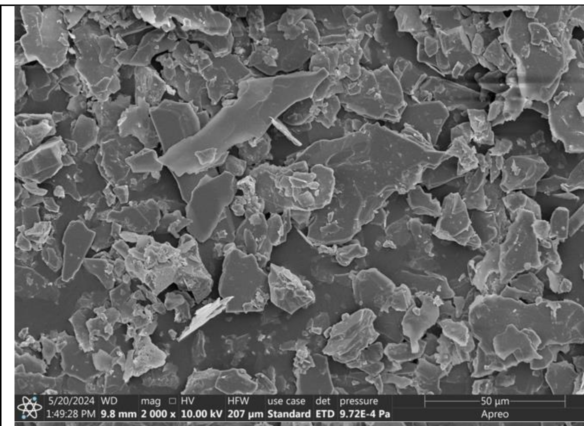
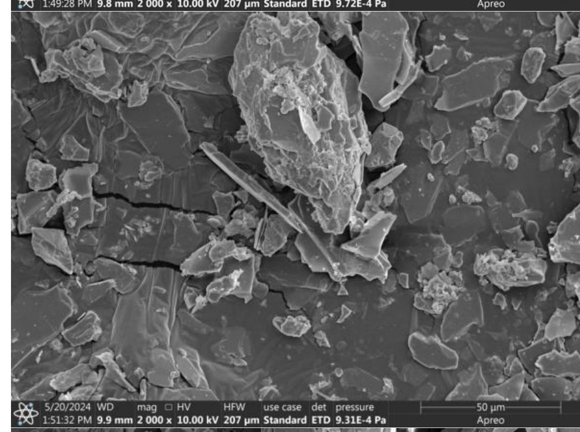
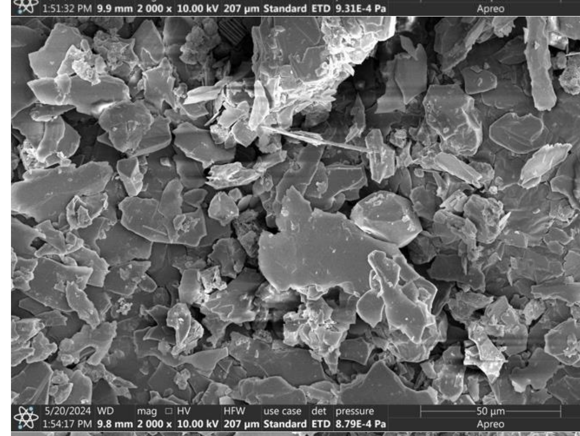
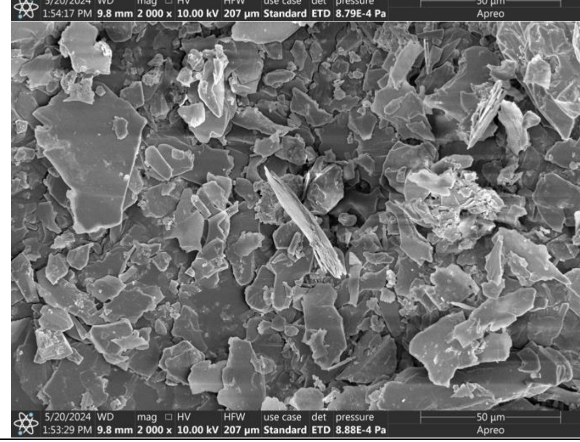
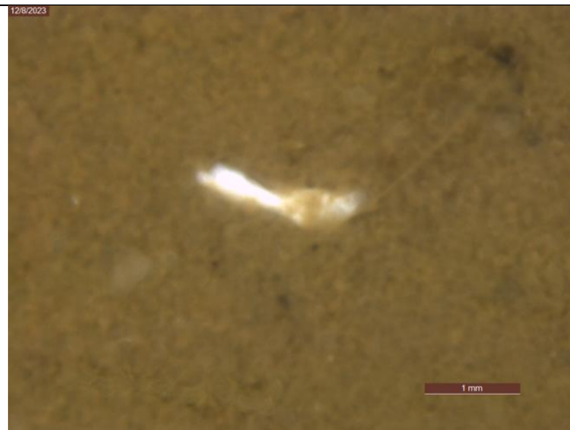
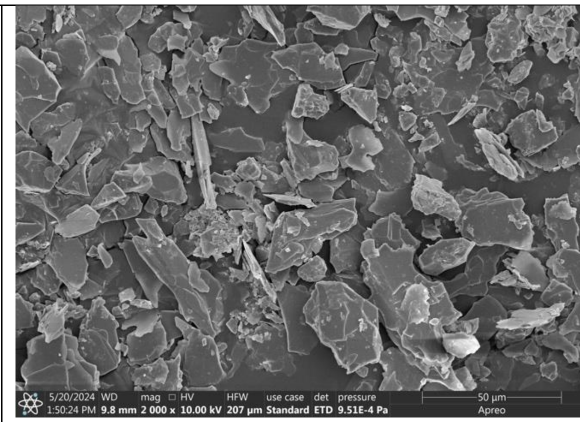
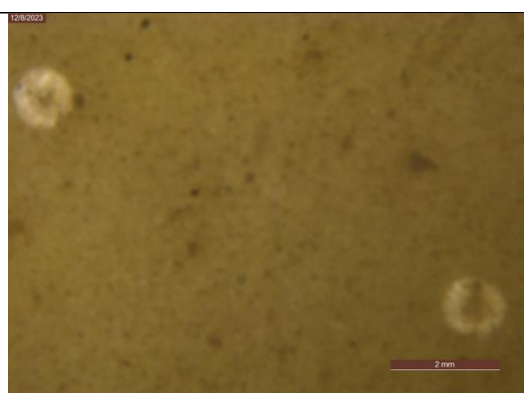
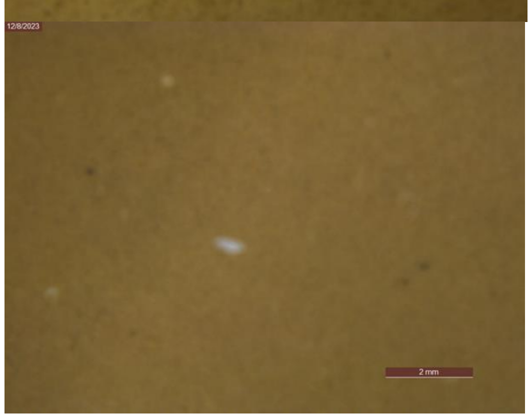
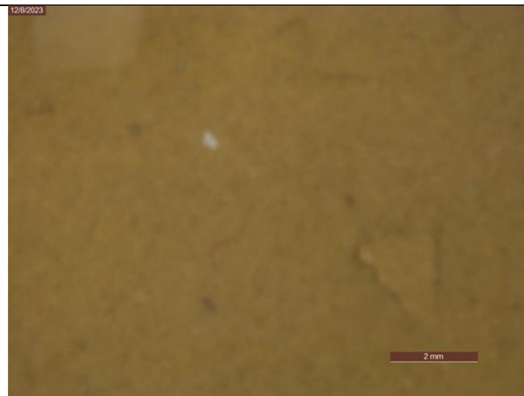
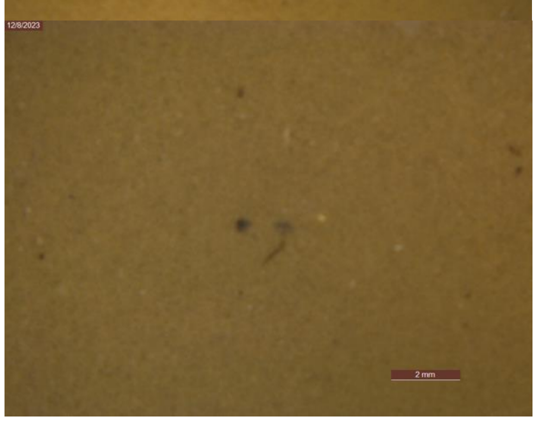
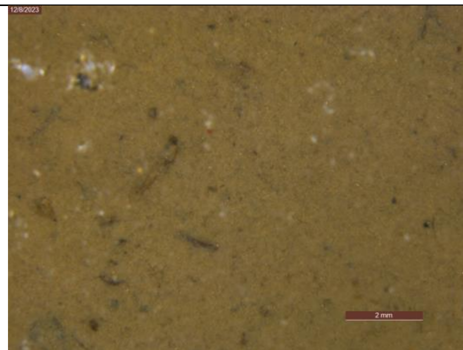
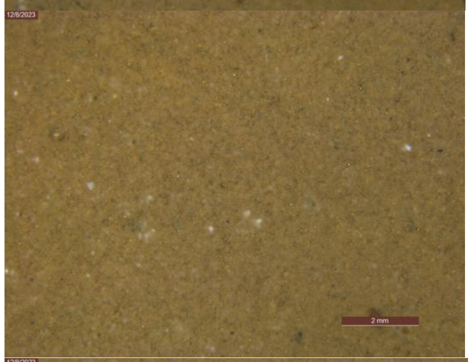
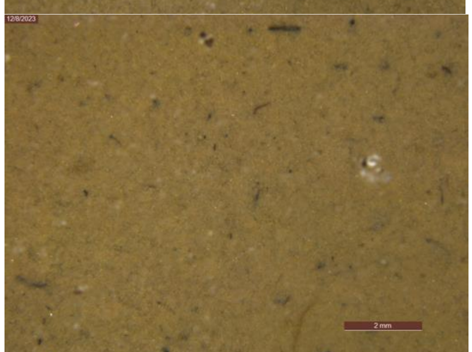
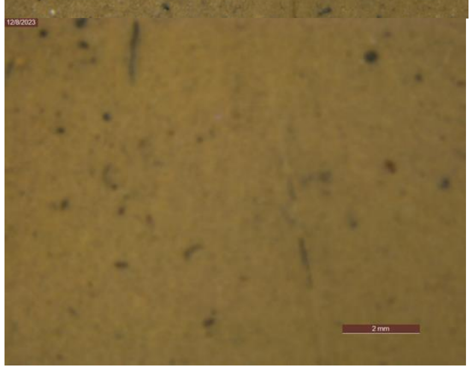
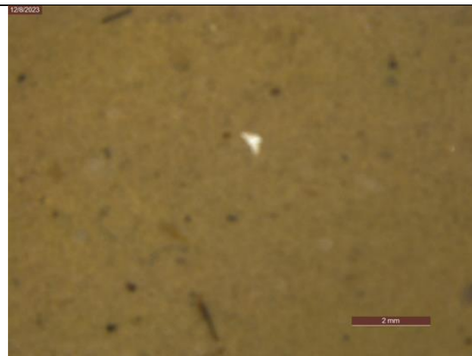
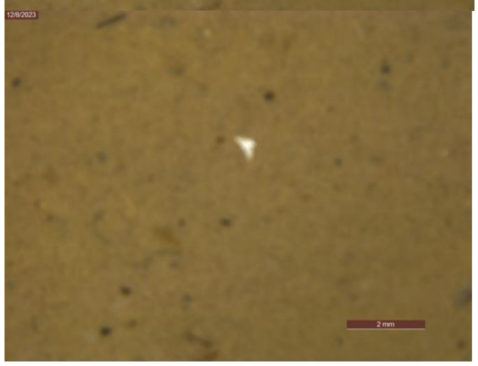
O-2	12/8/2023 2 mm 12/8/2023 1 mm	5/20/2024 WD mag HV HFW use case det pressure 50 µm 1:49:28 PM 9.8 mm 2 000 x 10.00 kV 207 µm Standard ETD 9.72E-4 Pa Apreo 5/20/2024 WD mag HV HFW use case det pressure 50 µm 1:51:32 PM 9.9 mm 2 000 x 10.00 kV 207 µm Standard ETD 9.31E-4 Pa Apreo 5/20/2024 WD mag HV HFW use case det pressure 50 µm 1:54:17 PM 9.8 mm 2 000 x 10.00 kV 207 µm Standard ETD 8.79E-4 Pa Apreo 5/20/2024 WD mag HV HFW use case det pressure 50 µm 1:53:29 PM 9.8 mm 2 000 x 10.00 kV 207 µm Standard ETD 8.88E-4 Pa Apreo

	 12/8/2023 1 mm  12/8/2023 2 mm	 5/20/2024 1:50:24 PM WD 9.8 mm mag 2 000 x HV 10.00 kV HFW 207 µm use case Standard det ETD pressure 9.51E-4 Pa 50 µm Apreo
O-3	 12/8/2023 2 mm  12/8/2023 2 mm	

O-3		

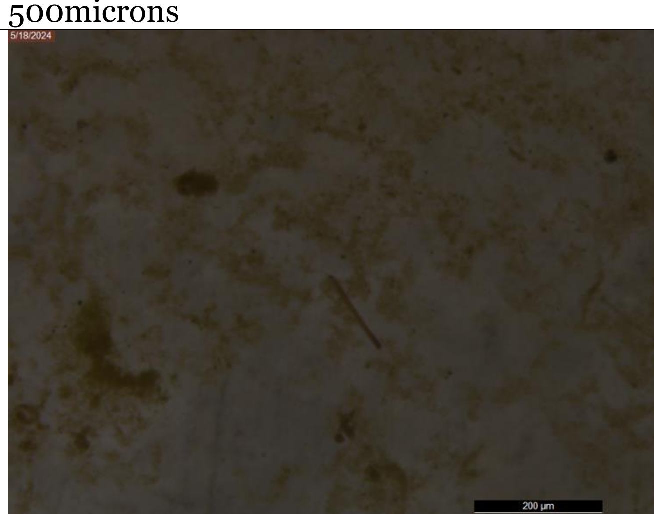
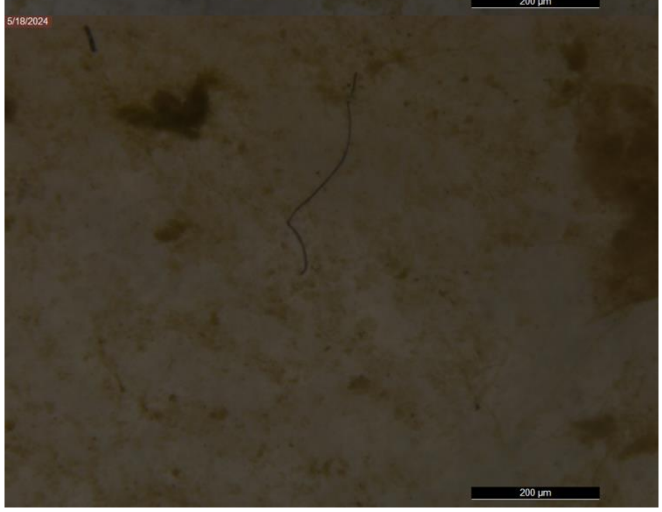
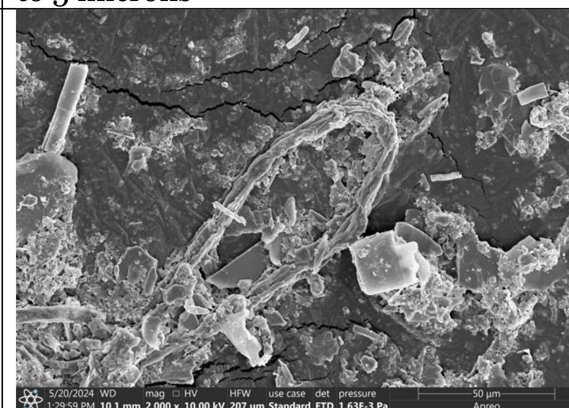
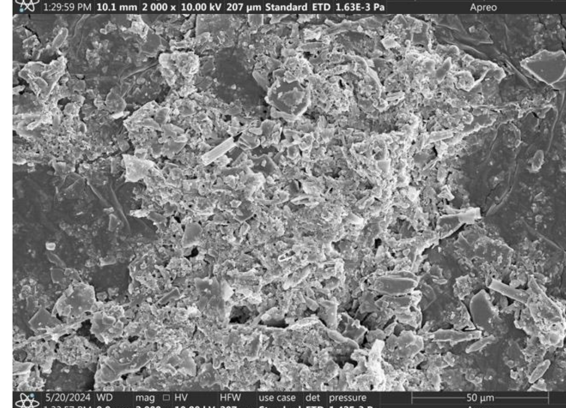
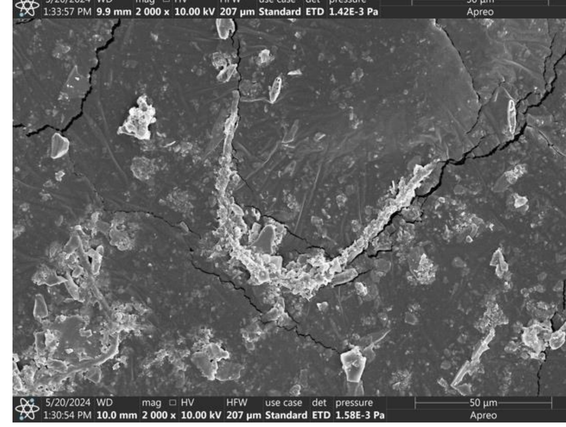
O-4	   	

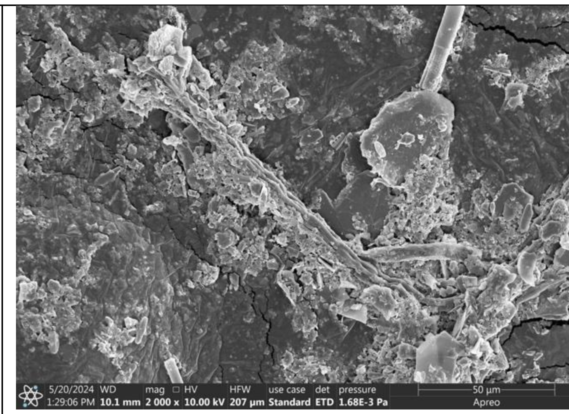
O-4	 	

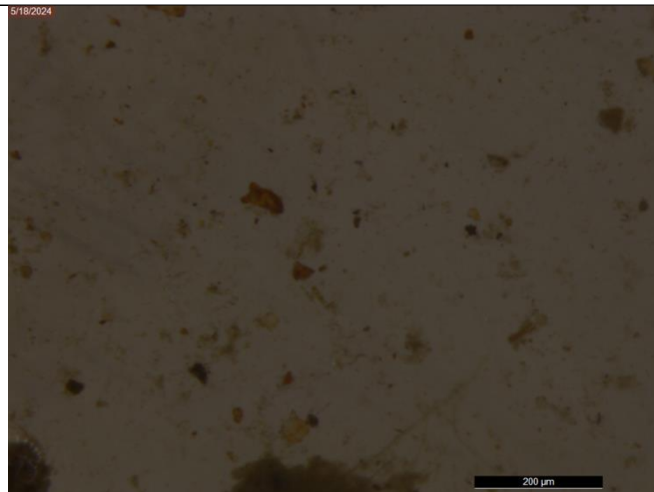
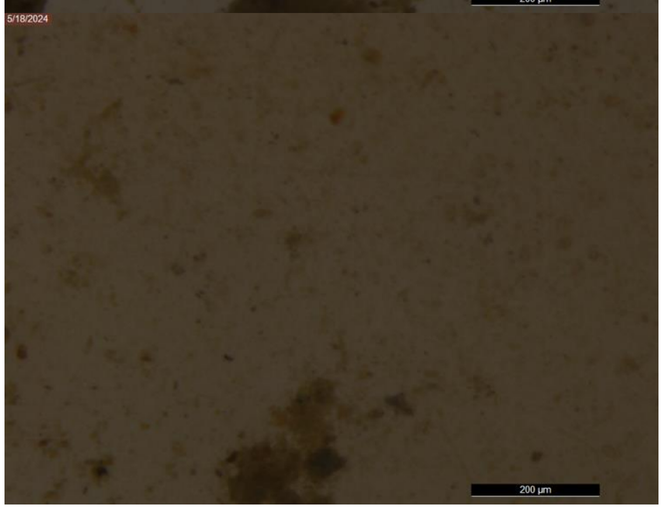
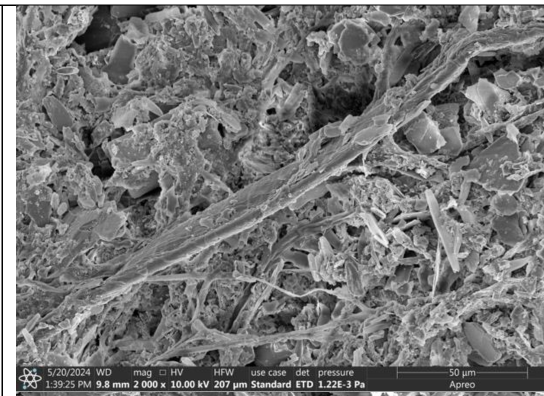
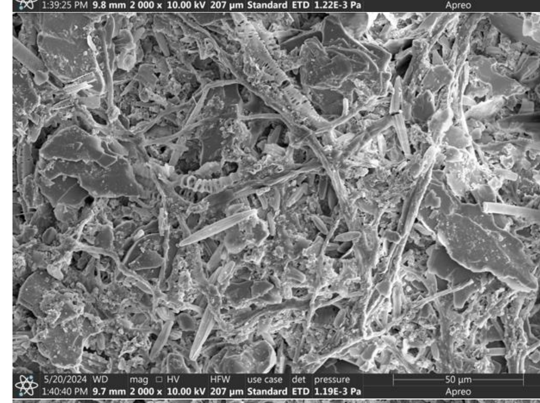
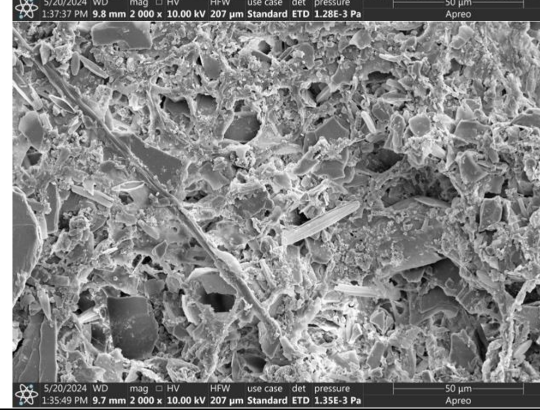
From the above table we can make a clear distinction in the content of microplastic in the present sample set of October 2023.
It is quite clear that the microplastic content is the highest with the highest human intervention in samples 1st and 4th. With the minimum microplastic content in the 2nd sample followed by the 3rd sample. In the all of the collected samples for October the filtrate about was the most compared to all the three sample sets being collected. Due to the high amount of silt present in the samples we can also visually signify that microplastic content is present in the range of 5 microns is in abundance.

The following table shows the results for the month of January 2024. This sample is collected after the cleaning of the canal system which is done annually in the month of Diwali in that particular year.

Table 6. Result for the month of January

Sample name	Under Binocular Microscope for the microplastic for the size of comparable to 500microns	Under SEM(Thermo Scientific Apreo S) for the microplastic size of comparable to 5 microns
J-1	 	  

J-1	5/18/2024 200 µm5/18/2024 200 µm	5/20/2024 WD mag HV HFW use case det pressure 1:29:06 PM 10.1 mm 2 000 x 10.00 kV 207 µm Standard ETD 1.68E-3 Pa 50 µm Apreo

J-2	5/18/2024 200 µm 5/18/2024 200 µm	5/20/2024 WD mag HV HFW use case det pressure 50 µm 1:39:25 PM 9.8 mm 2 000 x 10.00 kV 207 µm Standard ETD 1.22E-3 Pa Apreo 5/20/2024 WD mag HV HFW use case det pressure 50 µm 1:40:40 PM 9.7 mm 2 000 x 10.00 kV 207 µm Standard ETD 1.19E-3 Pa Apreo 5/20/2024 WD mag HV HFW use case det pressure 50 µm 1:37:37 PM 9.8 mm 2 000 x 10.00 kV 207 µm Standard ETD 1.28E-3 Pa Apreo 5/20/2024 WD mag HV HFW use case det pressure 50 µm 1:35:49 PM 9.7 mm 2 000 x 10.00 kV 207 µm Standard ETD 1.35E-3 Pa Apreo

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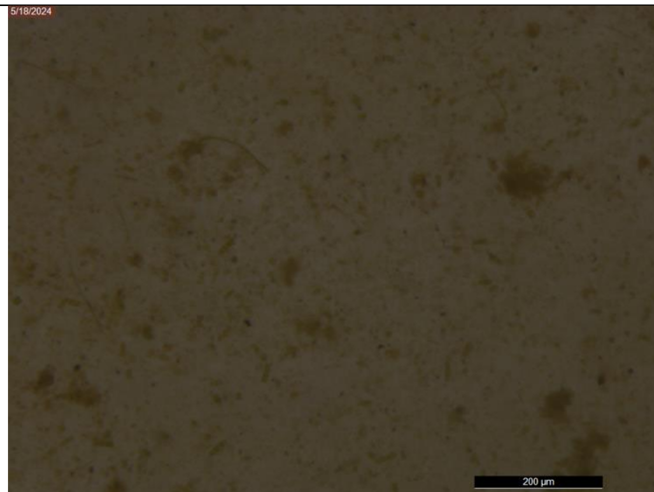

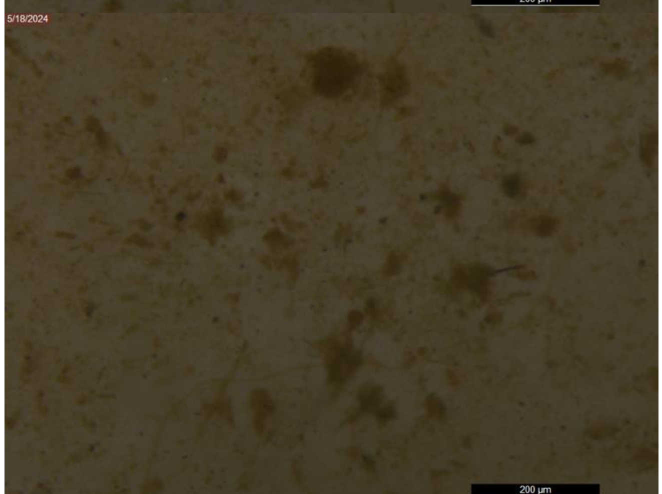

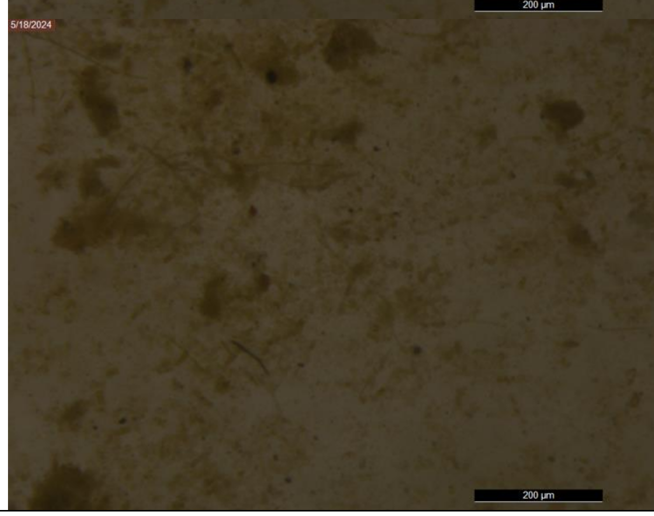

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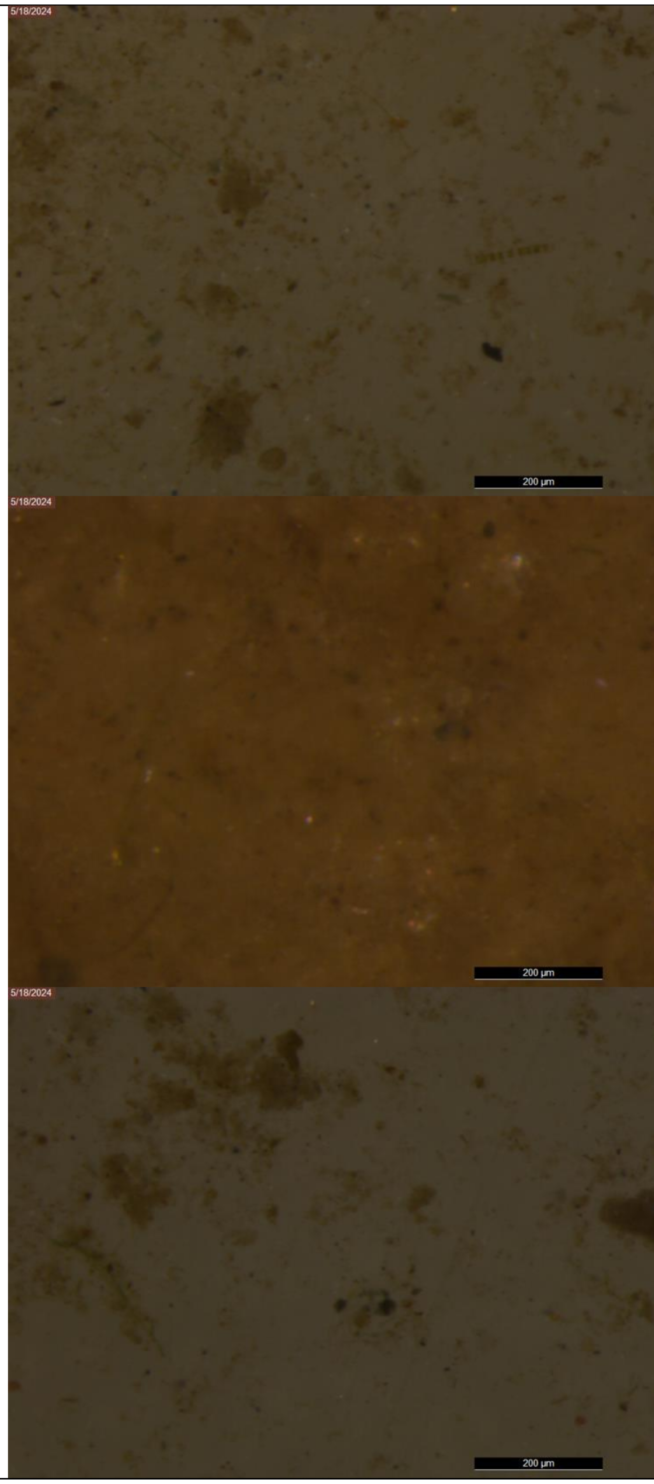
J-4		

From the above table we can make a clear distinction in the content of microplastic in the present sample set of January 2024.
It is quite clear that the microplastic content is the highest with the highest human intervention in samples 1st and 4th. With the minimum microplastic content in the 2nd

sample followed by the 3rd sample. In the all of the collected samples for January the filtrate about was the least compared to all the three sample sets being collected. Due to minimum human intervention in the form of tourism due to winters and the clear glacier run waters, we can also find microplastic in the range of 5 mm to be the least.

The following table shows the result for the month of April 2024, this is collected pre-monsoon so as to neglect the effect of monsoon runoff dragging in excess plastic waste with it.

Table 7. Result for the month of April

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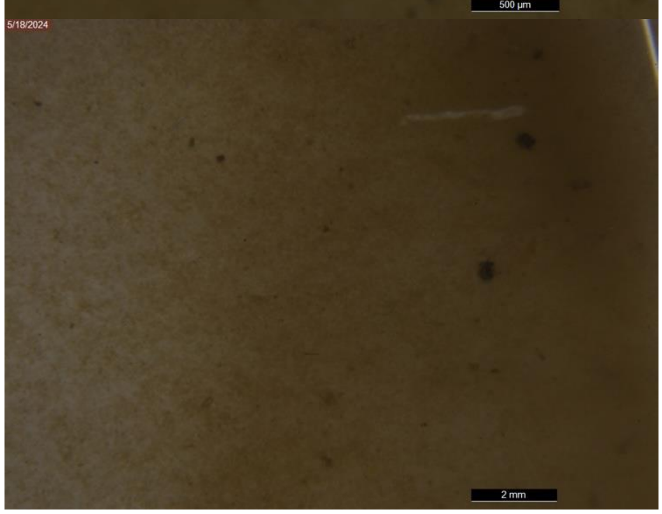
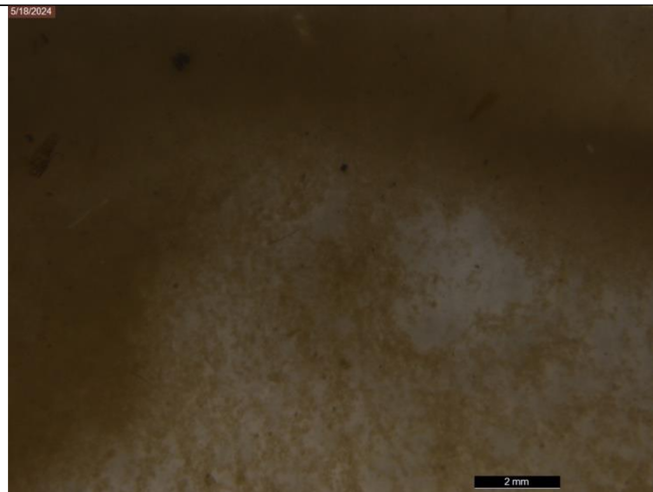
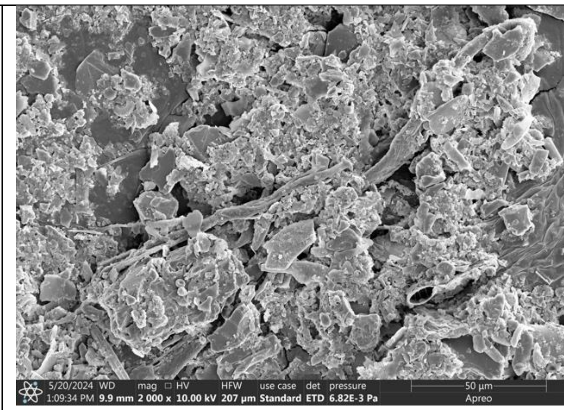
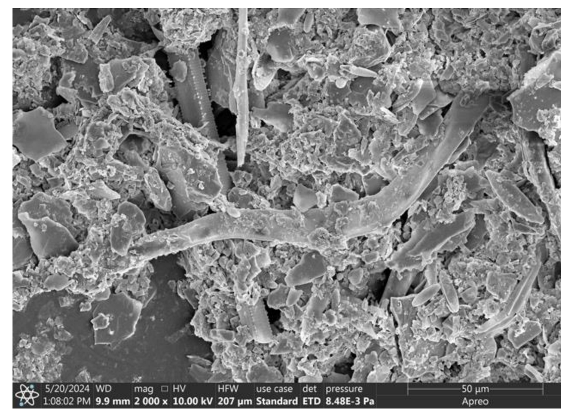
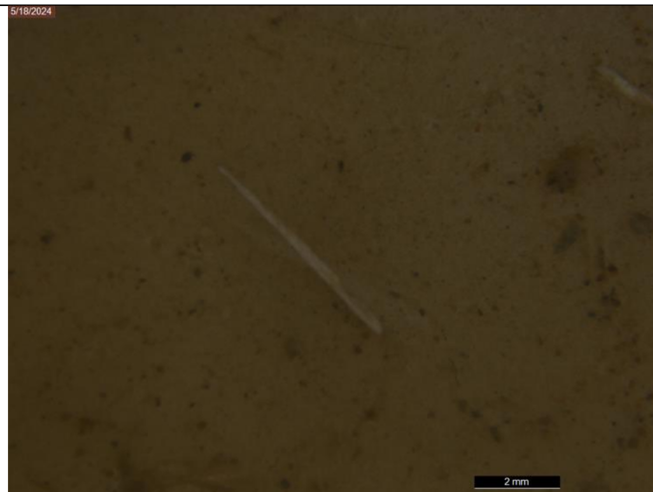
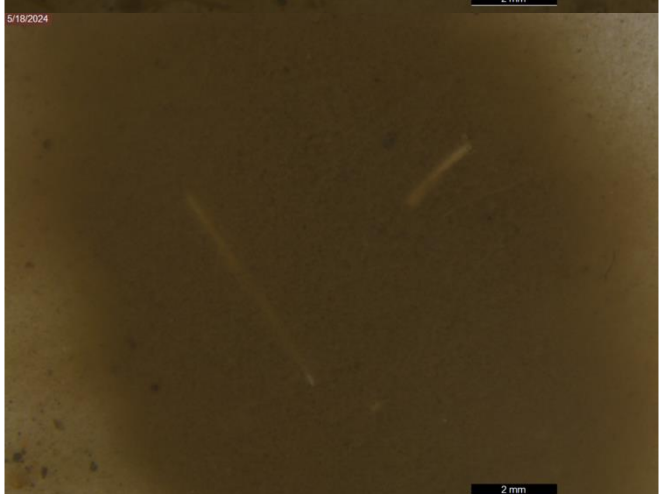
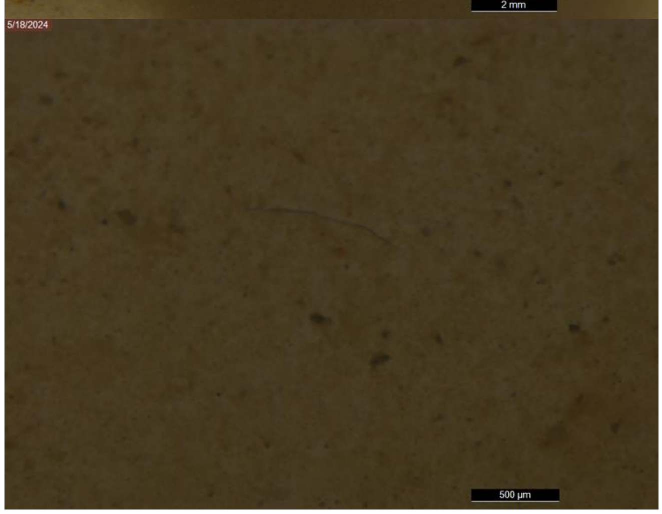
AP-1	 	 

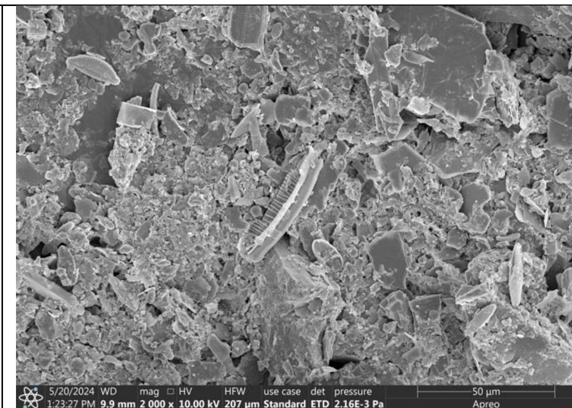
AP-1	5/18/2024 2 mm 5/18/2024 2 mm	5/20/2024 WD mag □ HV HFW use case det pressure 50 μm 1:09:34 PM 9.9 mm 2 000 x 10.00 kV 207 μm Standard ETD 6.82E-3 Pa Apreo 5/20/2024 WD mag □ HV HFW use case det pressure 50 μm 1:08:02 PM 9.9 mm 2 000 x 10.00 kV 207 μm Standard ETD 8.48E-3 Pa Apreo

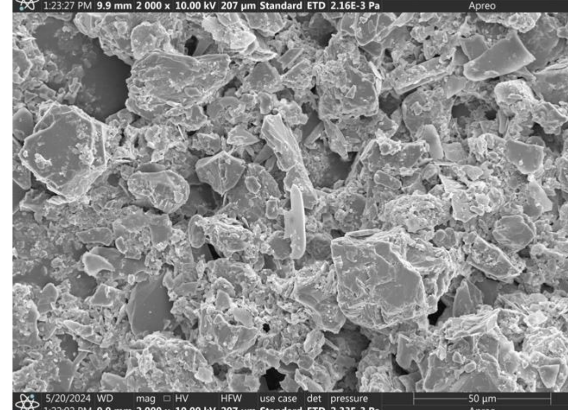
AP-2


5/18/2024
2 mm


5/18/2024
2 mm

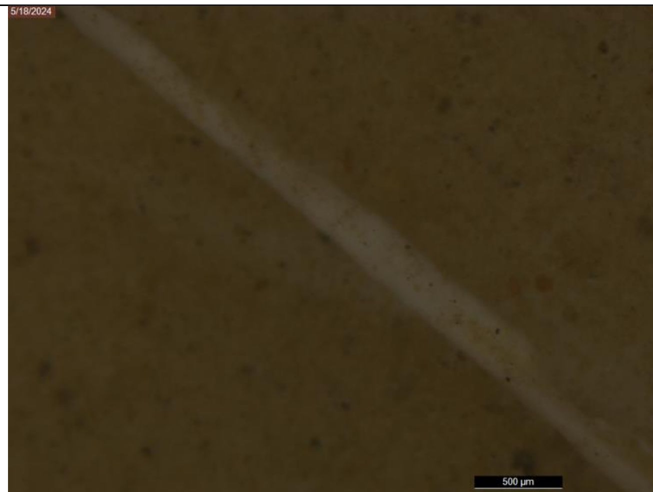

5/18/2024
500 µm

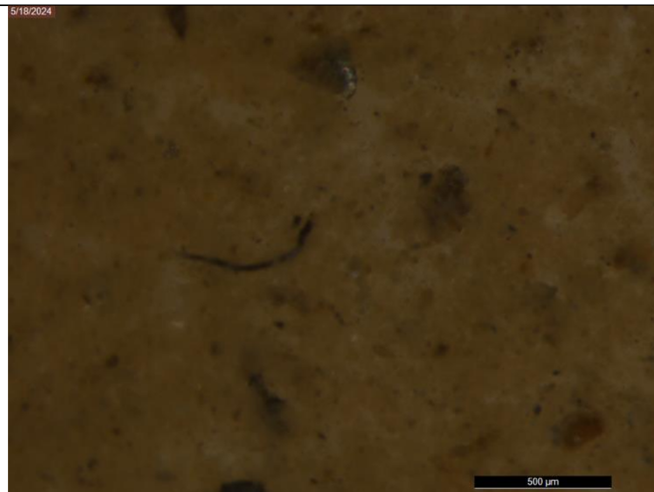
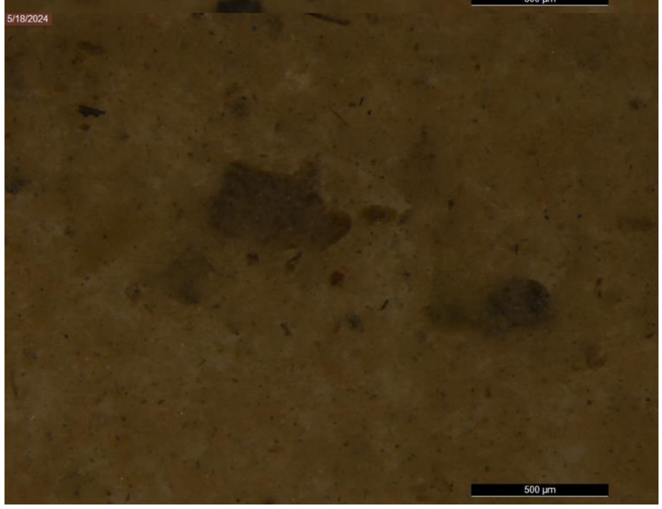

5/20/2024 WD mag HV HFW use case det pressure
1:23:27 PM 9.9 mm 2 000 x 10.00 kV 207 µm Standard ETD 2.16E-3 Pa
50 µm
Apreo

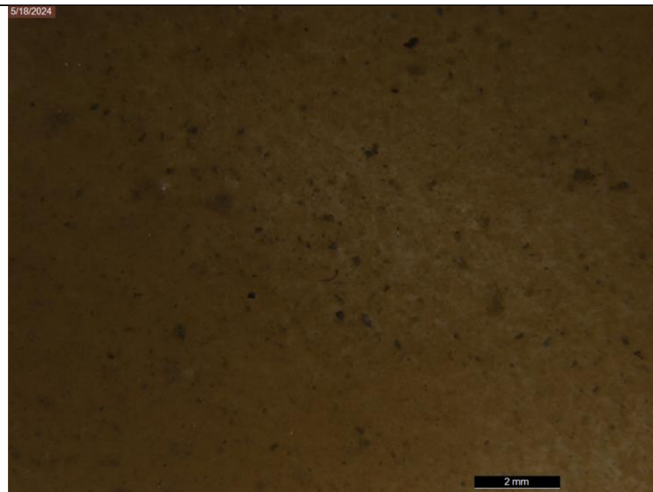
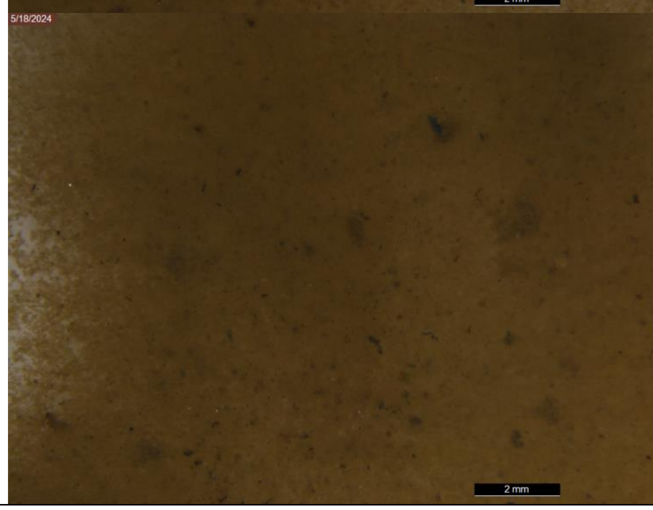

5/20/2024 WD mag HV HFW use case det pressure
1:22:02 PM 9.9 mm 2 000 x 10.00 kV 207 µm Standard ETD 2.33E-3 Pa
50 µm
Apreo

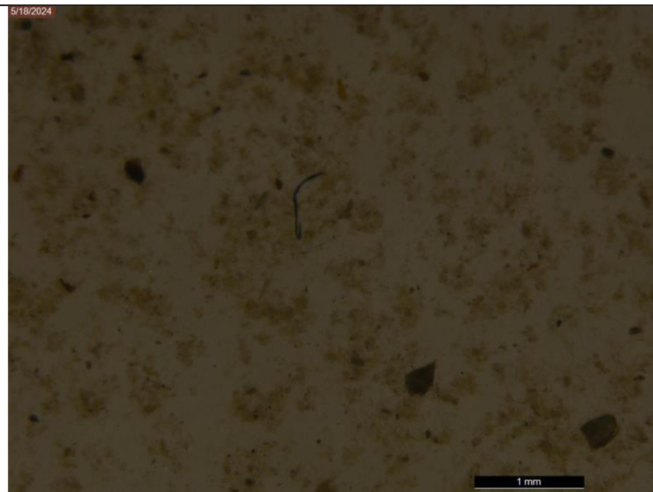
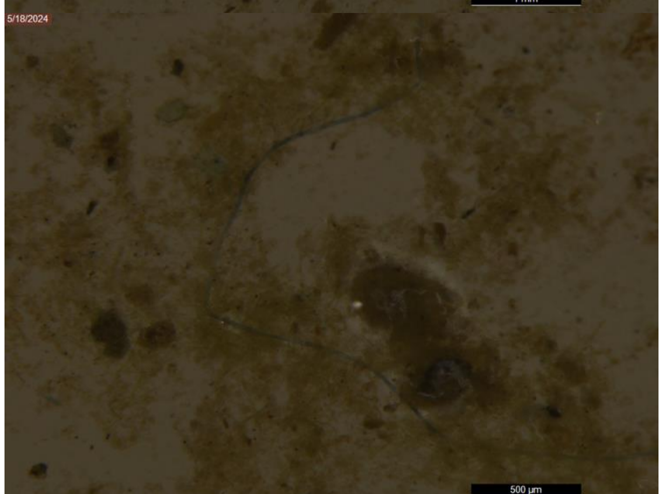
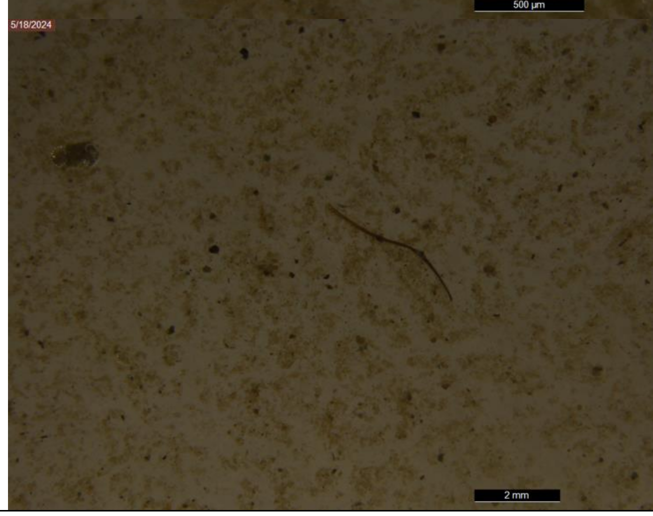

5/20/2024 WD mag HV HFW use case det pressure
1:18:08 PM 9.8 mm 2 000 x 10.00 kV 207 µm Standard ETD 2.99E-3 Pa
50 µm
Apreo

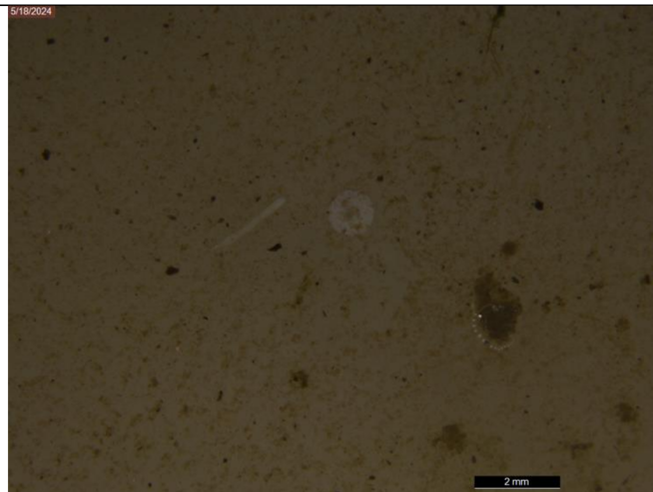
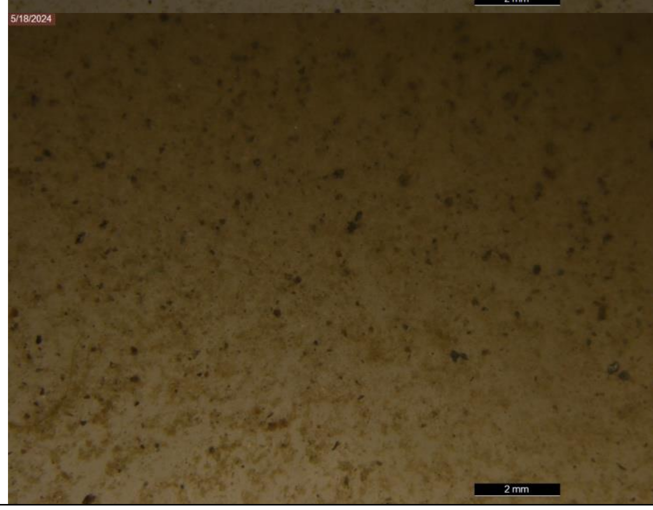

5/20/2024 WD mag HV HFW use case det pressure
1:16:45 PM 9.9 mm 2 000 x 10.00 kV 207 µm Standard ETD 3.29E-3 Pa
50 µm
Apreo

AP-2	 	

AP-3	 	

AP-3	 	

AP-4		

From the above table we can make a clear distinction in the content of microplastic in the present sample set of April 2024.

It is quite clear that the microplastic content is the highest with the highest human intervention in samples 1st and 4th. With the minimum microplastic content in the 2nd sample followed by the 3rd sample. In the all of the collected samples for April the filtrate was the moderate compared to all the three sample sets being collected. Due to minimum human intervention in the form of tourism due to post winters and the clear glacier run waters, we can also find microplastic in the range of 5 mm to be the not that much when compared to the other three sample sets.

Chapter 5
Conclusion

From the tests under the binocular microscope and SEM we can make the following observations regarding the general trend of microplastic with the changing seasons and human interventions.

1. As we compare the sample set within itself we can see that the content of microplastic increases with the increase in human intervention. As we go from test sample 1st to 2nd we can see a drastic decrease in the content of microplastic, however when we compare the 2nd test sample to the 3rd test sample we find the quantity of microplastic increasing with the most in 4th test sample.
2. It is also observed that the quantity of microplastic in context of seasons is most in the October i.e. post monsoon, with the least in January (The canal system is also cleaned after Diwali which is usually in the month of November) and then in April.
3. The smallest particle size is observed in October. The massive amount of silt present after monsoon causes the plastic to break down to sizes comparable to 5 microns.
4. The quantity of microplastic drastically decreases from 1st test sample to 2nd test sample majorly because of the uninterrupted stretch of 14kms in the canal system with no human intervention.

For further testing and to achieve the objective of quantification and identification of microplastic in the present samples we can use the techniques of FTIR and Ramen spectroscopy to have a deeper understanding of the microplastic present in the samples which will also help in the diagnostic of the problem and to predict the future health implications of the same.

References

Damaris Benny Daniel , P Muhamed Ashraf , Saly N Thomas 1 October 2020,
Abundance, characteristics and seasonal variation of microplastics in Indian white shrimps (Fenneropenaeus indicus) from coastal waters off Cochin, Kerala, India

Keziya James, Kripa Vasant , Shelton Padua , Vineetha Gopinath , Abilash K S , Jeyabaskaran R , Akhil Babu , Seban John May 2020
An assessment of microplastics in the ecosystem and selected commercially important fishes off Kochi, south eastern Arabian Sea, India

Damaris Benny Daniel , P Muhamed Ashraf , Saly N Thomas November 2020
Microplastics in the edible and inedible tissues of pelagic fishes sold for human consumption in Kerala, India

Keziya James , Kripa V , Vineetha G , Shelton Padua , Prema D , Abhilash K S , Akhil Babu , Seban John , Sebin John , Lavanya R , Reena V Joseph 2022 Mar
Microplastics in the environment and in commercially significant fishes of mud banks, an ephemeral ecosystem formed along the southwest coast of India

Tenzin Tsering a, Mika Sillanpää, Markus Sillanpää, Mirka Viitala, Satu-Pia Reinikainen 1 October 2021
Microplastics pollution in the Brahmaputra River and the Indus River of the Indian Himalaya

M. Tiwari , T.D. Rathod , P.Y. Ajmal , R.C. Bhangare, S.K. Sahu March 2019
Distribution and characterization of microplastics in beach sand from three different Indian coastal environments

Nirban Laskar, Upendra Kumar May 2019
Plastics and microplastics: A threat to environment

Chandan Krishna Seth & Amritanshu Shriwastav 25 August 2018
Contamination of Indian sea salts with microplastics and a potential prevention strategy

S. Veerasingam , M. Ranjani, R. Venkatachalapathy, Andrei Bagaev, Vladimir Mukhanov, Daria Litvinyuk, Liudmila Verzhevskaia, L. Guganathan, P. Vethamony December 2020

Microplastics in different environmental compartments in India: Analytical methods, distribution, associated contaminants and research needs

Mansi Vaid, Komal Mehra & Anshu Gupta 14 October 2021
Microplastics as contaminants in Indian environment: a review

The Central Pollution Control Board (CPCB) Annual Report (2019-20).
https://cpcb.nic.in/uploads/plasticwaste/Annual_Report_2019-20_PWM.pdf