

HEAVY METAL AND MICROPLASTIC ANALYSIS OF MARINE ORGANISMS FROM DIFFERENT FEEDING ZONES

Submitted in partial fulfilment of the requirements for an award of
Bachelor of Science Degree in Biotechnology

By

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DEPARTMENT OF BIOTECHNOLOGY

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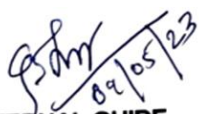
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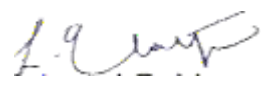


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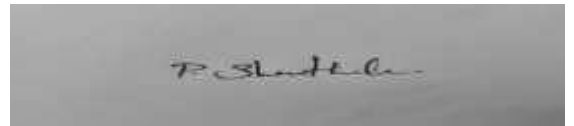
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I Shruthika. P, hereby declare that the Project Report entitled “Heavy metal analysis and microplastic pollution in marine organisms” done by me under the guidance of **Dr. Gracy jenifer** (Internal) and **Dr. T. Stalin Dhas** (External) at **Sathyabama Institute of Science and Technology, Chennai, Tamilnadu, India**, is submitted in partial fulfillment of the requirements for the award of **Bachelor of Science Degree in Biotechnology**.

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ABSTRACT

The purpose of this study was to inquire on the presence of heavy metals and microplastics in fish samples gathered from various aquatic environments. Heavy metal concentrations, including lead, cadmium, arsenic, and mercury, have been measured using passed analytical methods. The Heavy metal content has been measured using atomic absorption spectroscopy. Heavy metal concentrations of Zn, Se, Pb, Hg, Cd, Cr, Mn, As Fe were measured in water sediments and marine organisms. The samples are chosen based on their feeding patterns and location in Kovalam, and they are evaluated using atomic absorption spectroscopy. The highest concentrations of heavy metals in fish were detected in Zn (0.357), Se (0.574), Pb (0.758), Hg (0.227), Cd (1.348), Cr (0.961), Mn (1.201), Fe (3.605), and As (1.947) samples. Microplastics are anthropogenic hazards found in aquatic environments, lakes, and rivers. Any kind of water contains small (50-500 m) and extremely tiny (1-50 m) microplastic shards. They are filtered by membrane filtration and then viewed with a stereo zoom microscope. This review tackles different gaps in current knowledge and research on heavy metal build-up and microplastic pollution. The findings emphasise the importance of continuing to monitor the prevalence of heavy metals and microplastics in fish, as well as developing effective methods to reduce their impact on aquatic ecosystems and public health. The goal of this research and understanding of heavy metal toxicity and microplastics is to develop numerous efficient treatment methods to begin reducing pollution in the environment.

Keywords: heavy metal, microplastic, atomic absorption spectroscopy, toxicity, bioaccumulation.

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LIST OF ABBREVIATIONS

Zn	Zinc
Se	Selenium
Pb	Lead
Hg	Mercury
Cd	Cadmium
Cr	Chromium
As	Arsenic
Mg	Magnesium
Fe	Iron
g	Gram
mL	Millilitre
mm	Millimetre
µg	Microgram
min	Minutes
hrs	Hours
PCBs	Polychlorinated biphenyl
XRD	X-ray diffraction
AAS	Atomic absorption spectrometry
FAAS	Flame atomic absorption spectrometry
WHO	World Health organization
PET	Polyethylene terephthalate
FTIR	Fourier-transform infrared spectroscopy
ICP-MS	Inductively coupled plasma mass spectrometry

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CHAPTER 1

1. INTRODUCTION:

Heavy metal toxicity and microplastic contamination are two serious environmental hazards that can harm aquatic ecosystems and fish populations. Heavy metals such as lead, cadmium, and mercury can accumulate in fish tissues, causing a variety of detrimental health effects in both fish and humans who consume them (Scheuhammer et al., 2007). Similarly, microplastic pollution, which refers to the presence of microscopic plastic particles in water bodies, has been observed to accumulate in fish tissues, potentially leading to detrimental health impacts (Wright et al., 2013).

To address these problems, researchers have been undertaking studies to better understand the level of heavy metal and microplastic pollution in fish populations, as well as the possible health implications on both the fish and the humans who consume them as shown in the Figure1.1. These analyses used an array of approaches, such as spectroscopic and chromatographic methods, to detect and measure these pollutants in fish tissues (Li et al., 2020).

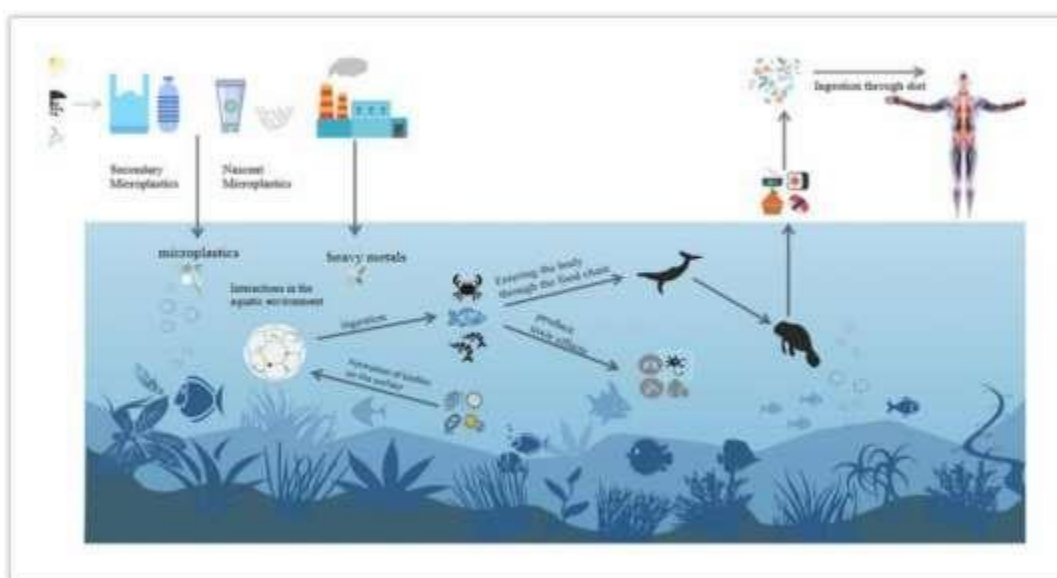


Figure 1.1: Effects of heavy metals and microplastic pollution

Heavy metal toxicity and microplastic contamination are two significant environmental concerns that have gained considerable attention in recent years due to their adverse effects on aquatic organisms, particularly fish. Heavy metals are known to be toxic to fish and can accumulate in their tissues, leading to various health problems and even death. On the other hand, microplastics are small plastic particles that are ubiquitous in aquatic environments and can be ingested by fish, potentially leading to adverse effects on their health and the ecosystem

Heavy metals are toxic pollutants that can accumulate in the tissues of aquatic organisms, leading to health problems and even death. On the other hand, microplastics, small plastic particles less than 5 mm in size, have become ubiquitous in aquatic environments, where they can be ingested by fish, potentially causing damage to their digestive system and affecting their overall health.

Heavy metal toxicity and microplastic contamination are significant environmental concerns that can have adverse effects on fish populations. These issues highlight the need for further research and increased awareness of the impact of human activities on aquatic ecosystem

BIOACCUMULATION AND BIOMAGNIFICATION:

Bioaccumulation is the process by which organisms, such as fish, accumulate and store harmful chemicals or substances from their surrounding environment. This can have serious implications for both the individual organism and the ecosystem. In fish, bioaccumulation can occur through their diet or through direct exposure to contaminated water or sediment as shown in Figure 1.2 (Snyder, 2021).

Research has shown that certain chemicals, such as mercury and polychlorinated biphenyls (PCBs), can accumulate in fish tissues to levels that may be harmful to both human and animal health (Schwarzenbach et al., 2010). High levels of mercury in fish can cause neurological and developmental problems in humans who consume them (Clarkson and Magos, 2006).

Therefore, it is important to monitor the levels of contaminants in fish populations and take measures to prevent or reduce their accumulation to protect human and environmental health. This can be done through regulations and policies that limit the use and release of harmful chemicals into the environment (Snyder, 2021).

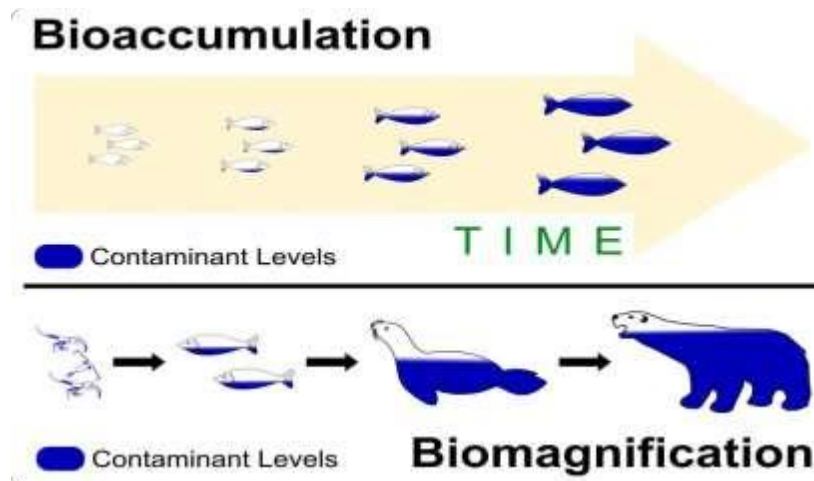


Figure1.2 Bioaccumulation and magnification

Biomagnification is a process where the concentration of a particular substance increases as it moves up the food chain. Fish are particularly vulnerable to biomagnification because they are often at the top of the aquatic food chain. One example of biomagnification in fish is the accumulation of mercury, which can lead to neurological damage in humans who consume contaminated fish (Gagné and Blaise, 2015).

For instance, a study conducted by Usenko et al. (2015) in the Gulf of Mexico found that biomagnification of mercury was occurring in the food web, resulting in high levels of mercury in top predator fish species such as tuna and swordfish. The study showed that biomagnification of mercury was occurring due to the accumulation of mercury in the food chain, and this poses a significant risk to human health.

One study conducted by Zhang et al. (2019) investigated the biomagnification of mercury in fish in a Chinese lake. The researchers found that the concentration of mercury increased significantly in fish as they moved up the food chain, with the highest levels of mercury found in the top predator, the largemouth bass. This biomagnification of mercury in fish has important implications for human health, as people who consume fish from polluted water bodies may be at risk of exposure to high levels of this toxic substance.

HEAVY METALS:

Heavy metals are a group of elements with high atomic weights that have been recognized as significant environmental pollutants due to their toxicity, persistence, and bioaccumulation. Among various organisms, fish are known to accumulate and magnify heavy metals in their tissues, making them a potential health risk to humans who consume them as a food source (Javed and Usmani, 2019).

Studies have shown that heavy metals such as cadmium, lead, mercury, and arsenic can accumulate in various fish species and pose serious threats to human health (Javed and Usmani, 2019). The accumulation of heavy metals in fish is mainly due to their long-term exposure to contaminated water, sediments, and food sources (Khan et al., 2019).

In a study conducted by Khan et al. (2019), the accumulation of heavy metals in fish samples from the River Sutlej in Pakistan was analysed. The results showed that the fish species examined, including *Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*, had significant levels of heavy metals, which exceeded the permissible limits set by the World Health Organization (WHO).

Heavy metal accumulation in fish is a growing environmental concern due to the potential risks it poses to human health and aquatic ecosystems. Heavy metals are elements with high atomic weights that are toxic to living organisms, even in low concentrations.

These metals can enter aquatic systems through natural processes such as weathering of rocks and volcanic activity, as well as human activities such as

mining, industrial processes, and agriculture. Some heavy metals, such as lead, cadmium, mercury, and arsenic, are toxic to living organisms even at low concentrations. Fish are known to accumulate heavy metals in their tissues, and their consumption can potentially harm human health.

In fact, several studies have shown that the consumption of fish contaminated with heavy metals can lead to various adverse health effects, including cardiovascular disease, kidney damage, and neurological disorders (Birch et al., 2014; Islam et al., 2015).

A study conducted in the United States found that people who consumed fish contaminated with mercury had a higher risk of developing cardiovascular disease (Mozaffarian et al., 2011). Similarly, a study conducted in Bangladesh showed that the consumption of fish contaminated with arsenic was associated with an increased risk of cardiovascular disease (Rahman et al., 2017). These findings highlight the importance of monitoring the levels of heavy metals in fish and implementing measures to reduce their accumulation in fish.

Heavy metal pollution in marine environments poses a significant threat to marine organisms, which can accumulate toxic levels of these metals in their tissues. To address this issue, atomic absorption spectroscopy (AAS) has emerged as a powerful analytical technique for detecting and quantifying heavy metals in marine organisms (Bhattacharya et al., 2016). AAS is a sensitive and precise method that can measure trace levels of metals in biological samples, making it an ideal tool for studying heavy metal pollution in marine organisms.

A study by Hossain et al. (2020) demonstrated the effectiveness of AAS in detecting heavy metals in different marine organisms, including fish, shrimp, and crab. The authors analysed the concentrations of several heavy metals, including lead, cadmium, and mercury, in different tissues of these organisms using AAS. The results showed that the concentrations of these metals varied significantly among the different species and tissues analysed, highlighting the importance of conducting comprehensive studies to evaluate heavy metal pollution in marine ecosystems.

MICROPLASTIC:

Toxic microplastics have become a major concern in recent years due to their widespread presence in aquatic environments and their potential to accumulate in the tissues of marine organisms, including fish. The accumulation of microplastics in fish can have harmful effects on human health through the consumption of contaminated seafood.

According to a study by Rochman et al. (2015), microplastics have been found in the gastrointestinal tracts of numerous marine species, including fish, which can lead to physical harm and toxicity. Furthermore, studies have shown that microplastics can absorb and concentrate toxins from the surrounding environment, which can then be released when ingested by marine organisms (Galloway et al., 2017).

The accumulation of toxic microplastics in fish can pose a risk to human health, as seafood is a common source of protein for many people. Ingestion of microplastics and associated toxins has been linked to negative health effects such as inflammation, oxidative stress, and damage to the liver and kidneys (Wang et al., 2019).

In summary, the accumulation of toxic microplastics in fish is a growing concern due to their potential to harm human health. It is important to continue researching the effects of microplastics on marine ecosystems and to develop strategies to reduce their impact on aquatic environments and the food chain.

Microplastic pollution has become a major environmental concern, particularly in marine ecosystems. It is essential to understand the extent and impact of microplastics on marine organisms. One technique used for this purpose is the analysis of microplastics in marine organisms using a stereo zoom microscope.

According to Li et al. (2020), stereo zoom microscopy is a useful tool for detecting microplastics in marine organisms due to its ability to visualize the samples in three dimensions. This technique enables researchers to accurately

identify and quantify the microplastics present in the organism's digestive tract, tissues, and organs.

There are several methods available to detect heavy metals and microplastic pollution in marine organisms. Some of the commonly used techniques are:

- Atomic absorption spectroscopy (AAS): AAS has been used to detect heavy metals such as cadmium, lead, and mercury in different marine organisms (Huang et al., 2015). Atomic Absorption Spectroscopy (AAS) is a widely used analytical technique for the quantitative determination of trace metals and metalloids in various samples. In AAS, atoms absorb light at specific wavelengths and then emit this energy as light of a different wavelength, which can be detected and quantified (Holler et al., 2016).
- X-ray fluorescence (XRF): XRF is a non-destructive technique that can be used to detect heavy metals in marine organisms. The technique involves the use of X-rays to excite the metal atoms in the sample, and the emission of characteristic X-rays is measured. The concentration of the metal in the sample is determined by comparing the intensity of the emission to a calibration curve; (Cordova et al., 2016). XRF has been used to detect heavy metals in marine organisms such as mussels; (Schuhmacher et al., 2016).
- Fourier transform infrared spectroscopy (FTIR): FTIR is a technique that can be used to detect microplastic pollution in marine organisms. The technique involves the use of infrared radiation to identify the type of plastic present in the sample. FTIR has been used to detect microplastics in marine organisms such as fish (Williams et al., 2015).
- Raman spectroscopy: Raman spectroscopy is a technique that can be used to detect microplastic pollution in marine organisms. The technique involves the use of a laser to excite the molecules in the sample, and the scattered radiation is measured. Raman spectroscopy has been used to detect microplastics in marine organisms such as oysters (O'Connor et al., 2018).

Sample collection:

The collection of different monsoon samples for heavy metal analysis is important because the concentrations of heavy metals can vary significantly between different regions and times of the year due to a variety of factors such as atmospheric deposition, geological features, and anthropogenic activities (Bhattacharyya et al., 2016; Wu et al., 2016). By collecting samples from multiple locations and times, a more comprehensive understanding of the distribution and sources of heavy metals can be obtained.

A study by Bhattacharyya et al. (2016) collected monsoon water samples from 12 different locations in the Indo-Gangetic plain and analysed them for heavy metal concentrations. The results showed significant spatial and temporal variations in heavy metal concentrations, with some locations having concentrations well above the recommended safe limits.

Similarly, a study by Wu et al. (2016) collected rainwater samples from multiple sites in a Chinese urban area and found that the concentrations of heavy metals varied significantly depending on the distance from industrial and traffic emission sources.

Therefore, collecting different monsoon samples for heavy metal analysis is crucial for understanding the spatial and temporal distribution of heavy metals and identifying potential sources of contamination.

CHAPTER 2

2. REVIEW OF LITREATURE:

Heavy metal toxicity in fish has become a global concern due to its impact on aquatic ecosystems and human health. Analysing heavy metal levels in fish is crucial for monitoring and assessing the degree of pollution in aquatic environments. Atomic absorption spectroscopy (AAS) is a common method used for detecting and quantifying heavy metals in fish tissues (Dheeba et al., 2013).

A study by Mwangi et al. (2021) analysed heavy metal concentrations in fish tissues from Lake Victoria in Kenya using AAS. The results showed high levels of lead, cadmium, and chromium in the fish samples, indicating a significant risk to human health.

Another study by Liu et al. (2018) assessed the heavy metal contamination in fish from the Pearl River Delta in China using AAS. The study found that the heavy metal levels in the fish tissues were significantly higher in areas where industrial activities and urbanization were more prevalent.

Additionally, a study by Qiu et al. (2019) investigated the effects of different cooking methods on heavy metal levels in fish using AAS. The study found that frying and grilling fish resulted in higher levels of heavy metals compared to boiling or steaming.

Numerous studies have utilized acid digestion for analysing heavy metal content in fish tissues. For instance, a study by Wang et al. (2019) used acid digestion to analyse the concentrations of heavy metals in the muscle and liver tissues of several fish species collected from a polluted river in China. The results showed that the concentrations of some heavy metals, such as mercury and lead, were higher than the maximum permissible limits set by the World Health Organization (WHO) and the Chinese National Food Safety Standard.

Another study by Yilmaz and Yilmaz (2018) analysed the heavy metal content in the muscle and liver tissues of several fish species collected from a river in Turkey using acid digestion. The results indicated that some fish species had

high levels of heavy metals, such as cadmium and lead, which could pose a risk to human health if consumed.

Microplastics have become a major environmental issue in recent years, with their presence being detected in various aquatic organisms including fish. The analysis of microplastics in fish requires a method that effectively separates and identifies microplastics from other contaminants. One such method involves the use of a solution of acid KOH, which dissolves organic materials, leaving microplastics behind (Jabeen et al., 2017).

Jabeen et al. (2017) conducted a study on the presence of microplastics in three commercially important fish species in Pakistan using the acid KOH method. They found that all three species contained microplastics, with the highest concentration found in *Scomberomorus Camerson*. The acid KOH method was effective in separating microplastics from other contaminants in the fish tissue.

Another study by Catarino et al. (2017) used a modified version of the acid KOH method to analyse microplastics in several fish species in the North Atlantic. They found that the method was effective in detecting microplastics in all of the fish species tested. The study also noted that the method was less time-consuming and less expensive than other methods for analysing microplastics in fish.

The study by Adeogun et al. (2014) examined the histopathological effects of heavy metal exposure on *Namatalosa nausus*. The researchers exposed the fish to a mixture of lead, cadmium, and zinc for 21 days and found that the fish showed significant histopathological changes in their gills, liver, and kidney tissues. The authors concluded that the exposure to heavy metals can cause damage to the internal organs of *Namatalosa nausus*.

A study conducted by Nirmala et al. (2021) analysed the accumulation of microplastics in the edible crab *Scylla serrata* in the Parangipettai coastal waters of the Bay of Bengal, India. The researchers found that the crabs had ingested microplastics, with an average of 2.4 microplastics per crab. The most common type of microplastic found was polyethylene terephthalate (PE).

Similarly, another study by Begum et al. (2020) assessed microplastic accumulation in the gut of the mud crab, *Scylla serrata*, from the coastal waters of Bangladesh. The results indicated the presence of microplastics in the crabs, with the highest concentration found in the hepatopancreas. The most common type of microplastic found was also PET.

One study conducted by Rahman et al. (2020) reported that exposure to heavy metals, including lead, cadmium, and arsenic, can result in oxidative stress and inflammation, leading to various diseases such as cancer, neurodegenerative disorders, and cardiovascular diseases. Another study by Satarug et al. (2020) suggested that heavy metal toxicity can affect the kidneys, liver, and nervous system, leading to renal dysfunction, liver damage, and cognitive impairment.

Moreover, heavy metals can also accumulate in the environment, causing long-term damage to ecosystems. A study conducted by Wang et al. (2021) demonstrated that heavy metals, such as mercury, lead, and cadmium, can accumulate in soil, water, and air, leading to soil and water pollution and affecting plant growth and human health.

Studies that have analysed heavy metals in *Mugil cephalus* fish, which is a commonly consumed species in many countries. One study conducted in Turkey analysed the levels of six heavy metals (cadmium, copper, lead, nickel, zinc, and iron) in *M. cephalus* collected from the Çandarlı Bay area using flame atomic absorption spectrometry (FAAS); (Özdemir et al., 2008). The study found that the highest concentration of heavy metals was zinc (50.6 µg/g), followed by iron (30.4 µg/g), copper (3.9 µg/g), nickel (3.3 µg/g), lead (2.2 µg/g), and cadmium (0.03 µg/g).

CHAPTER 3

3. AIM AND OBJECTIVE:

- To Extent the Heavy Metal toxicity and Microplastic pollution in marine organisms from different feeding zones.
- The main objectives of study were to monitor the Heavy metals concentrations and to detect microplastic in marine organism with different feeding zones.

CHAPTER 4

4. MATERIALS AND METHODS:

SAMPLING:

Pre-Monsoon samples from different locations are collected for heavy metal analysis because heavy metal pollution can vary significantly across different regions and even within the same region. Heavy metals can originate from natural sources, such as rock weathering, as well as anthropogenic sources, such as industrial activities and traffic emissions. Collecting different monsoon samples for heavy metal analysis is crucial in understanding the extent and distribution of heavy metal pollution in each region and for designing effective pollution control strategies

Furthermore, specific sampling techniques are required to properly analyze heavy metal and microplastic contamination. For example, samples may need to be collected at different depths or locations or filtered to separate out microplastic particles. Collecting specific samples using appropriate methods can ensure that accurate and reliable data is obtained.

- *Mertrix casta* (clams)

A filter- feeder.

- *Namatulosa nausus* (Bloch's Gizzard shad)

A filter- feeder.

- *Sylla serrata* (crab)

Omnivorous, molluscs, crustaceans and worms, occasionally algae.

- *Mugil Cephalous* (mullet)

Consuming mainly zooplanktons, dead plant matter, and detritus. Mullet has thick-walled gizzard-like segments in their stomach along with a long gastrointestinal tract that enables them to feed on detritus.

- *Plotous canius* (catfish)

Feed on crustaceans, mollusks and fishes.



A)



B)



C)



D)



E)

Fig 4.1A- *Namatulosa nausius* (Bloch's Gizzard shad)

B- *Mertrix casta* (clams)

C- *Sylla serrata* (crab)

D- *Mugil Cephalous* (mullet)

E- *Plotous canius* (catfish)



A)



B)

Fig 4.2 Soil samples collected from two different area of kovalam estuaries

ACID DIGESTION:

Acid digestion is a commonly used technique for the analysis of heavy metals in various types of samples, such as soil, sediment, water, and biological tissues. The following protocol outlines a typical acid digestion procedure for heavy metal analysis

- Weigh the sample (about 0.3 g dry sample) into a glass vessel.
- Add 15 mL of concentrated HNO_3 to the sample and place the digestion vessel onto an electromagnetic stirrer and heat gradually to 100 °C for 15-20 min.
- Remove the digestion vessel from the stirrer and allow it to cool to room temperature.
- Transfer the solution to a clean plastic or glass container and is send for atomic absorption spectroscopy (AAS) to find the concentration of heavy metal.

Heavy metal analysis: To analyze the heavy metal content, the fish can be digested using acid and then analyzed using techniques such as inductively coupled plasma-mass spectrometry (ICP-MS) or atomic absorption spectrometry (AAS).

KOH DIGESTION:

KOH digestion is a common method used for the analysis of microplastics in environmental samples. The following is a general protocol for performing KOH digestion for microplastic analysis

- To prepare 10 % potassium hydroxide (KOH) solution, weigh out 10 g of KOH pellets using a digital balance and place them in a clean and dry glass beaker. Add about 90 mL of distilled water to the beaker and stir the mixture gently until all the KOH dissolves completely.
- Weigh 0.6 g of the environmental sample and place it into a glass beaker.
- Add 20 mL of 10 % KOH solution to the beaker.
- Put the beaker in stirrer for 12-24 hrs at room temperature to allow the microplastics to break down.
- Filter the mixture using the Millipore filter and collect the membrane
- Place the filter membrane with the microplastics in an oven at 60 °C for 30 min to dry.
- Transfer the filtered sample to a microscope slide and examine under a microscope to identify and count microplastics.

Micro plastic analysis: To analyze the micro plastic content, the fish can be dissected, and the gastrointestinal tract can be removed and analyzed for micro plastic particles using a microscope or other analytical techniques.

Data analysis:

Finally, the data obtained from the heavy metal and micro plastic analyses can be analyzed and compared to regulatory limits and guidelines to assess the level of contamination in the fish.

CHAPTER 5

5. RESULT AND DISCUSSION:

Heavy metal and microplastic contamination are major threats to the health of aquatic ecosystems and the fish that reside within them. The amount and composition of heavy metals in the monsoon samples can therefore provide important information about the level of pollution in a particular region and its potential impact on the environment and human health.

Here are some possible results following a study analyzing the effects of heavy metal and microplastic pollution on marine samples.

5.1 HEAVY METAL CONCENTRATION:

The heavy metal concentrations in the samples were analyzed, including zinc, selenium, lead, mercury, cadmium, chromium, arsenic, magnesium and iron.

PRE- MONSOON:

Namatulosa nausius (Bloch's Gizzard shad)

S.NO	ELEMENTS	Gut	Gill	Muscle	Skin
1	Zn	0.121	0.065	0.009	0.056
2	Se	0.088	0.228	0.299	0.07
3	Pb	0.303	0.163	0.07	0.303
4	Hg	0.054	0.14	0.227	0.054
5	Cd	0.04	0.241	0.625	0.141
6	Cr	0.051	0.309	0.798	0.18
7	Mn	0.04	0	0	0.04
8	Fe	0.085	0.235	0.17	0.128
9	As	0.046	0.082	0.035	0.176

Table 5.1.1 Heavy metal concentration of *Namatulosa nausius*(pre-monsoon)

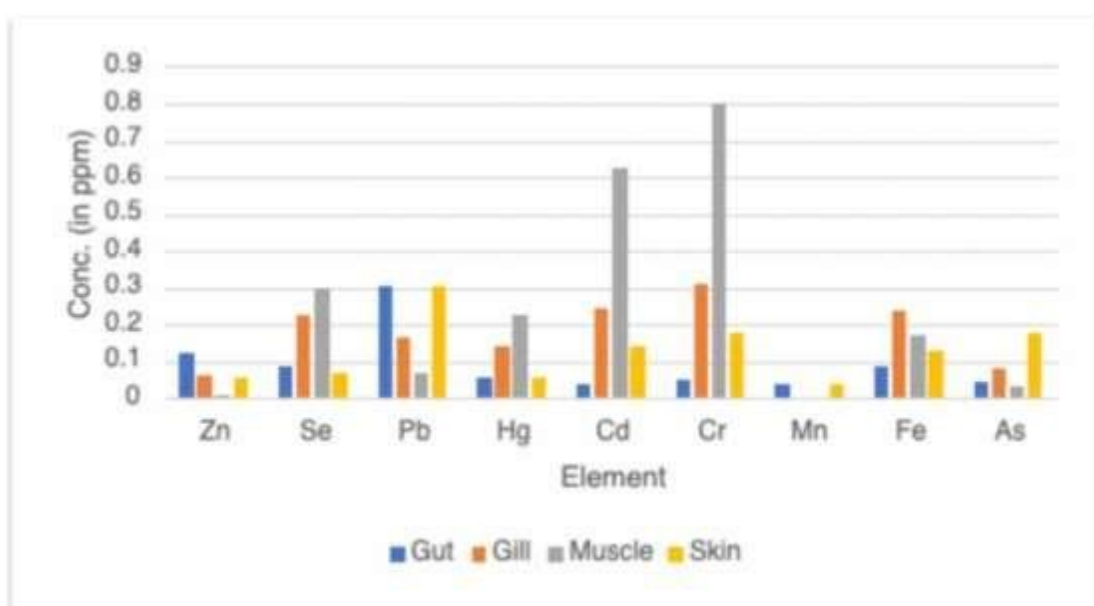


Fig 5.1.1 AAS of *Namatulosa nausus* (pre-monsoon)

Plotous canius (catfish)

S.NO	ELEMENTS	Skin	Gut	Gill	Tissue
1	Zn	0.357	0.034	0.025	0.059
2	Se	0.037	0.018	0.222	0.574
3	Pb	0.691	0.089	0.691	0.089
4	Hg	0.009	0.009	0	0.009
5	Cd	0.611	0.161	0.953	0.755
6	Cr	0.576	0.961	0.048	0.192
7	Mn	1.201	0.072	0.024	0
8	Fe	0.432	2.187	3.605	1.947
9	As	0.576	0.889	1.947	0.192

Table 5.1.2 Heavy metal concentration of *Plotous canius* (pre-monsoon)

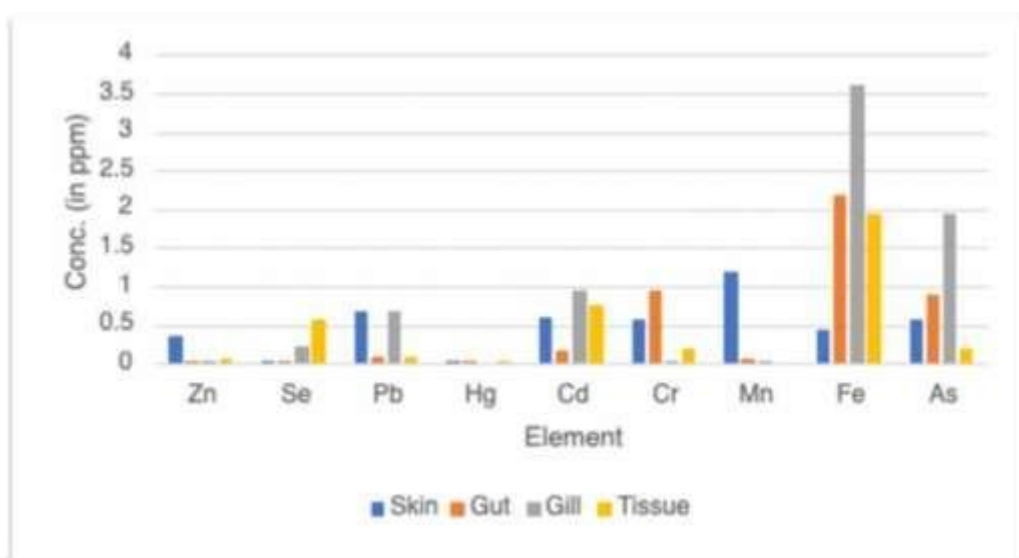


Fig 5.1.2 AAS of *Plotous canius* (pre-monsoon)

Mertrix casta (clams)

S.NO	ELEMENTS	Adductor Muscle	Foot	Muscle	Gill
1	Zn	0.119	0.042	0.178	0.034
2	Se	0.055	0.222	0.055	0.259
3	Pb	0.691	0.133	0.691	0.089
4	Hg	0.009	0	0.019	0.009
5	Cd	0.143	0.611	1.348	0.809
6	Cr	0.432	0.504	0.216	0.024
7	Mn	0	0	0.024	0.048
8	Fe	1.706	0.576	0.192	0.096
9	As	0.12	0.6	1.322	1.73

Table 5.1.3 Heavy metal concentration of *Mertrix casta* (pre-monsoon)

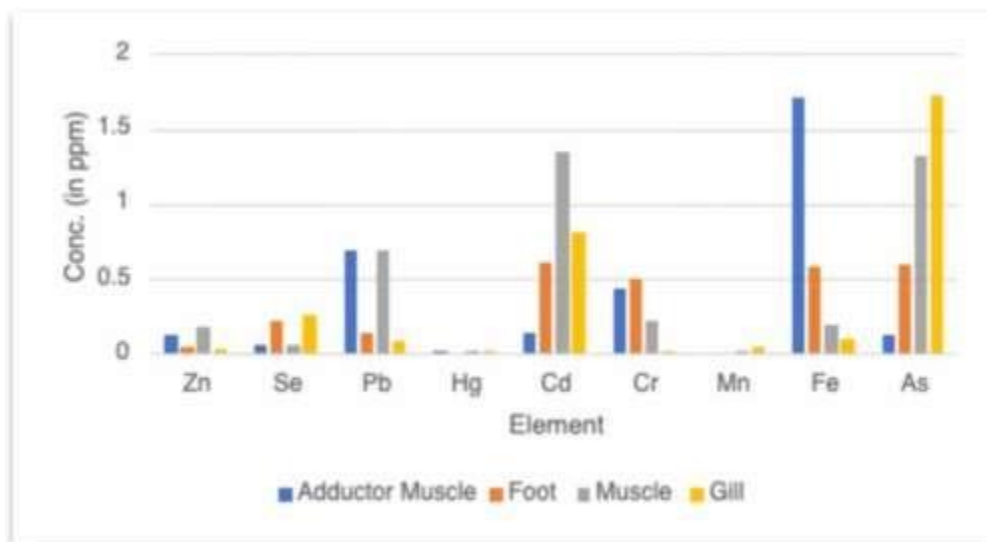


Fig 5.1.3 AAS of *Mertrix casta* (pre-monsoon)

Mugil Cephalous (mullet)

S.NO	ELEMENTS	Skin	Gut	Tissue	Gill
1	Zn	0.225	0.204	0.01	0.034
2	Se	0.24	0.074	0.259	0.425
3	Pb	0.089	0.758	0.312	0.111
4	Hg	0.009	0.099	0.099	0
5	Cd	0.125	0.575	1.043	0.143
6	Cr	0.336	0.096	0.552	0.408
7	Mn	0.072	0.024	0.48	0.24
8	Fe	0.192	0.432	0.817	0.672
9	As	0.817	1.947	0.192	0.168

Table 5.1.4 Heavy metal concentration of *Mugil Cephalous* (pre-monsoon)

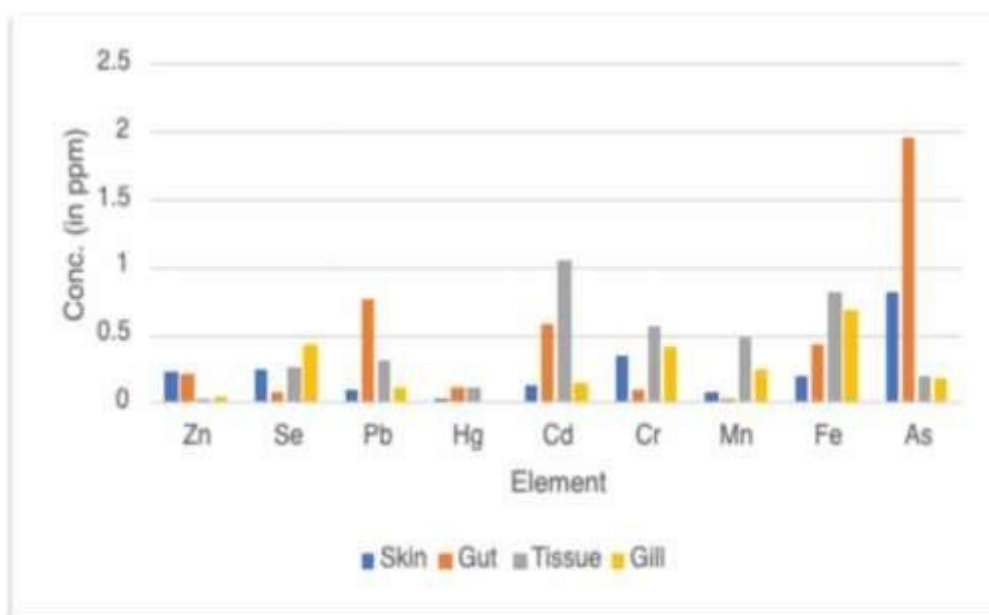


Fig 5.1.4 AAS of *Mugil Cephalous* (pre-monsoon)

Sylla serrata (crab):

S.NO	ELEMENTS	Tissue	Hepatopancreas	Gill
1	Zn	0.034	0.102	0.034
2	Se	0.018	0.037	0.018
3	Pb	0.111	0.29	0.089
4	Hg	0.009	0.009	0.019
5	Cd	0.557	0.413	0.071
6	Cr	0.072	0.096	0.072
7	Mn	0.031	0	0.048
8	Fe	0.309	0.721	0.024
9	As	0.432	1.009	0.096

Table 5.1.5 Heavy metal concentration of *Sylla serrata* (pre-monsoon)

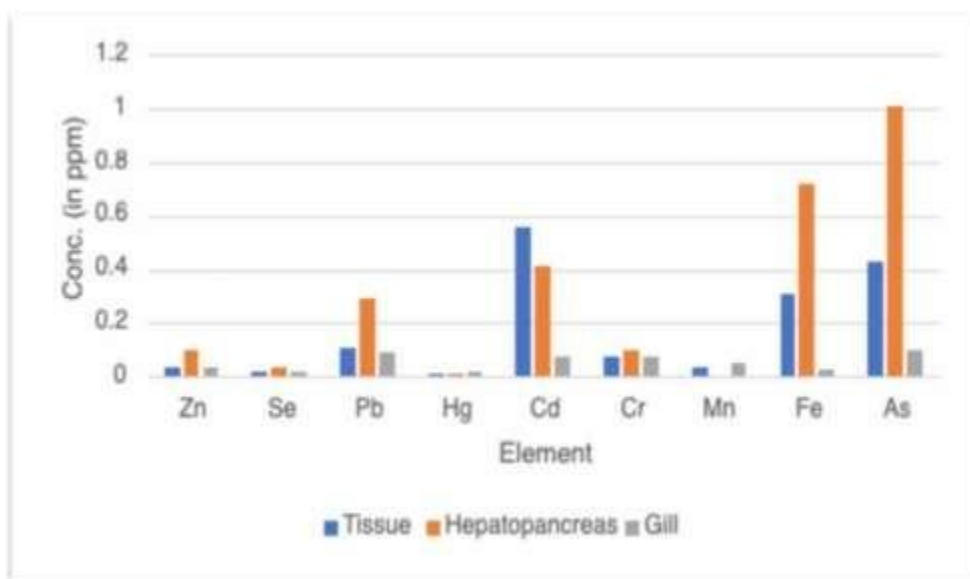


Fig 5.1.5 AAS of *Sylla serrata* (pre-monsoon)

WATER SAMPLE:

S.NO	ELEMENTS	1	2
1	Zn	0.224	0.112
2	Se	0.475	0.105
3	Pb	0.116	0.303
4	Hg	0.151	0.021
5	Cd	0.02	0.161
6	Cr	0.025	0.206
7	Mn	0.161	0.024
8	Fe	0.277	0.149
9	As	0.093	0.281

Table 5.1.6 Heavy metal concentration of water samples collected from kovalam estuaries (pre-monsoon)

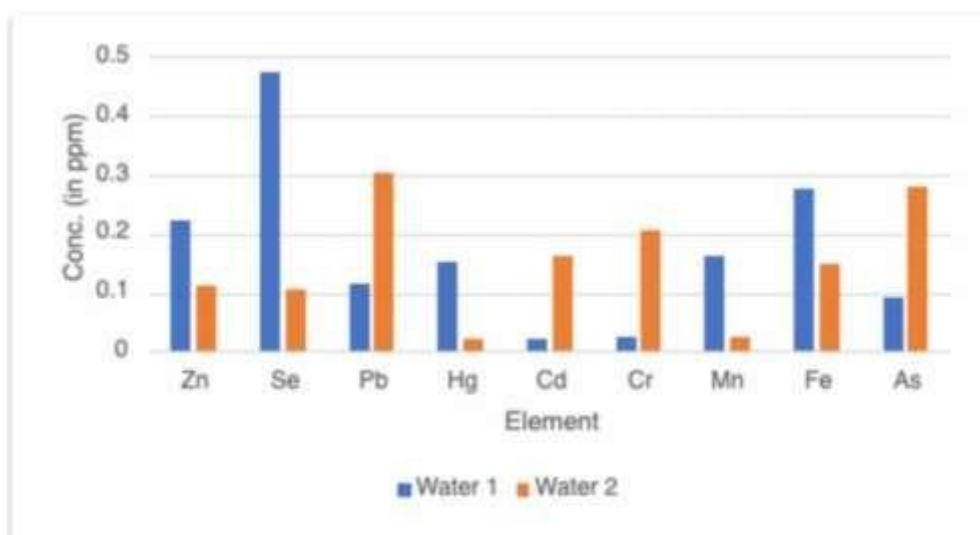


Fig 5.1.6 Different heavy metals of water samples collected from kovalam estuaries (pre-monsoon)

SOIL SAMPLE:

S.NO	ELEMENTS	1	2
1	Zn	0.056	0.168
2	Se	0.299	0.052
3	Pb	0.14	0.07
4	Hg	0.097	0.183
5	Cd	0.221	0.12
6	Cr	0.283	0.154
7	Mn	0.04	0.08
8	Fe	0.364	0.235
9	As	0.399	0.046

Table 5.1.7 Heavy metal concentration of soil samples collected from kovalam estuaries (pre-monsoon)

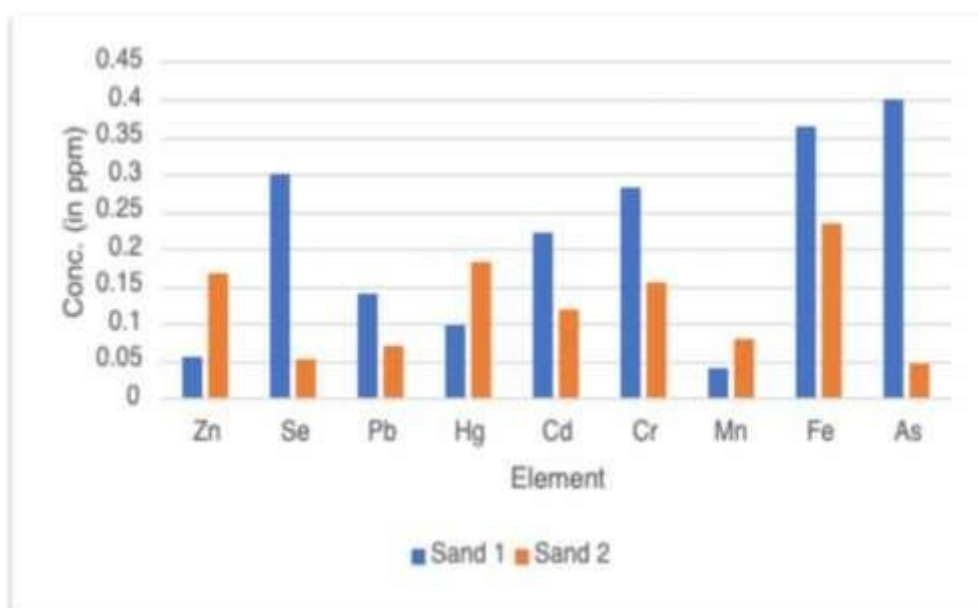


Fig 5.1.7 Different heavy metals of soil samples collected from kovalam estuaries (pre-monsoon)

POST MONSOON:

Namatulosa nausus (Bloch's Gizzard shad)

S.NO	Elements	Gill	Gut	Skin	Muscle
1	Zn	0.46	0.057	0.153	0.076
2	Se	0.132	0.106	0.176	0.53
3	Pb	0.07	0.03	0.21	0.026
4	Hg	0.01	0.03	0.03	0.003
5	Cd	0.02	0.01	0.06	0.02
6	Cr	0.023	0.09	0.026	0.06
7	Mn	0.47	0.06	0.05	0.06
8	Fe	0.19	0.06	0.06	0.04
9	As	0.07	0.04	0.21	0.21

Table 5.1.8 Heavy metal concentration of *Namatulosa nausus* (post-monsoon)

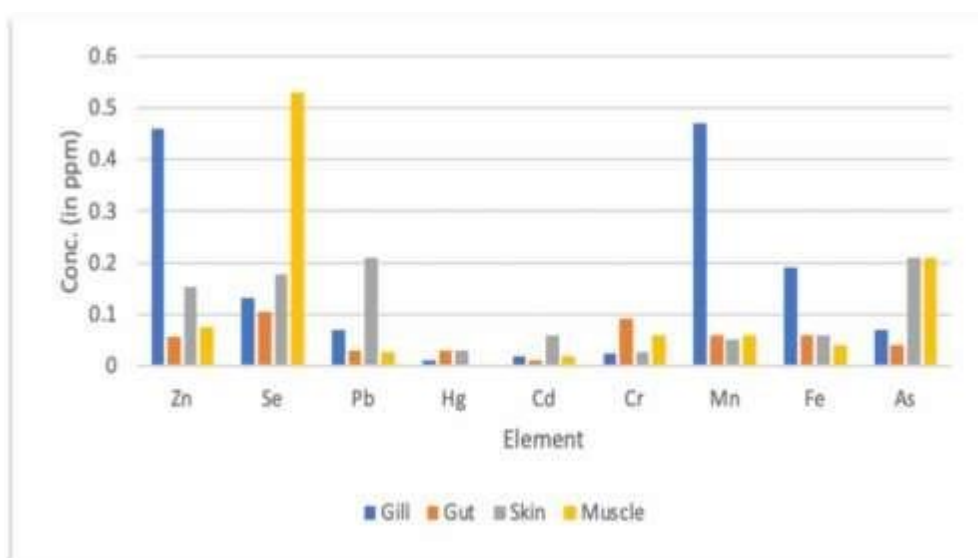


Fig 5.1.8 AAS of *Namatulosa nausius* (post-monsoon)

Plotous canius (catfish)

S.NO	Elements	Gill	Gut	Muscle	Skin
1	Zn	0.23	0.51	0.057	0.46
2	Se	0.088	0.265	0.132	0.132
3	Pb	0.21	0.07	0.105	0.07
4	Hg	0.03	0.03	0.01	0.03
5	Cd	0.01	0.02	0.03	0.02
6	Cr	0.18	0.06	0.03	0.18
7	Mn	0.15	0.47	0.23	0.15
8	Fe	0.06	0.03	0.06	0.19
9	As	0.21	0.07	0.07	0.05

Table 5.1.9 Heavy metal concentration of *Plotous canius* (post- monsoon)

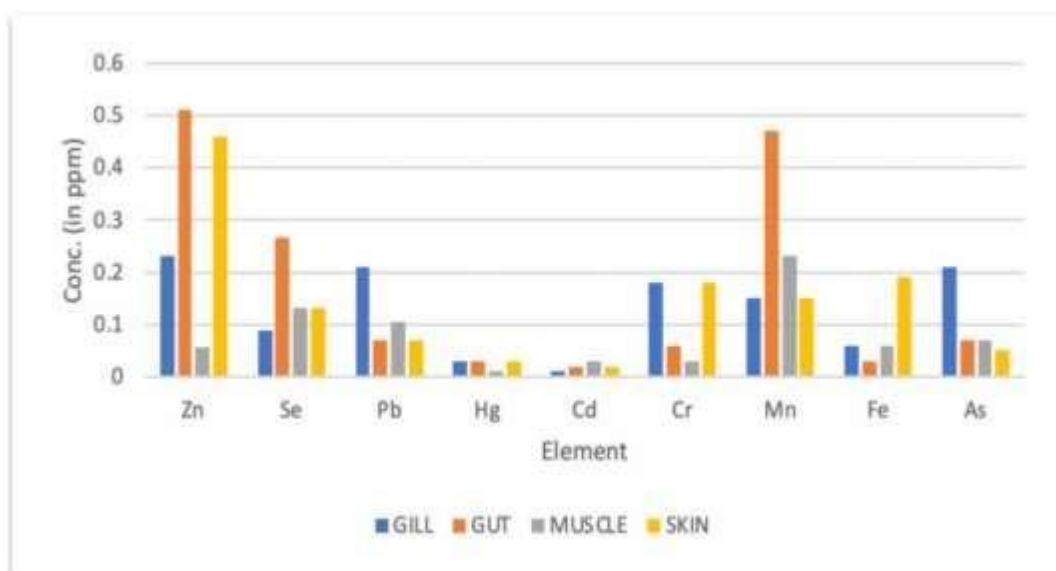


Fig 5.1.9 AAS of *Plotous canius* (post-monsoon)

Mertrix casta (clams)

S.NO	Elements	Gill	Foot	Muscle	Adductor Muscle
1	Zn	0.065	0.065	0.153	0.153
2	Se	0.132	0.048	0.025	0.53
3	Pb	0.04	0.026	0.21	0.105
4	Hg	0.006	0.003	0.006	0.007
5	Cd	0.01	0.007	0.06	0.03
6	Cr	0.03	0.06	0.18	0.18
7	Mn	0.09	0.23	0.47	0.15
8	Fe	0.03	0.02	0.03	0.06
9	As	0.04	0.07	0.05	0.04

Table 5.1.10 Heavy metal concentration of *Mertrix casta* (post-monsoon)

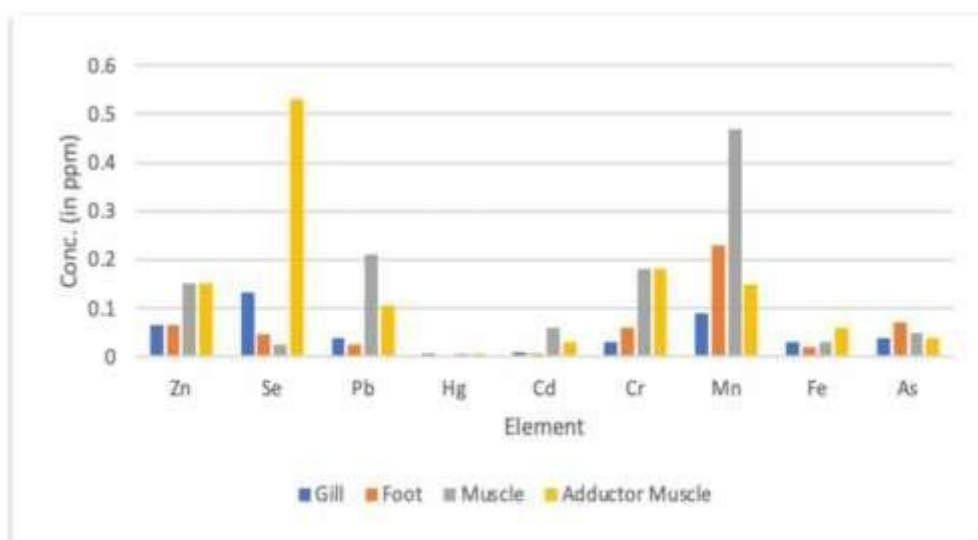


Fig 5.1.10 AAS of *Mertrix casta* (post-monsoon)

Mugil Cephalous (mullet)

S.NO	Elements	Gill	Gut	Skin	Muscle
1	Zn	0.153	0.115	0.153	0.065
2	Se	0.075	0.088	0.076	0.176
3	Pb	0.07	0.105	0.052	0.07
4	Hg	0.01	0.015	0.01	0.03
5	Cd	0.02	0.03	0.06	0.007
6	Cr	0.06	0.09	0.18	0.18
7	Mn	0.05	0.15	0.15	0.07
8	Fe	0.06	0.16	0.09	0.19
9	As	0.21	0.21	0.05	0.07

Table 5.1.11 Heavy metal concentration of *Mugil Cephalous* (post-monsoon)

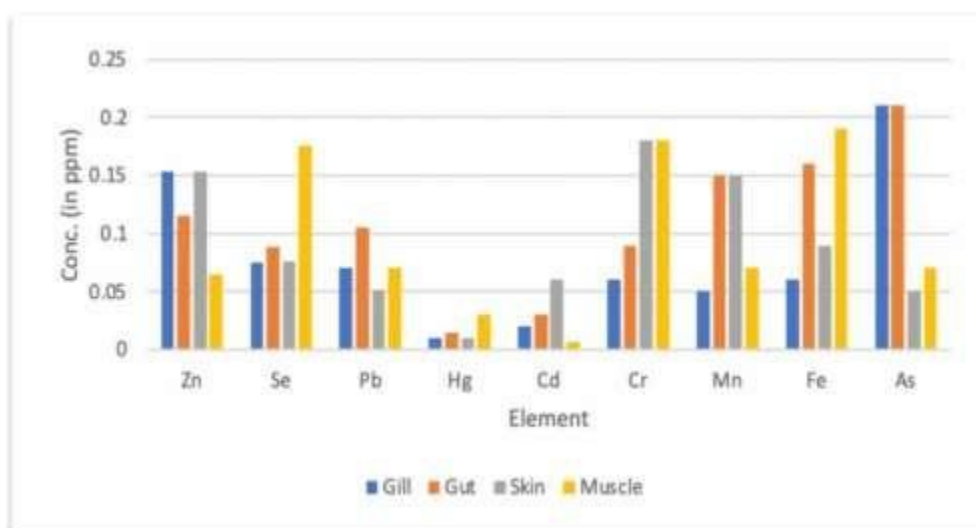


Fig 5.1.11 AAS of *Mugil Cephalous* (post-monsoon)

Sylla serrata (crab):

S.NO	Elements	Gill	Tissue	Hepatopancreas
1	Zn	0.057	1.53	0.46
2	Se	0.066	0.53	0.025
3	Pb	0.05	0.052	0.21
4	Hg	0.007	0.01	0.015
5	Cd	0.007	0.02	0.002
6	Cr	0.04	0.06	0.06
7	Mn	0.23	0.059	0.15
8	Fe	0.06	0.06	0.19
9	As	0.042	0.07	0.05

Table 5.1.12 Heavy metal concentration of *Sylla serrata* (post-monsoon)

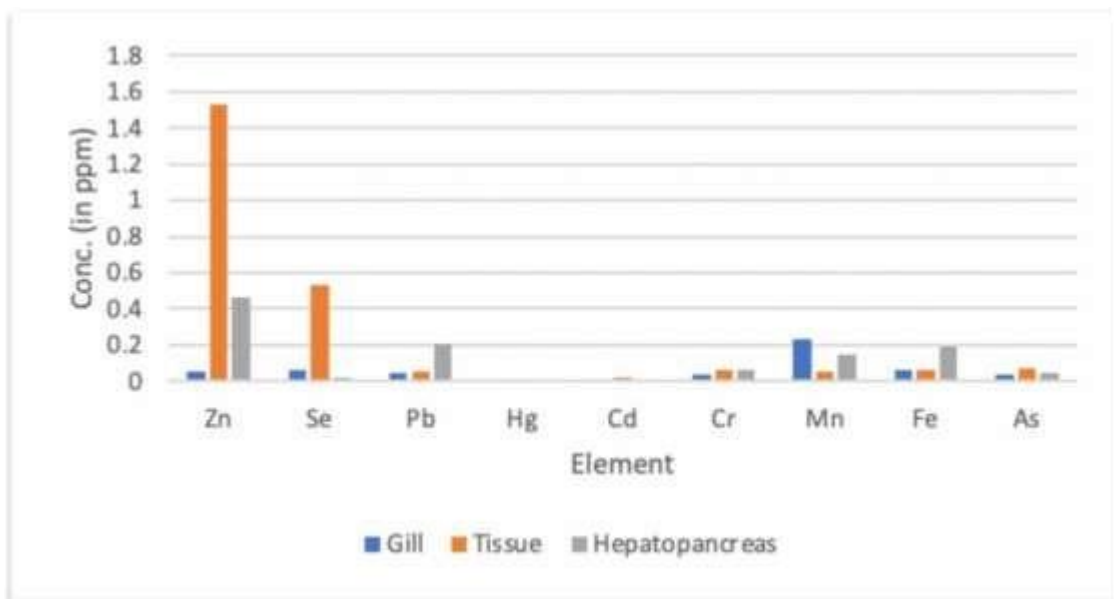


Fig 5.1.12 AAS of *Sylla serrata* (post- monsoon)

WATER SAMPLE:

S.NO	Elements	1	2
1	Zn	0.143	0.057
2	Se	0.176	0.53
3	Pb	0.07	0.21
4	Hg	0.007	0.006
5	Cd	0.03	0.03
6	Cr	0.18	0.09
7	Mn	0.06	0.15
8	Fe	0.04	0.03
9	As	0.07	0.21

Table 5.1.13 Heavy metal concentration of water samples collected from kovalam estuaries (post-monsoon)

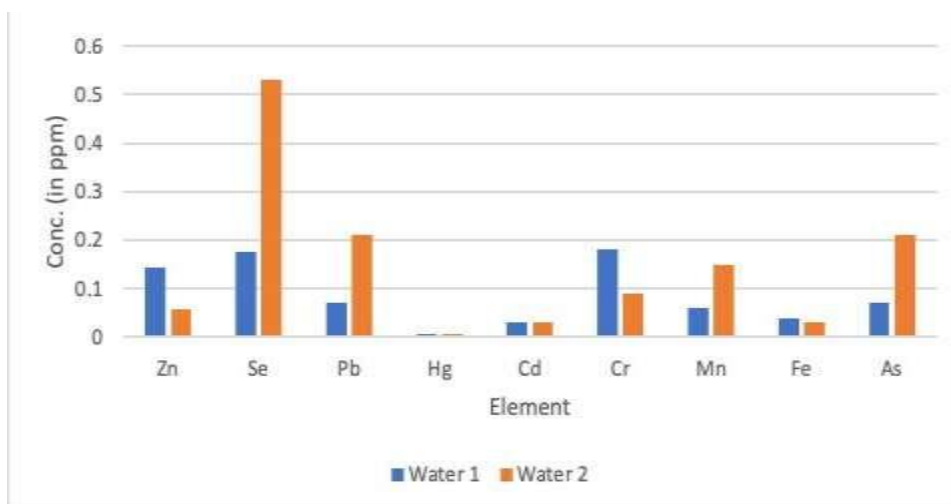


Fig 5.1.13 Different heavy metals of water samples collected from kovalam estuaries (post-monsoon)

SOIL SAMPLE:

S.NO	Elements	1	2
1	Zn	0.065	0.065
2	Se	0.044	0.176
3	Pb	0.105	0.042
4	Hg	0.01	0.03
5	Cd	0.03	0.01
6	Cr	0.03	0.03
7	Mn	0.059	0.047
8	Fe	0.06	0.19
9	As	0.07	0.042

Table 5.1.14 Heavy metal concentration of soil samples collected from kovalam estuaries (post monsoon)

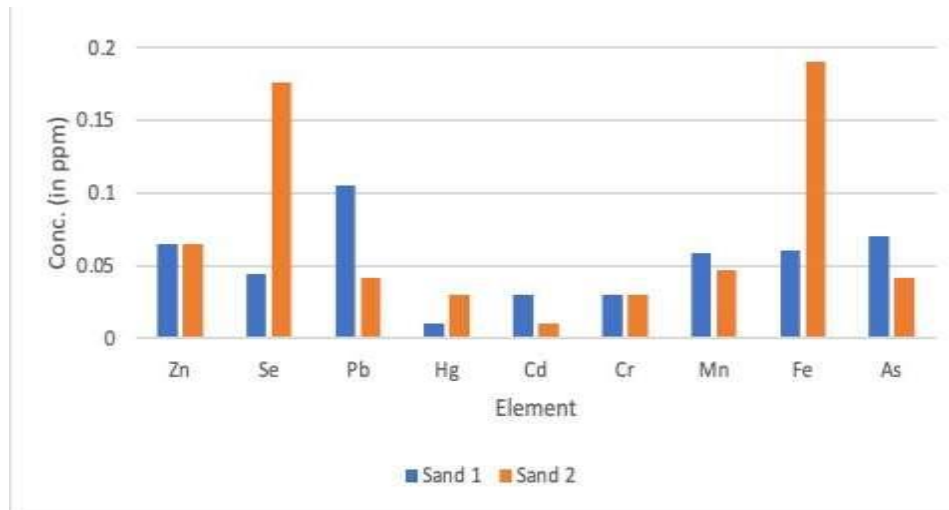


Fig 5.1.14 Different heavy metals of soil samples collected from kovalam estuaries (post monsoon)

5.2 MICROPLASTIC ANALYSIS:

The identified microplastics in the membrane filter samples using microscopic analysis after Koh digestion are given. The microplastics such as Fibers, film and other particales were characterized as small, irregularly shaped particles with a range of colors, including black, blue, red, green, and clear.

PRE-MONSOON:

Namatulosa nausus GILL SAMPLE:

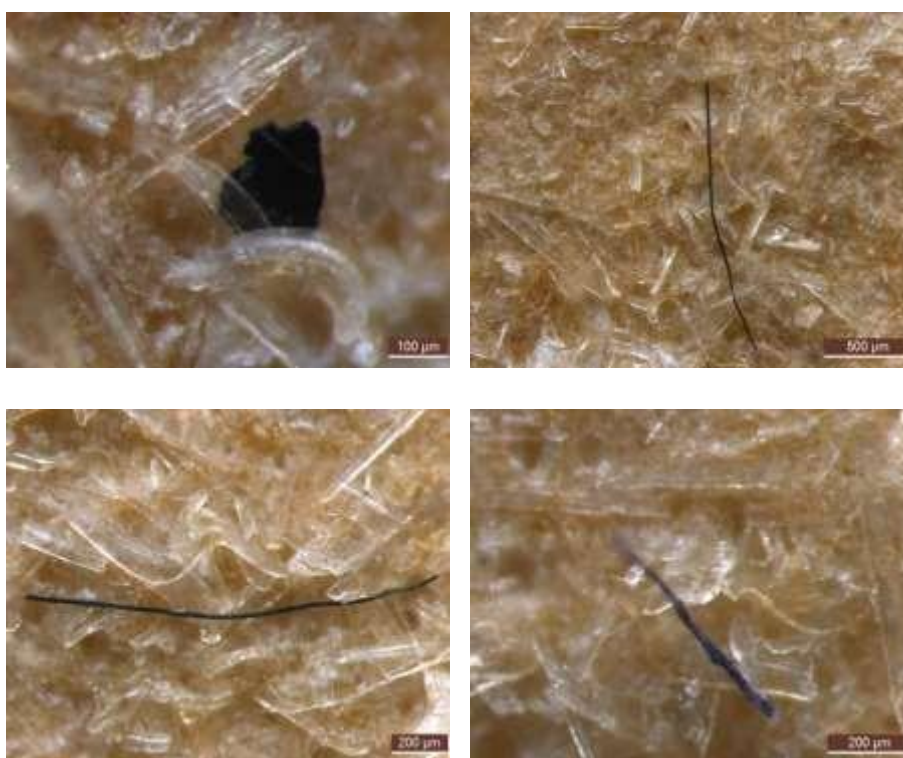


Fig 5.2.1 The microplastics found in the membrane filter of the *Namatulosanausus* gill sample using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using a stereo zoom microscope. The pre-monsoon result (fig 5.2.1) shows the microplastic particles present in the filter membrane of *Namatulosa nausus* gill.

***Namatulosa nausus* GUT SAMPLE:**



Fig 5.2.2 The microplastics found in the membrane filter of the *Namatulosanausus* gut sample using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The pre-monsoon result (fig 5.2.2) shows the microplastic particles present in the filter membrane of *Namatulosa nausus* gut.

***Namatulosa nausus* SKIN SAMPLE:**



Fig 5.2.3 The microplastics found in the membrane filter of the *Namatulosanausus* skin sample using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The pre-monsoon result (fig 5.2.3) shows the microplastic particles present in the filter membrane of *Namatulosa nausus* skin.

***Namatulosa nausus* MUSCLE SAMPLE:**



Fig 5.2.4 The microplastics found in the membrane filter of the *Namatulosanausus* muscle sample using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope. The pre-monsoon result (fig 5.2.4) shows the microplastic particles present in the filter membrane of *Namatulosa nausus* muscle.

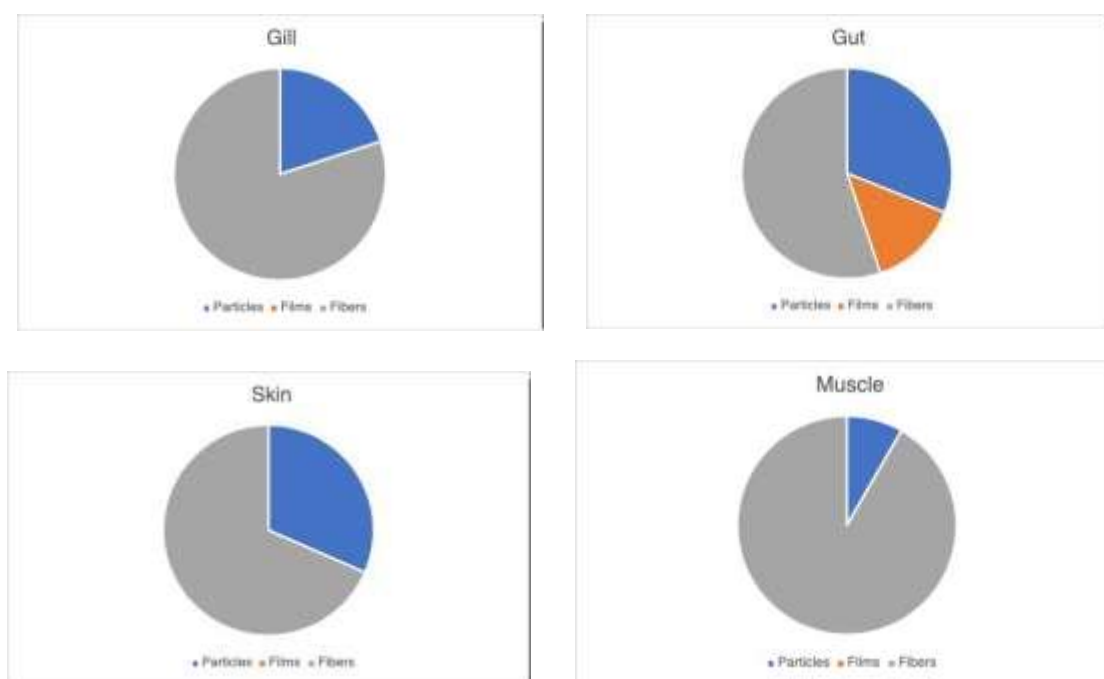


Fig 5. 2. 5 The number of Identified microplastics in the membrane filter of *Namatulosa nausius* (pre-monsoon).

N.N		Particles	film	fiber					
				black	blue	white	green	red	pink
1	Gill	2	0	4	4	0	0	0	0
2	Gut	9	4	1	1	12	1	1	0
3	Skin	6	0	3	3	5	0	2	0
4	Muscle	1	0	4	1	2	2	1	1

Table 5.2.1 Types of microplastic present in *Namatulosa nausius* (pre-monsoon)

The most common type of microplastic found was fibers, films and other polyethylene particles. The pre-monsoon result (Fig 5.2.5) and (Table 5.2.1) showed the microplastic particles that are present in the filter membrane of *Namatulosa nausius*.

***Sylla serrata* GILL SAMPLE:**

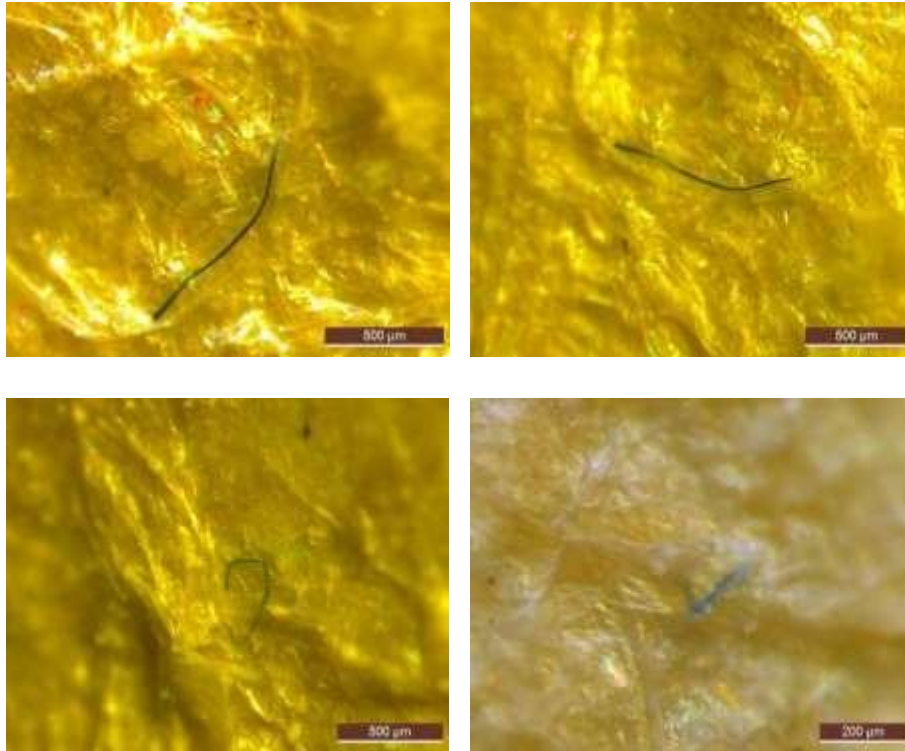


Fig 5.2.6 The microplastics found in the membrane filter of the *Sylla serrata* gill using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope. The pre-monsoon results (fig 5.2.6) shows the microplastic particles present in the filter membrane of *Sylla serrata* gill

***Sylla serrata* HEPATOPANCREASE SAMPLE:**

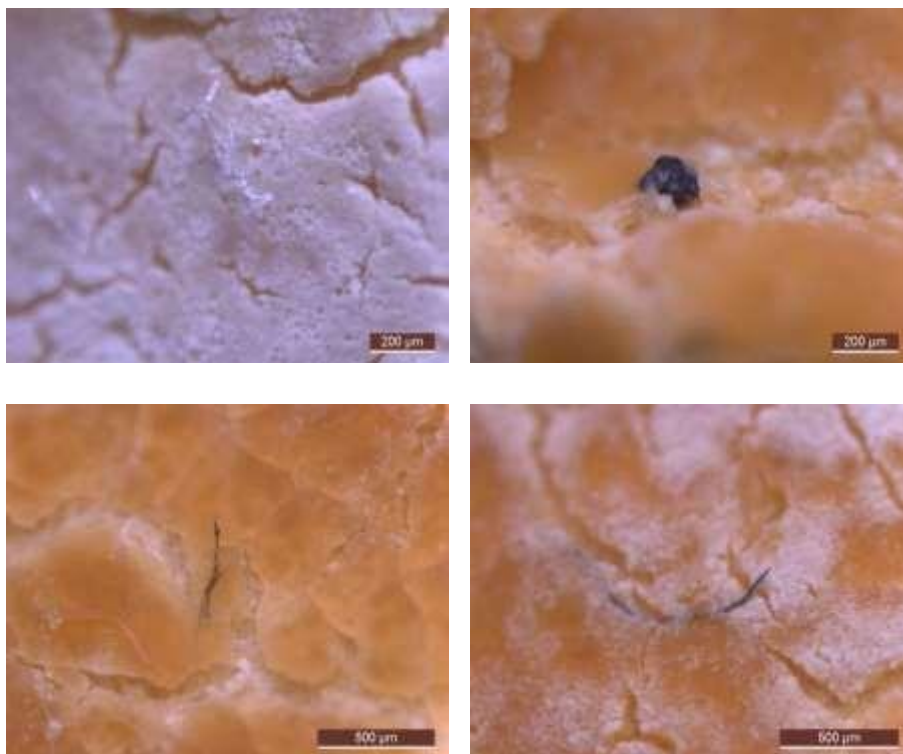


Fig 5.2.7 The microplastics found in the membrane filter of the *Sylla serrata* hepatopancrease using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The pre-monsoon result (fig 5.2.7) shows the microplastic particles present in the filter membrane of *Sylla serrata* hepatopancrease.

***Sylla serrata* TISSUE SAMPLE:**

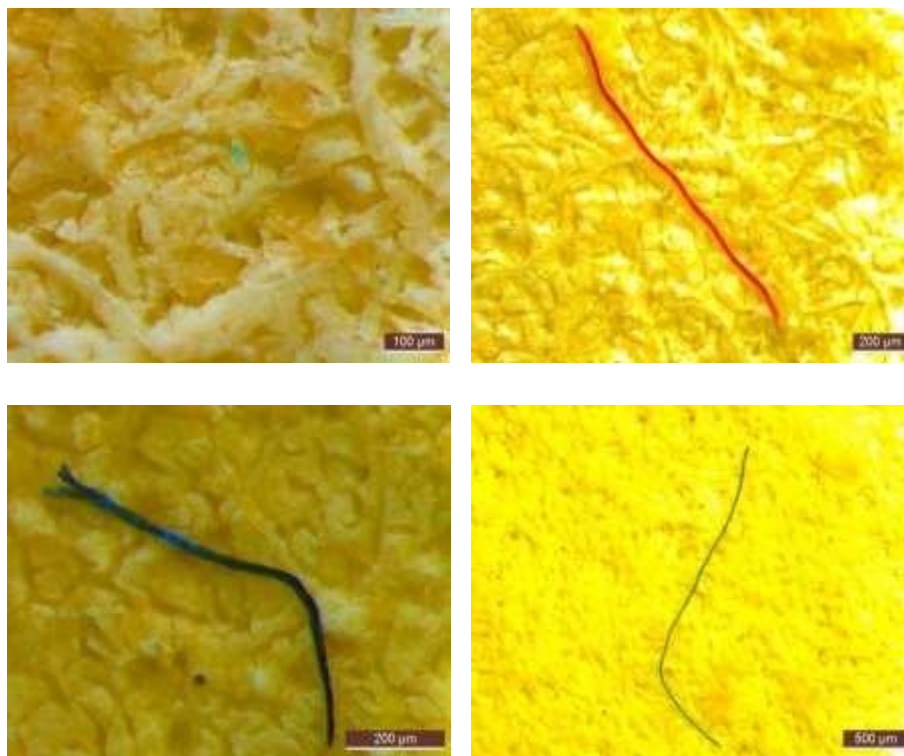


Fig 5.2.8 The microplastics found in the membrane filter of the *Sylla serrata* tissue using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope. The pre-monsoon result (fig 5.2.8) shows the microplastic particles present in the filter membrane of *Sylla serrata* tissue.

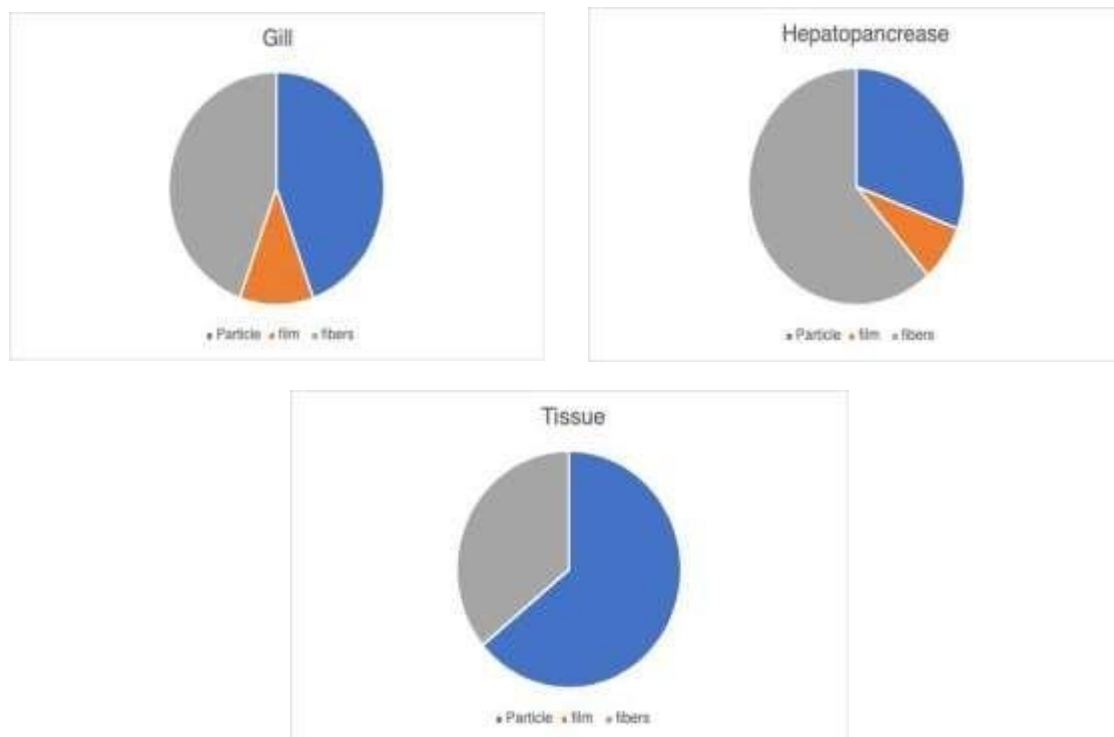


Fig 5. 2. 9 The number of Identified microplastics in the membrane filter of *Sylla serrata* (pre-monsoon).

S.S		Particle	film	Fibers					
				black	blue	white	green	red	pink
1	Gill	4	1	1	0	0	3	0	0
2	H.p	4	1	4	1	3	0	0	0
3	Tissue	16	0	0	1	5	2	1	0

Table 5.2.2 Types of microplastic present in *Sylla serrata* (pre-monsoon)

The most common type of microplastic found was fibers, films and other polyethylene particles. The pre-monsoon results (Fig 5.2.9) and (Table 5.2.2) showed the microplastic particles that are present in the filter membrane of *Sylla serrata*.

***Mugil Cephalous* GILL SAMPLE:**

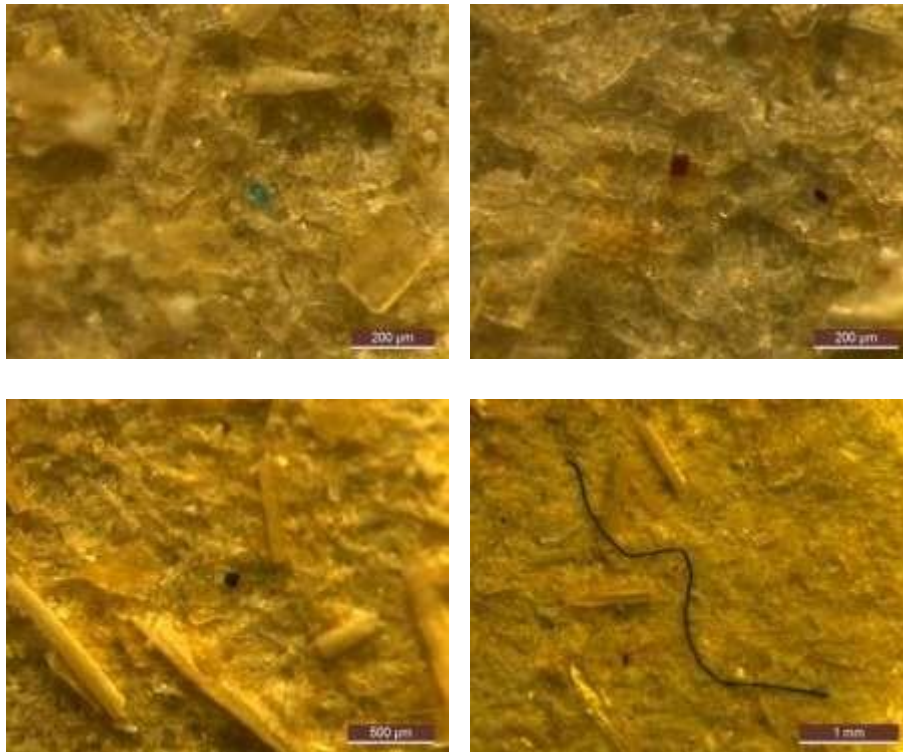


Fig 5.2.10 The microplastics found in the membrane filter of the *Mugil Cephalous* gill using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope. The pre-monsoon result (fig 5.2.10) shows the microplastic particles present in the filter membrane of *Mugil Cephalous* gill.

***Mugil Cephalous* GUT SAMPLE:**

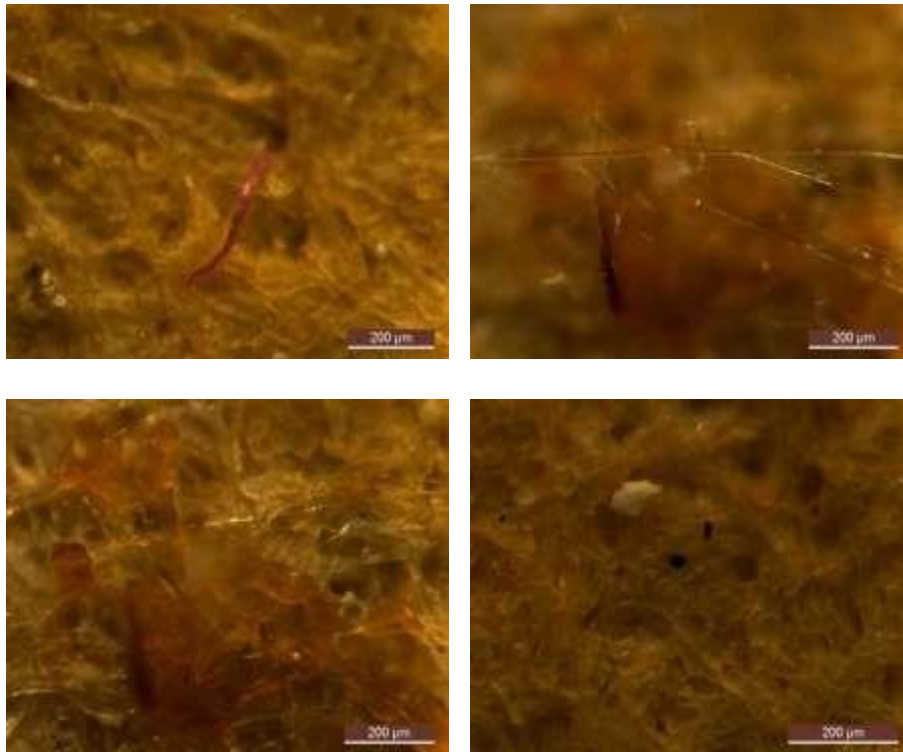


Fig 5.2.11 The microplastics found in the membrane filter of the *Mugil Cephalous* gut using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The pre-monsoon result (fig 5.2.11) shows the microplastic particles present in the filter membrane of *Mugil Cephalous* gut.

***Mugil Cephalous* SKIN SAMPLE:**

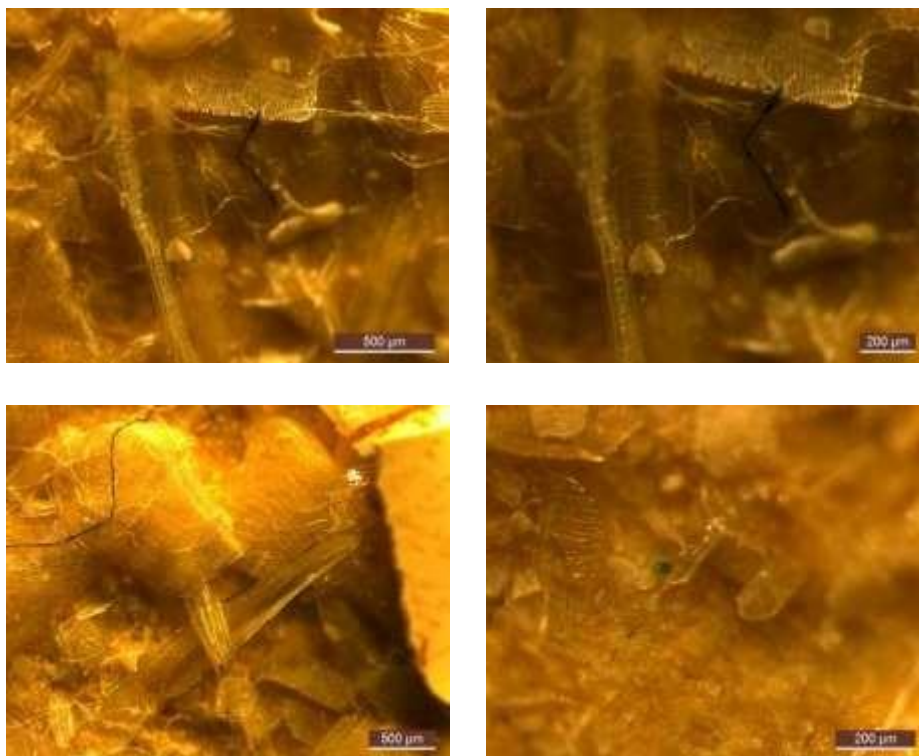


Fig 5.2.12 The microplastics found in the membrane filter of the *Mugil Cephalous* skin using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The pre-monsoon results (fig 5.2.12) shows the microplastic particles present in the filter membrane of *Mugil Cephalous* skin.

***Mugil Cephalous* MUSCLE SAMPLE:**

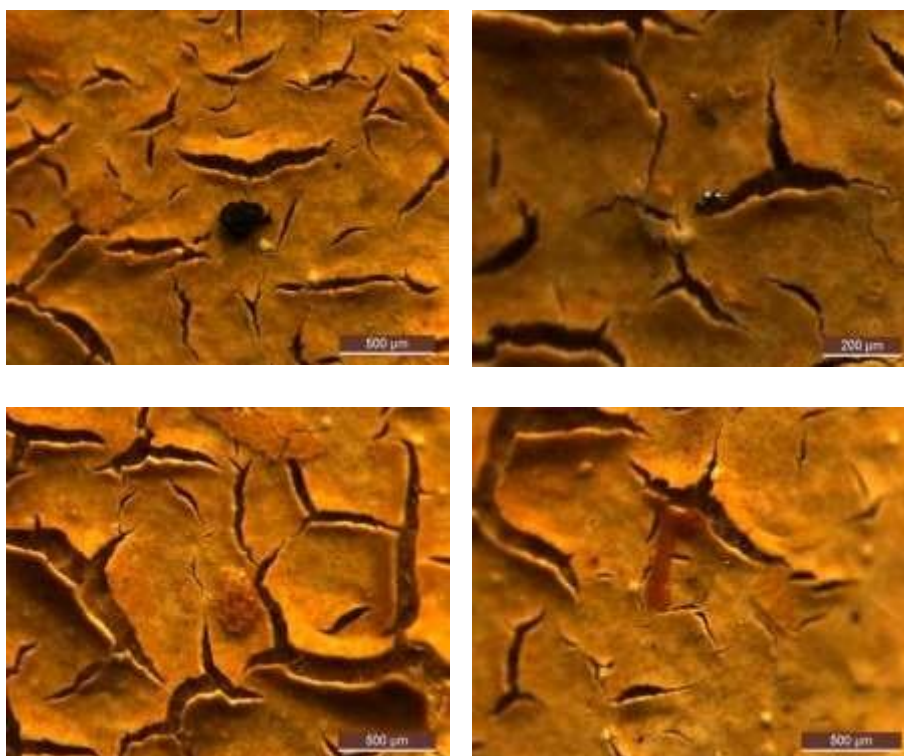


Fig 5.2.13 The microplastics found in the membrane filter of the *Mugil Cephalous* muscle using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope. The pre-monsoon result (fig 5.2.13) shows the microplastic particles present in the filter membrane of *Mugil Cephalous* muscle.

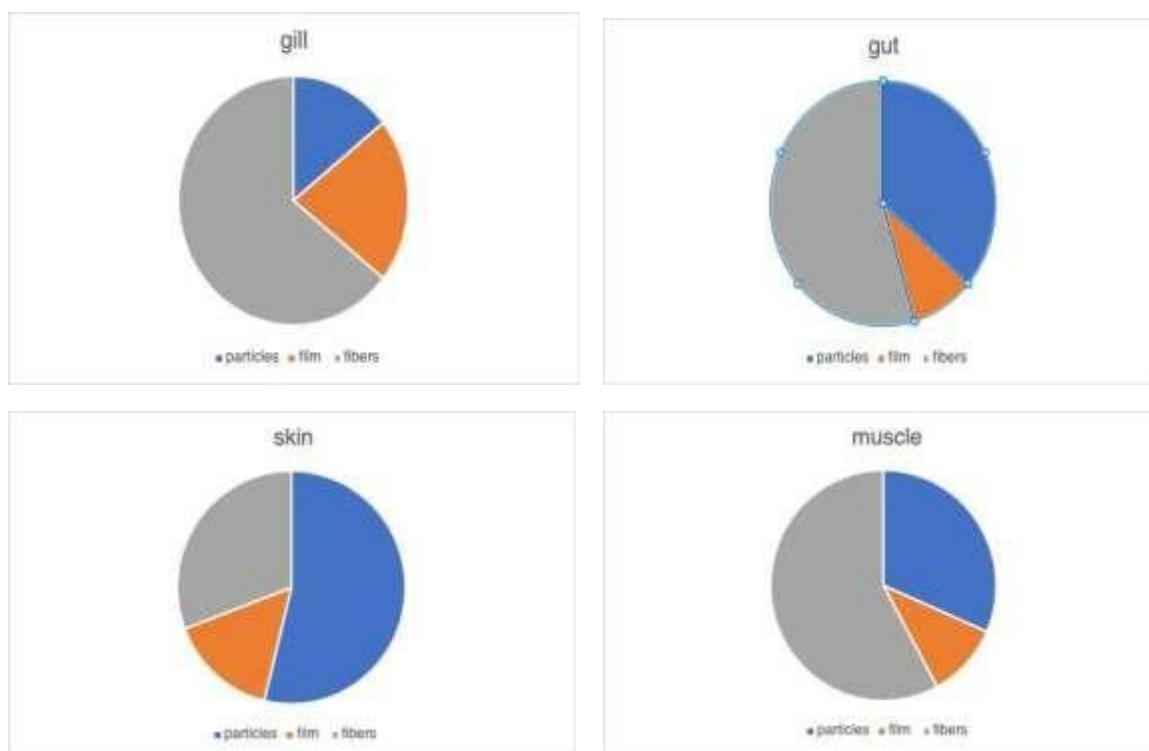


Fig 5. 2.14 The number of Identified microplastics in the membrane filter of *Mugil Cephalous* (pre-monsoon)

Mugil		particles	film	fiber					
				black	blue	white	green	red	pink
1	gill	2	3	4	0	2	0	3	0
2	gut	8	2	3	0	6	2	1	0
3	skin	7	2	0	0	3	0	1	0
4	muscle	6	2	4	0	5	1	1	0

Table 5.2.3 Types of microplastic present in *Mugil Cephalous* (pre-monsoon)

The most common type of microplastic found was fibers, films and other polyethylene particles. The pre-monsoon result (Fig 5.2.14) and (Table 5.2.3) showed the microplastic particles that are present in the filter membrane of *Mugil Cephalous*

***Mertrix casta* GILL SAMPLE:**

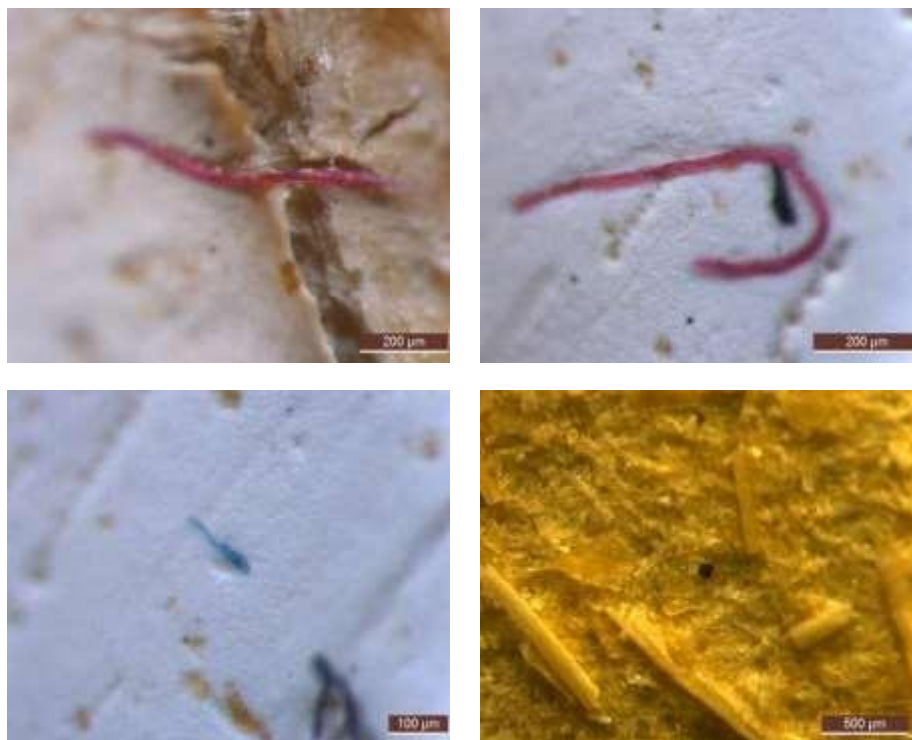


Fig 5.2.15 The microplastics found in the membrane filter of the *Mertrix casta* gill using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The pre-monsoon results (fig 5.2.15) shows the microplastic particles present in the filter membrane of *Mertrix casta* gill.

***Mertrix casta* Muscle SAMPLE:**

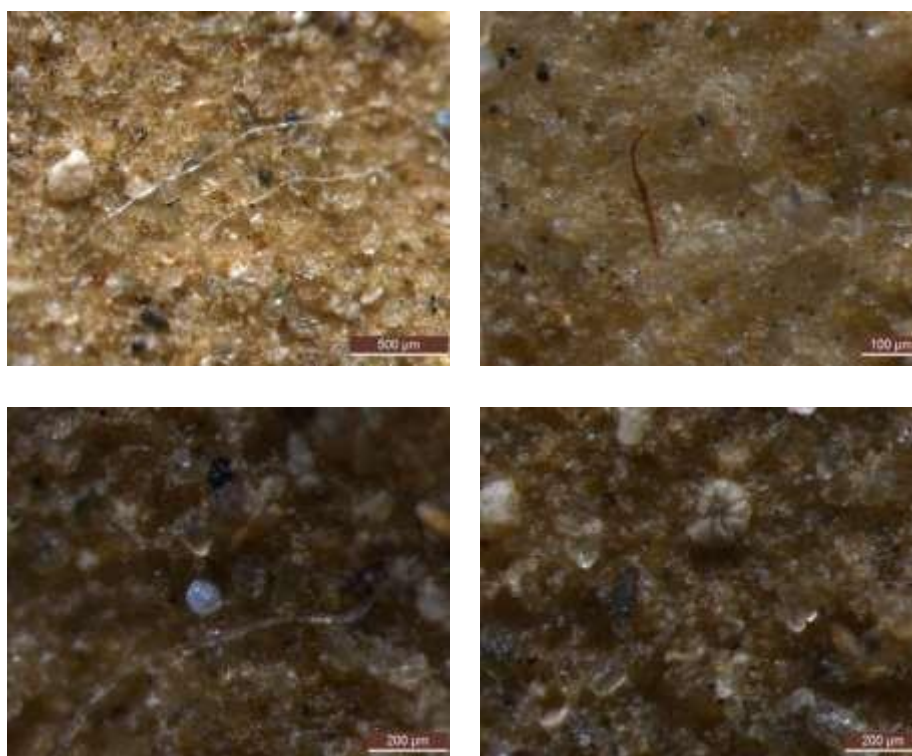


Fig 5.2.16 The microplastics found in the membrane filter of the *Mertrix casta* muscle using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The pre-monsoon result (fig 5.2.16) shows the microplastic particles present in the filter membrane of *Mertrix casta* muscle.



Fig 5. 2.17 The number of Identified microplastics in the membrane filter of *Mertrix casta* (pre-monsoon).

M.Casta		Particle	film	fiber					
				black	blue	white	green	red	pink
1	gill	5	3	0	1	0	0	2	0
2	muscle	6	0	0	0	3	0	1	0

Table 5.2.4 Types of microplastic present in *Mertrix casta* (pre-monsoon)

The most common type of microplastic found was fibers, films and other polyethylene particles. The pre-monsoon result (Fig 5.2.17) and (Table 5.2.4) showed the microplastic particles that are present in the filter membrane of *Mertrix casta*.

***Plotous canius* GILL SAMPLE**

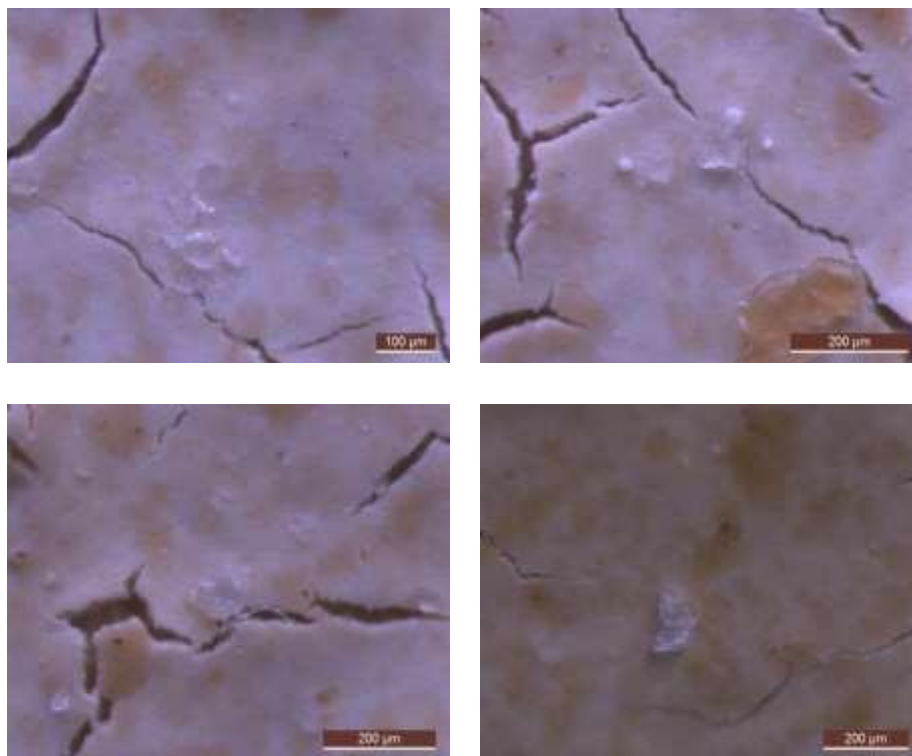


Fig 5.2.18 The microplastics found in the membrane filter of the *Plotous canius* gill using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope. The pre-monsoon result (fig 5.2.18) shows the microplastic particles present in the filter membrane of *Plotous canius* gill.

***Plotous canius* GUT SAMPLE**

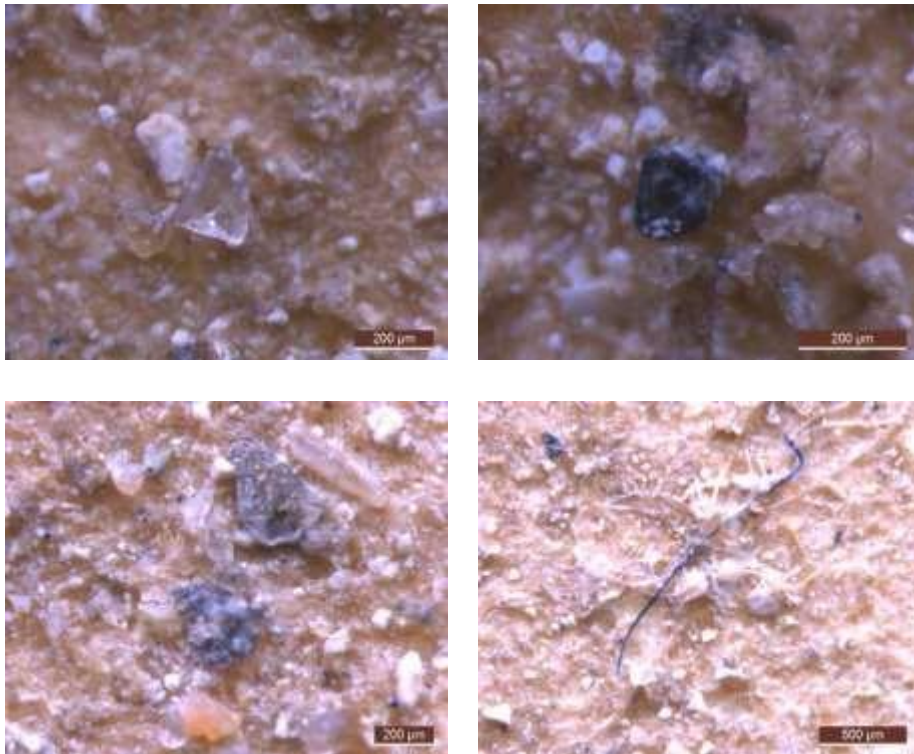


Fig 5.2.19 The microplastics found in the membrane filter of the *Plotous canius* gut using microscope (pre-monsoon) .

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The pre-monsoon result (fig 5.2.19) shows the microplastic particles present in the filter membrane of *Plotous canius* gut.

***Plotous canius* TISSUE SAMPLE**

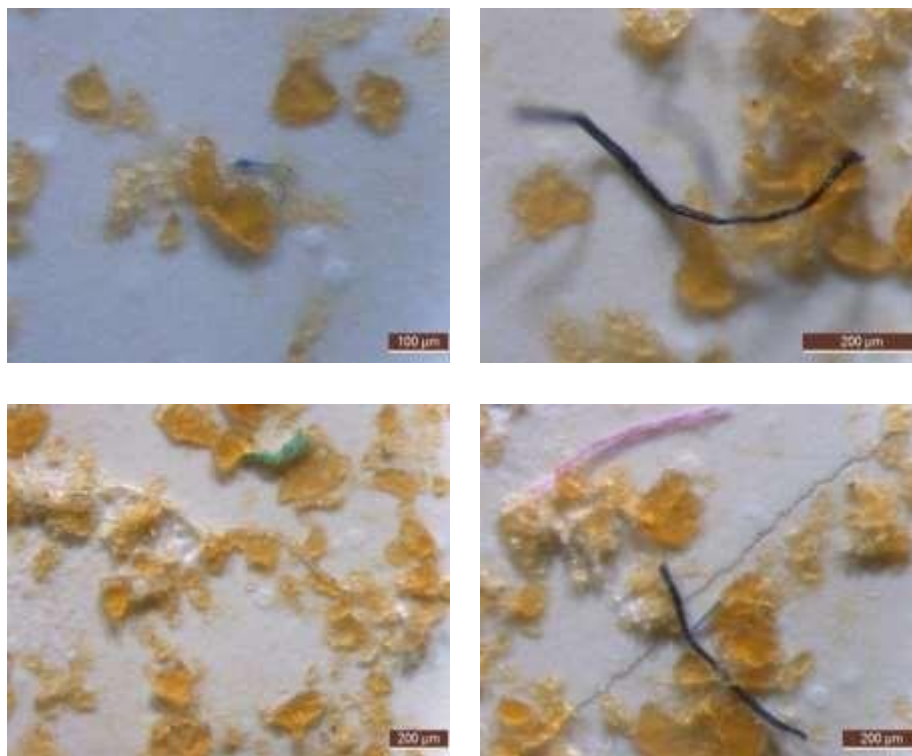


Fig 5.2.20 The microplastics found in the membrane filter of the *Plotous canius* tissue using microscope (pre-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope. The pre-monsoon result (fig 5.2.20) shows the microplastic particles present in the filter membrane of *Plotous canius* tissue.

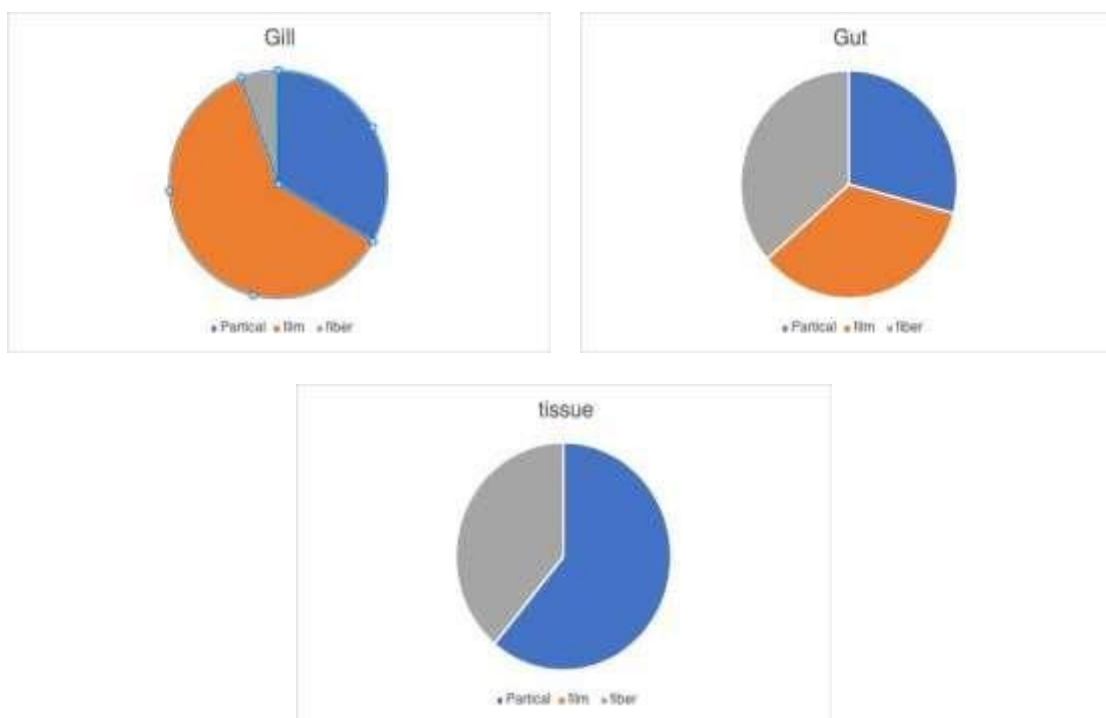


Fig 5. 2. 21 The number of Identified microplastics in the membrane filter of *Plotous canius* (pre-monsoon).

PC		Particles	film	fiber					
				black	blue	white	green	red	pink
1	Gill	6	11	0	0	1	0	0	0
2	Gut	16	19	1	2	15	0	2	0
3	tissue	11	0	1	3	1	1	0	1

Table 5.2.5 Types of microplastic present in *Plotous canius* (pre-monsoon).

The most common type of microplastic found was fibers, films and other polyethylene particles. The pre-monsoon result (Fig 5.2.21) and (Table 5.2.5) showed the microplastic particles that are present in the filter membrane of *Plotous canius*

POST MONSOON:

***Namatulosa nausius* GILL SAMPLE**

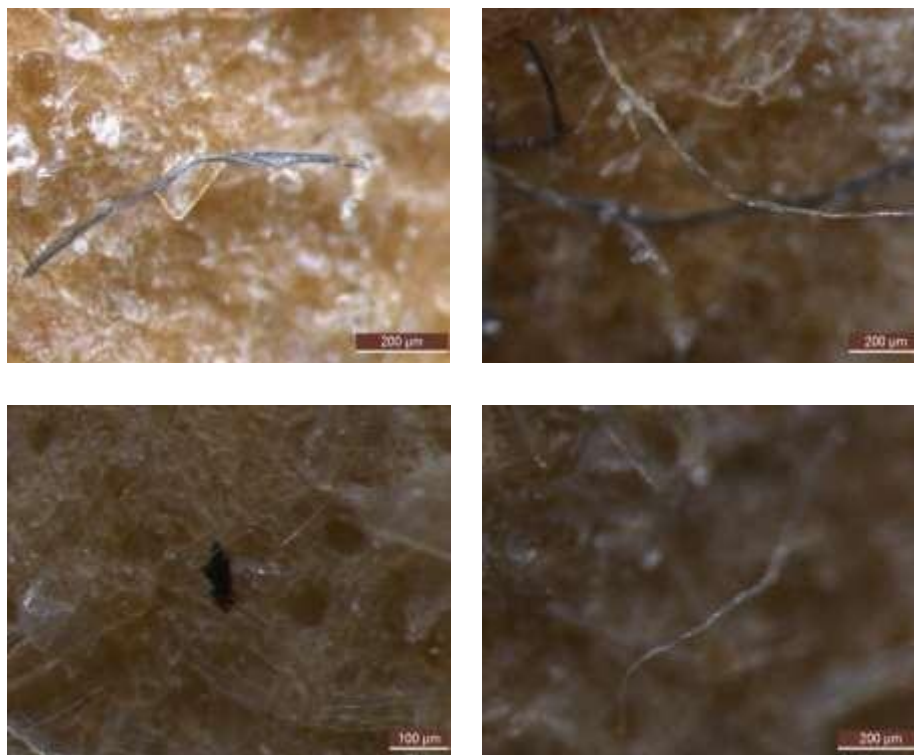


Fig 5.2.22 The microplastics found in the membrane filter of the *Namatulosa nausius* gill sample using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using a stereo zoom microscope. The post-monsoon results (Fig 5.2.22) shows the microplastic particles present in the filter membrane of *Namatulosa nausius* gill

***Namatulosa nausus* Gut SAMPLE**



Fig 5.2.23 The microplastics found in the membrane filter of the *Namatulosa nausus* gut sample using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using a stereo zoom microscope. The post-monsoon results (Fig 5.2.23) shows the microplastic particles present in the filter membrane of *Namatulosa nausus* gut.

***Namatulosa nausius* SKIN SAMPLE**

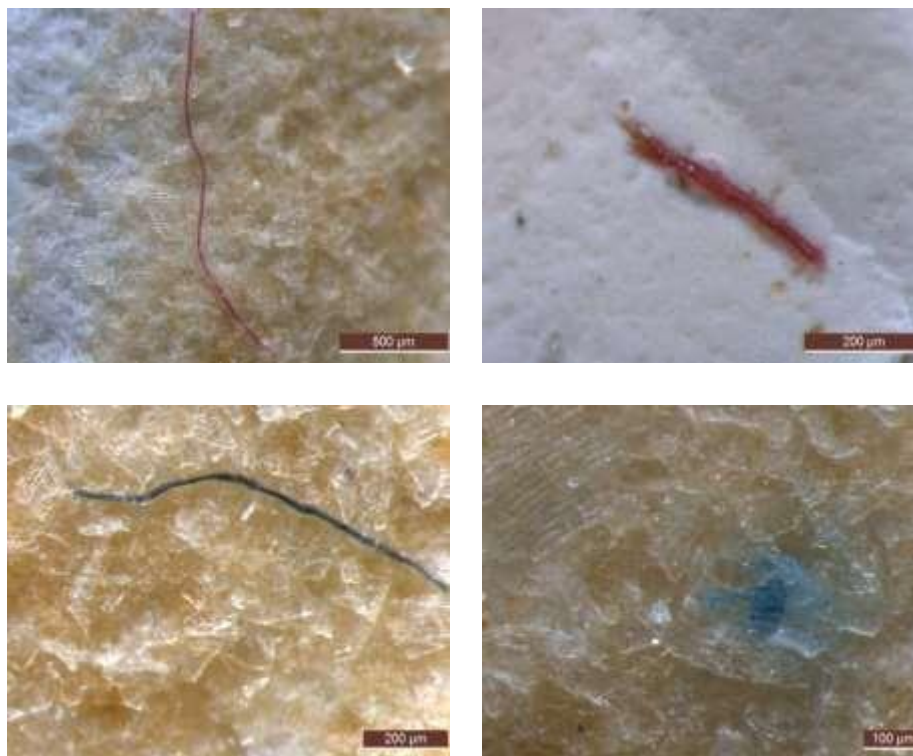


Fig 5.2.24 The microplastics found in the membrane filter of the *Namatulosa nausius* skin sample using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using a stereo zoom microscope. The post-monsoon results (Fig 5.2.24) shows the microplastic particles present in the filter membrane of *Namatulosa nausius* skin.

***Namatulosa nausus* MUSCLE SAMPLE**

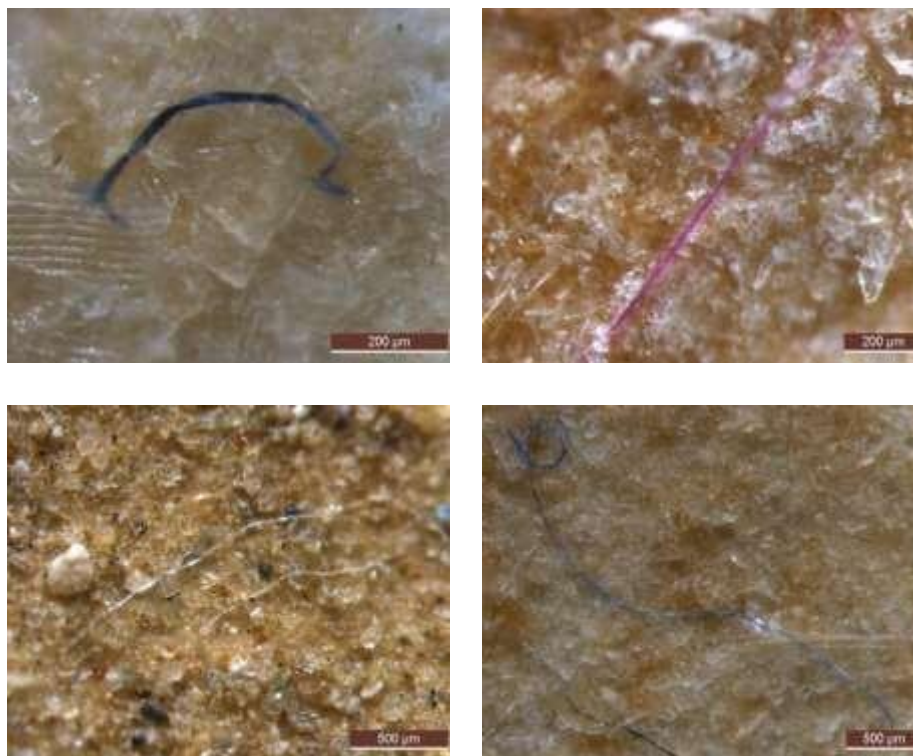


Fig 5.2.25 The microplastics found in the membrane filter of the *Namatulosa nausus* muscle sample using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using a stereo zoom microscope. The post-monsoon results (Fig 5.2.25) shows the microplastic particles present in the filter membrane of *Namatulosa nausus* muscle.

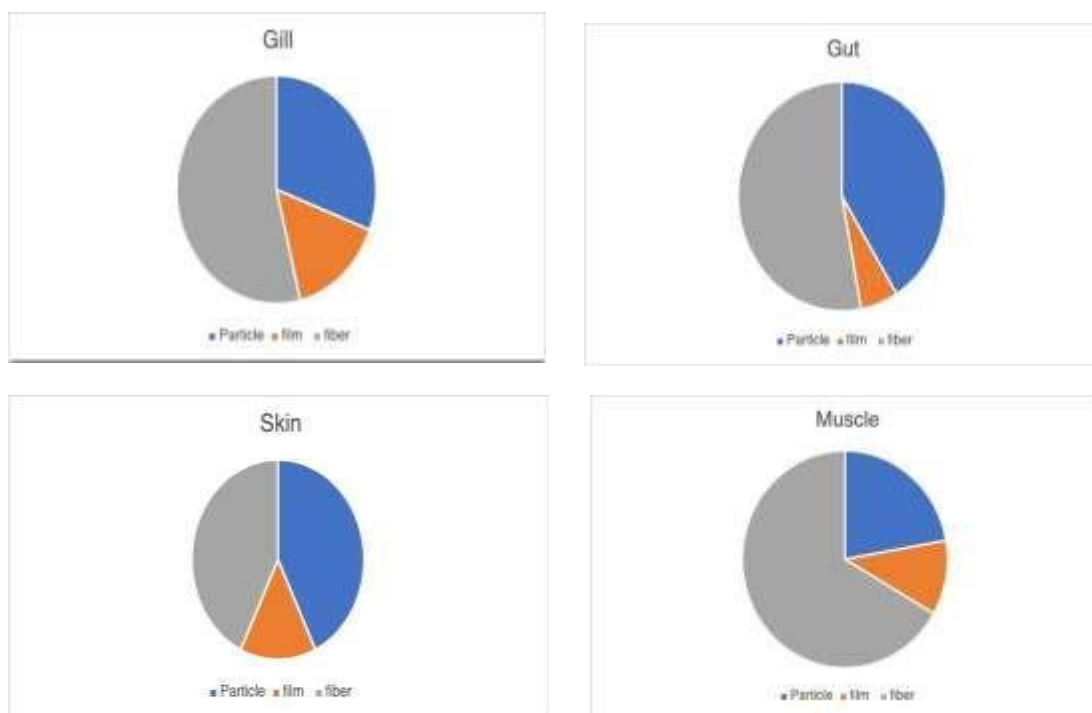


Fig 5. 2. 26 The number of Identified microplastics in the membrane filter of *Namatulosa nausius* (post-monsoon)

N.N		Partical	film	fiber					
				black	blue	white	green	red	pink
1	Gill	4	2	3	0	4	0	0	0
2	Gut	7	1	0	1	7	0	1	0
3	Skin	3	1	1	0	0	0	1	1
4	Muscle	2	1	0	3	2	0	0	1

Table 5.2.6 Types of microplastic present in *Namatulosa nausius* (post-monsoon)

The most common type of microplastic found was fibers, films and other polyethylene particles. The post-monsoon results (Fig 5.2.26) and (Table 5.2.6) showed the microplastic particles that are present in the filter membrane of *Namatulosa nausius*.

***Sylla serrata* Gill SAMPLE:**

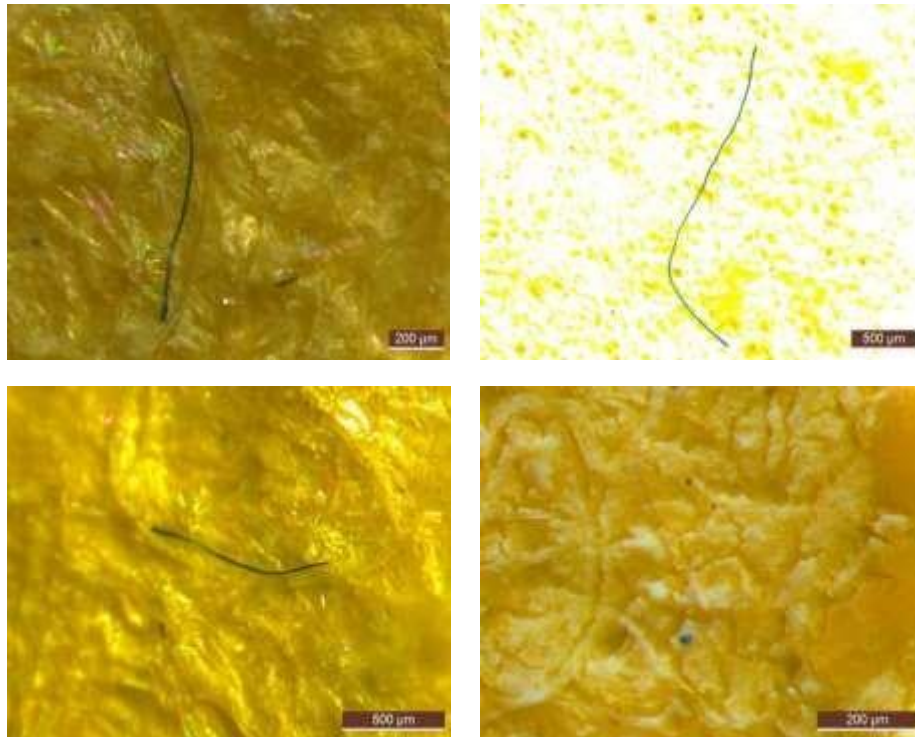


Fig 5.2.27 The microplastics found in the membrane filter of the *Sylla serrata* gill using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The post-monsoon result (fig 5.2.27) shows the microplastic particles present in the filter membrane of *Sylla serrata* gill.

***Sylla serrata* HEPATOPANCREASE SAMPLE:**

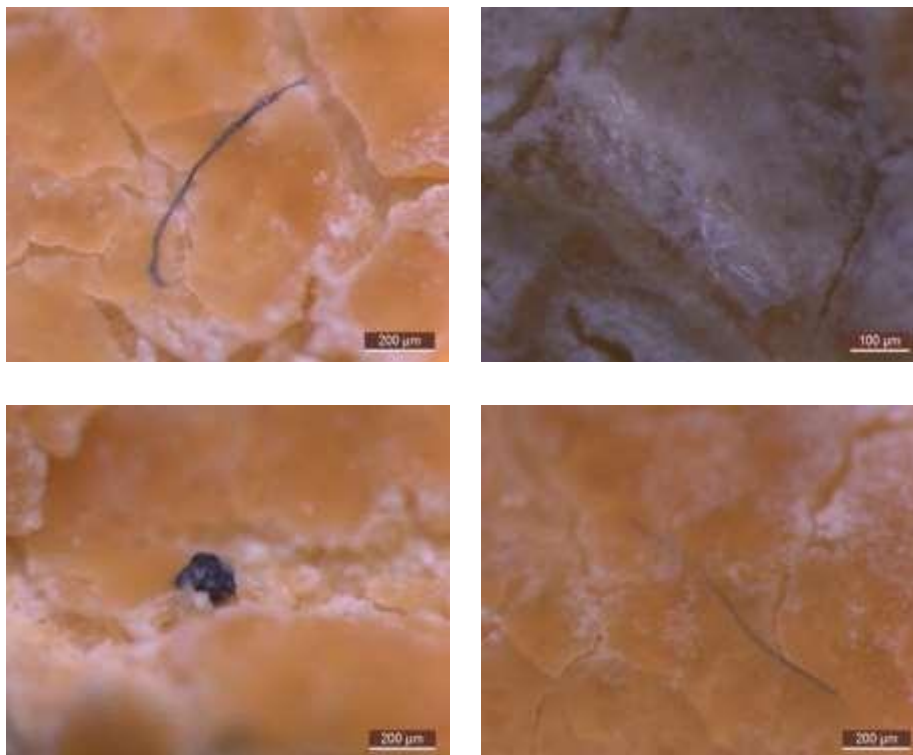


Fig 5.2.28 The microplastics found in the membrane filter of the *Sylla serrata* hepatopancrease using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The post-monsoon result (fig 5.2.28) shows the microplastic particles present in the filter membrane of *Sylla serrata* hepatopancrease.

***Sylla serrata* TISSUE SAMPLE:**

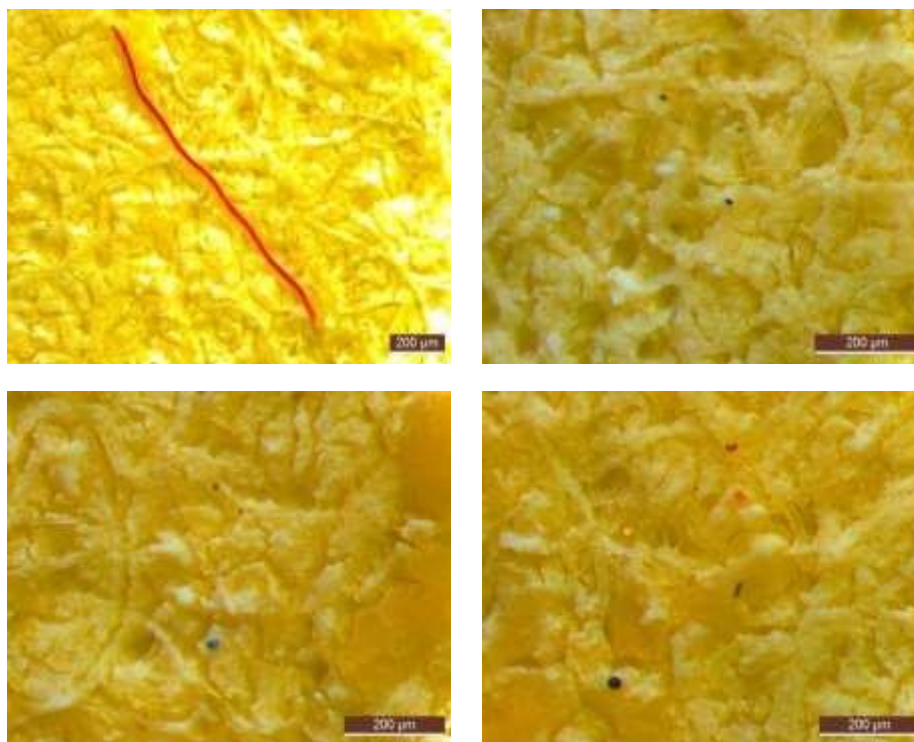


Fig 5.2.29 The microplastics found in the membrane filter of the *Sylla serrata* tissue using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The post-monsoon result (fig 5.2.29) shows the microplastic particles present in the filter membrane of *Sylla serrata* tissue.

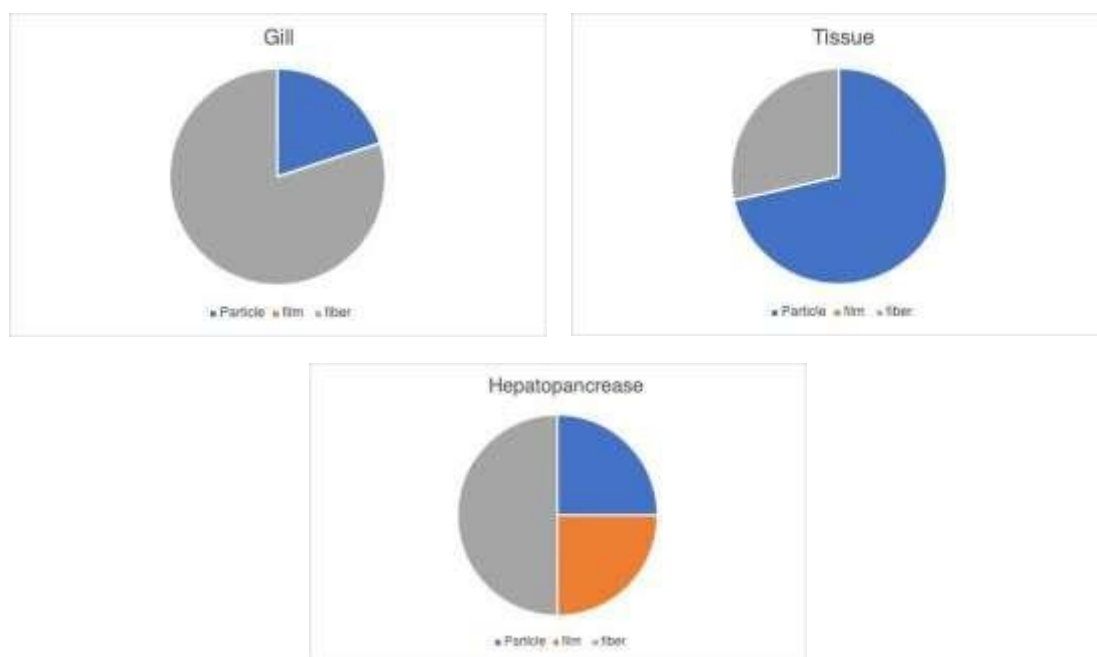


Fig 5. 2. 30 The number of Identified microplastics in the membrane filter of *Sylla serrata* (Post-monsoon).

S.S		Partical	film	fiber					
				black	blue	white	green	red	pink
1	Gill	1	0	2	1	0	1	0	0
2	HP	1	1	0	2	0	0	0	0
3	Tissu e	5	0	1	0	1	0	1	0

Table 5.2. 7 Types of microplastic present in *Sylla serrata* (post-monsoon)

The most common type of microplastic found was fibers, films and other polyethylene particles. The post- monsoon results (Fig 5.2.30) and (Table 5.2.7) showed the microplastic particles that are present in the filter membrane of *Sylla serrata*.

***Plotous canius* Gill SAMPLE**

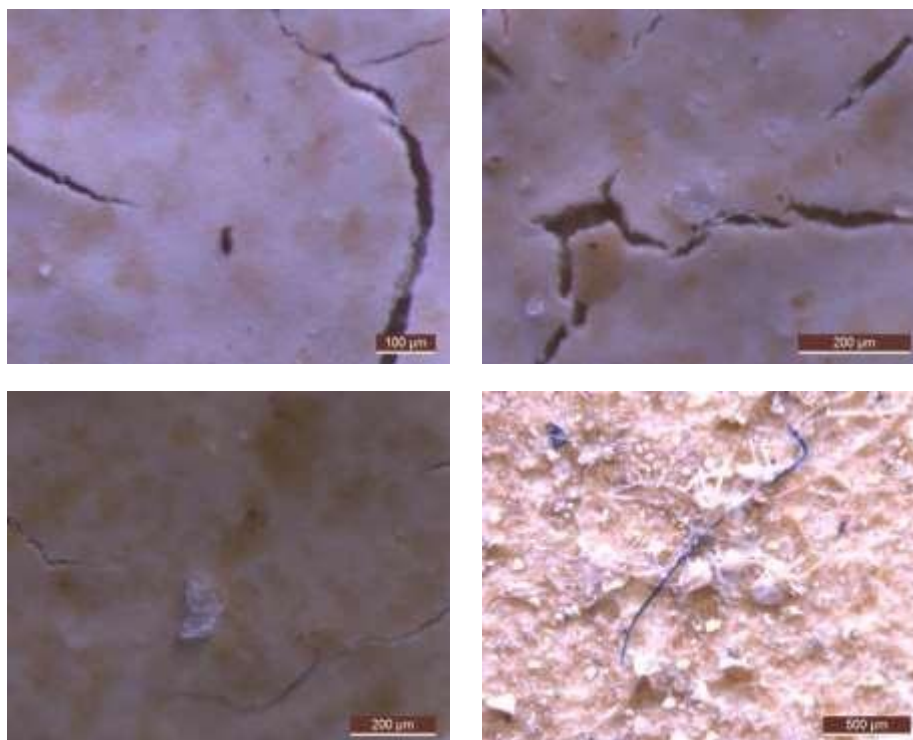


Fig 5.2.31 The microplastics found in the membrane filter of the *Plotous canius* gill using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The Post-monsoon result (fig 5.2.31) shows the microplastic particles present in the filter membrane of *Plotous canius* gill.

***Plotous canius* Gut SAMPLE**

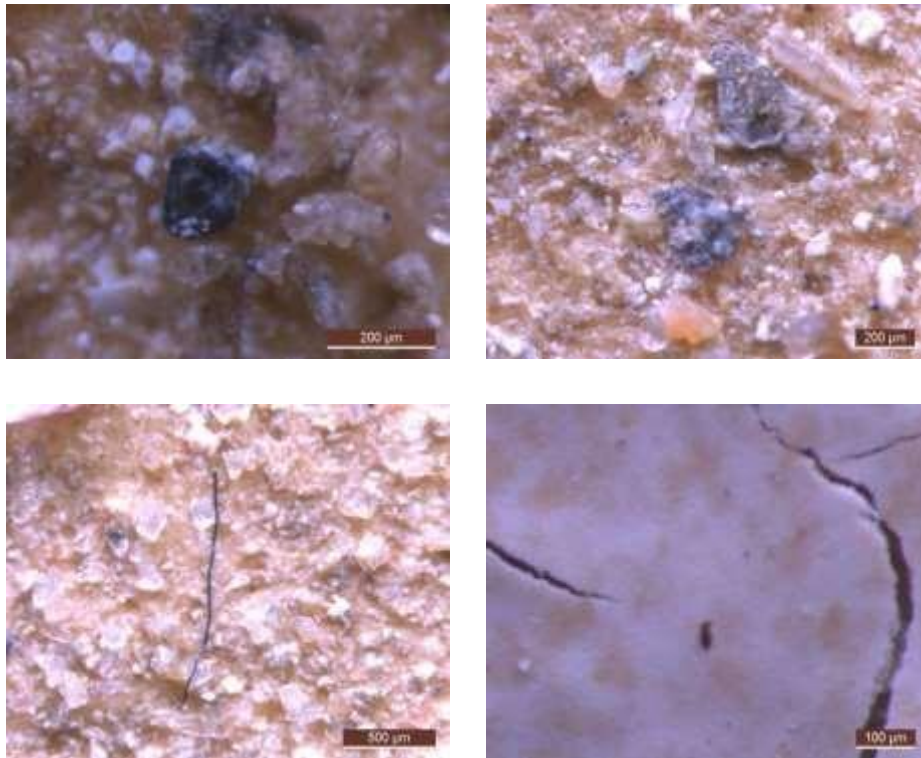


Fig 5.2.32 The microplastics found in the membrane filter of the *Plotous canius* gut using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The Post-monsoon result (fig 5.2.32) shows the microplastic particles present in the filter membrane of *Plotous canius* gut.

***Plotous canius* TISSUE SAMPLE**

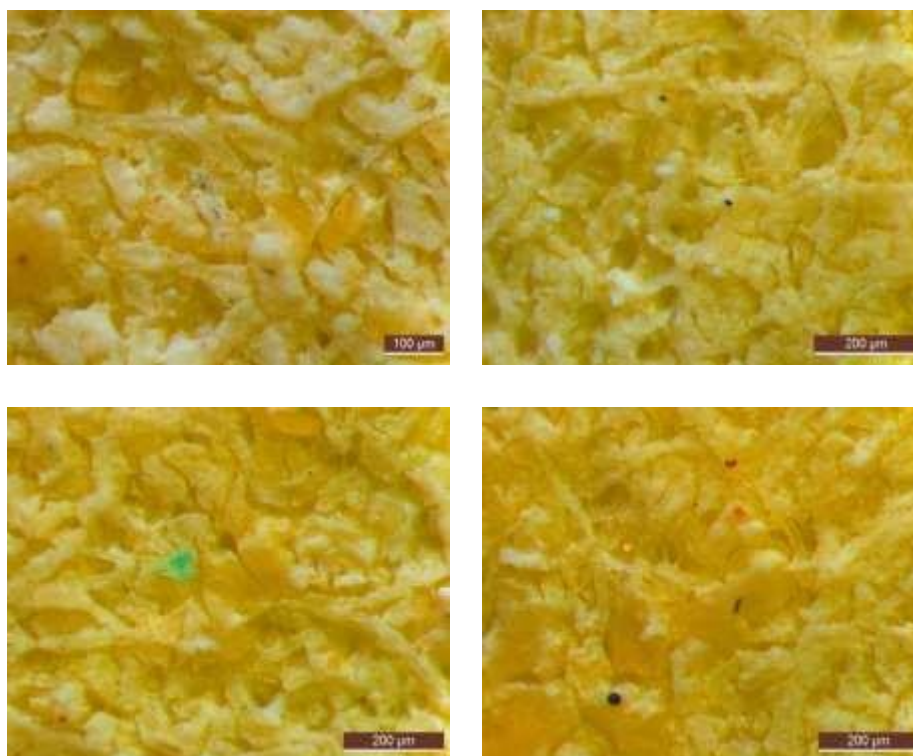


Fig 5.2.33 The microplastics found in the membrane filter of the *Plotous canius* tissue using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The Post-monsoon result (fig 5.2.33) shows the microplastic particles present in the filter membrane of *Plotous canius* tissue.

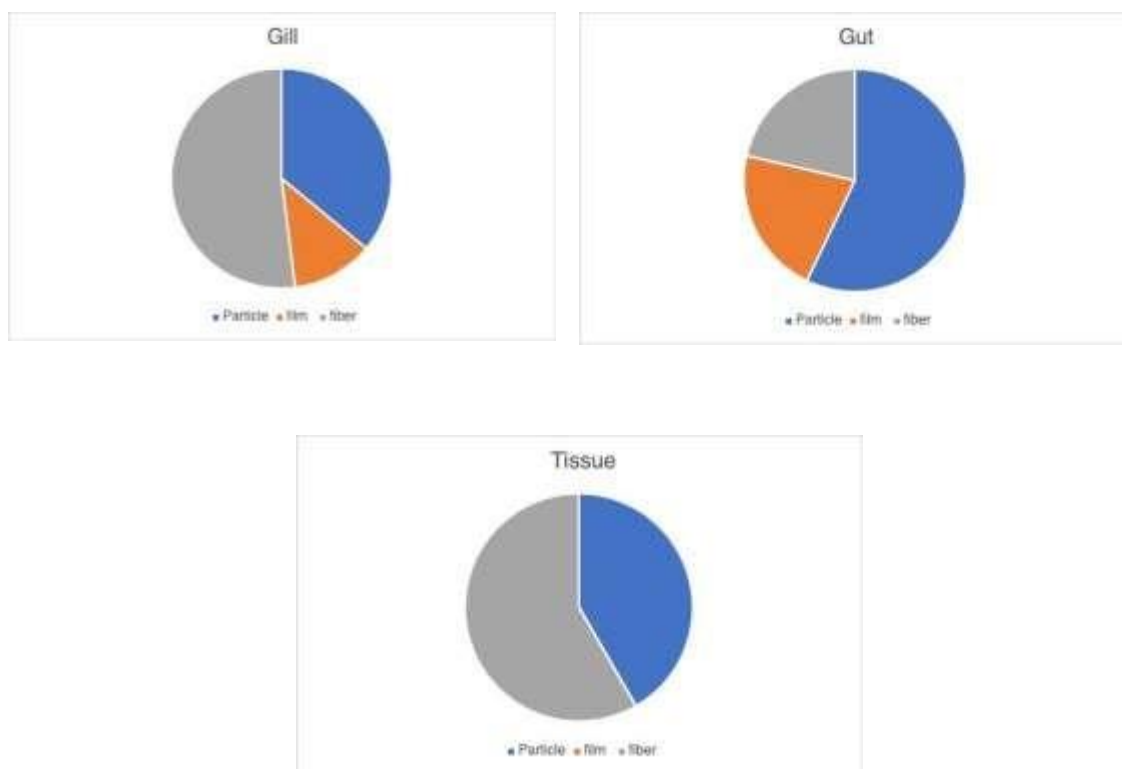


Fig 5. 2. 34 The number of Identified microplastics in the membrane filter of *Plotous canius* (Post-monsoon).

PC		Particle	film	fiber					
				black	blue	white	green	red	pink
1	Gill	9	3	0	1	10	0	2	0
2	Gut	8	3	1	0	1	0	1	0
3	Tissue	5	0	1	0	3	1	2	0

Table 5.2. 8 Types of microplastic present in *Plotous canius* (post-monsoon)

The most common type of microplastic found was fibers, films and other polyethylene particles. The post mon-soon result (Fig 5.2.34) and (Table 5.2.8) showed the microplastic particles that are present in the filter membrane of *Plotous canius*

***Mugil Cephalous* GILL SAMPLE:**

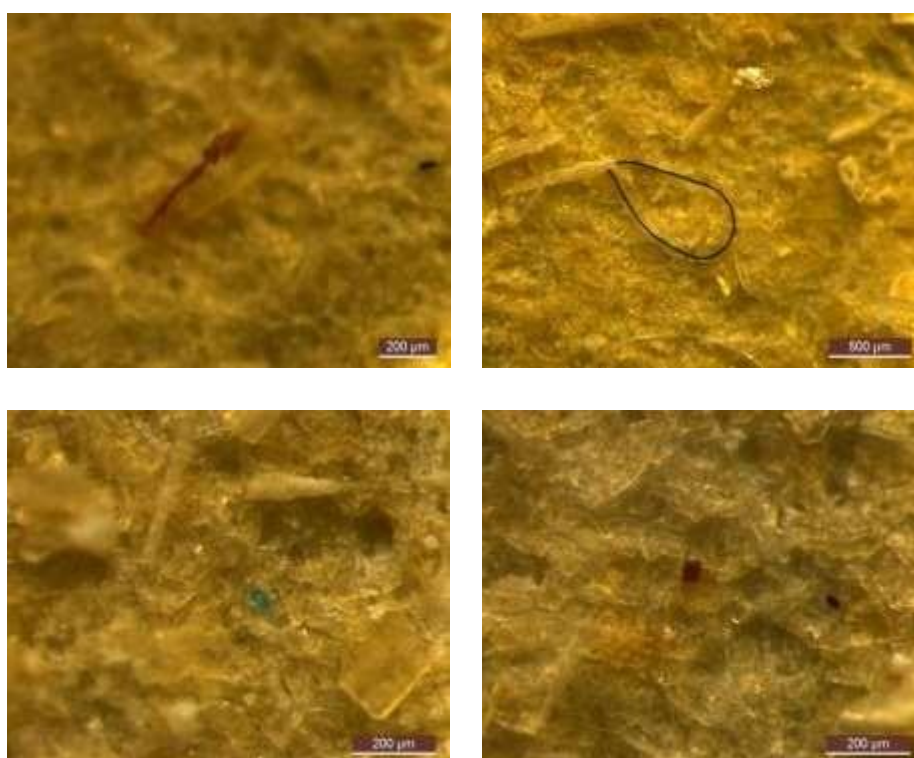


Fig 5.2.35 The microplastics found in the membrane filter of the *Mugil cephalous* gill using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The post-monsoon result (fig 5.2.35) shows the microplastic particles present in the filter membrane of *Mugil cephalous* gill.

***Mugil Cephalous* GUT SAMPLE:**

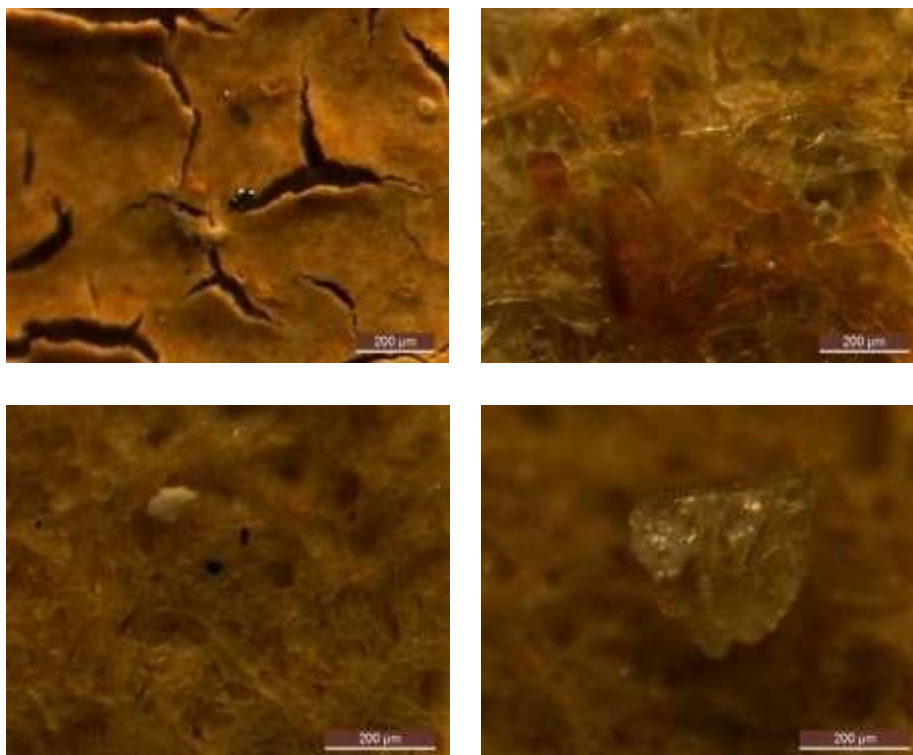


Fig 5.2.36 The microplastics found in the membrane filter of the *Mugil cephalous* gut using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The post-monsoon result (fig 5.2.36) shows the microplastic particles present in the filter membrane of *Mugil cephalous* gut.

***Mugil Cephalous* SKIN SAMPLE:**

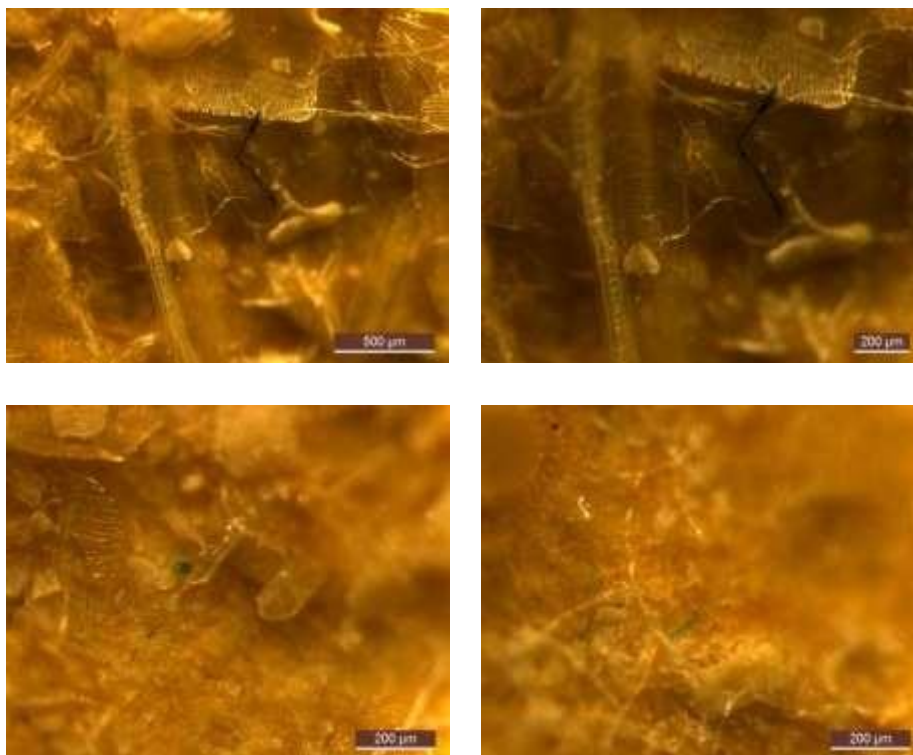


Fig 5.2.37 The microplastics found in the membrane filter of the *Mugil cephalous* skin using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The post-monsoon result (fig 5.2.37) shows the microplastic particles present in the filter membrane of *Mugil cephalous* skin.

***Mugil Cephalous* MUSCLE SAMPLE:**

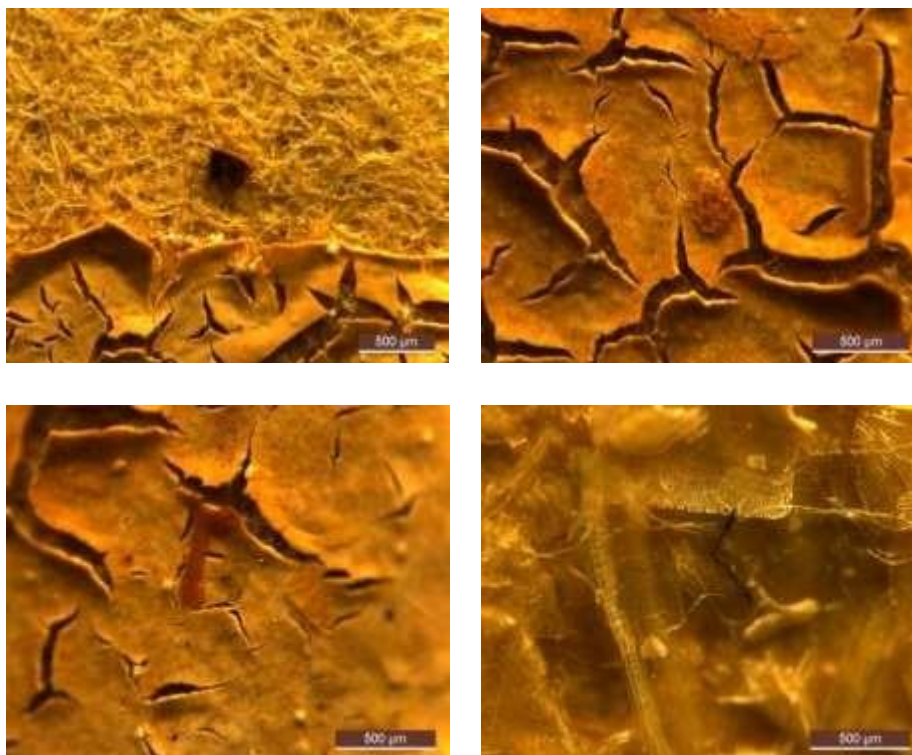


Fig 5.2.38 The microplastics found in the membrane filter of the *Mugil cephalous* Muscle using microscope (post-monsoon).

Microplastics were extracted from the filter membrane using a KOH digestion method. After digestion, the particles were filtered into a membrane filter and analyzed using stereo zoom microscope . The post-monsoon result (fig 5.2.38) shows the microplastic particles present in the filter membrane of *Mugil cephalous* muscle.

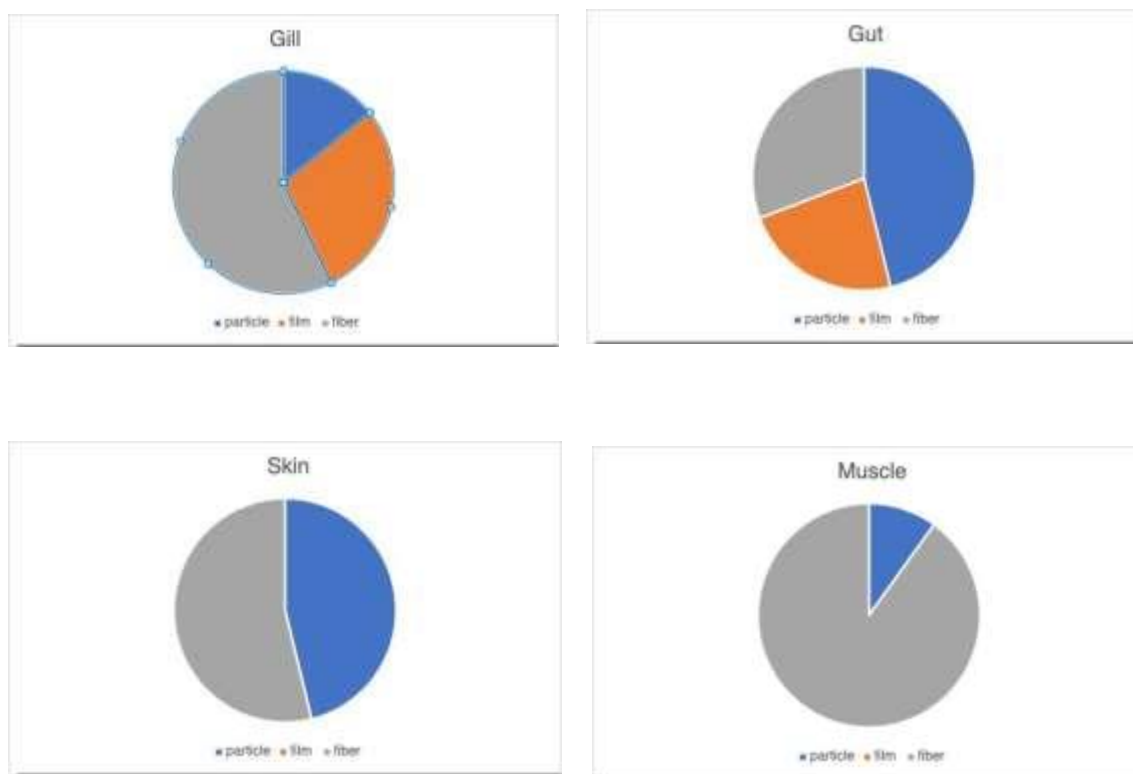


Fig 5. 2.39 The number of Identified microplastics in the membrane filter of *Mugil Cephalous* (post-monsoon).

Mugil		Particle	film	fiber					
				black	blue	white	green	red	pink
1	Gill	1	2	2	1	0	0	1	0
2	Gut	6	3	1	0	3	0	0	0
3	Skin	6	0	1	0	5	1	0	0
4	Muscle	1	0	3	0	5	1	0	0

Table 5.2.9 Types of microplastic present in *Mugil Cephalous* (post-monsoon).

The most common type of microplastic found was fibers, films and other polyethylene particles. The post-monsoon result (Fig 5.2.39) and (Table 5.2.9) showed the microplastic particles that are present in the filter membrane of *Mugil Cephalous*

CHAPTER 6

6. CONCLUSION AND SUMMARY:

The analysis of heavy metals and microplastic pollution in marine organisms is crucial in understanding the impact of human activities on marine ecosystems. Heavy metals such as mercury, cadmium, and lead, can accumulate in marine organisms and cause harm to both the environment and human health.

Microplastics, on the other hand, are small plastic particles that can be ingested by marine organisms and cause physical damage, as well as the release of toxic chemicals. The accumulation of microplastics in the food chain can also have harmful effects on human health.

Studies have shown that both heavy metals and microplastic pollution are present in various marine organisms, including fish, crustaceans, and mollusks. The levels of these pollutants can vary depending on the species, location, and environmental conditions.

Effective management and regulation of human activities that contribute to the pollution of the marine environment are necessary to minimize the accumulation of heavy metals and microplastics in marine organisms. Further research is also needed to better understand the long-term effects of these pollutants on the marine ecosystem and human health.

CHAPTER 7

7. REFERENCE:

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