Microplastic Content in Non-Point Source And Point Sources of Colombo And Suburbs – Experimental Study on the Impact of Seasonal Variation

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ABSTRACT

Microplastics, which can enter aquatic environments through various sources, are small plastic pieces that are less than 5 mm in length. There are two types: primary and secondary microplastics. Sri Lanka has limited studies on microplastics in inland water bodies, so this research aims to quantify the levels of microplastic pollution in Colombo's surface waters in a spatiotemporal manner.

Samples were taken from Beira Lake, Dutch canal network, Talangama canal, in wet and dry seasons. Microplastic concentrations were determined using NOAA guidelines and an optical microscope. Statistical analysis was performed using IBM SPSS version 21, including One-way Anova and Pearson correlations to identify significant differences and correlations.

The study found that Dutch Canal had the highest average microplastic concentration of 12.7 mg/L during the wet season, and the lowest of 4.2 mg/L during the dry season. Both Dutch Canal and Talangama canal showed significantly higher microplastic concentrations during the wet season than the dry season, while the opposite was found in Beira Lake. The statistical analysis showed significant differences between microplastic concentrations in wet and dry seasons in all three water bodies. The microplastic levels in Beira Lake were higher on the surface water during the dry season (4.32 mg/L) and wet season (13.77 mg/L) compared to point sources (4.05 mg/L and 11.68 mg/L, respectively). Furthermore, Dutch canal's point sources showed higher during the dry season (8.47 mg/L) than the wet season (11.51 mg/L) and concentration of microplastics on the surface water was higher during the wet season (5.73 mg/L) than the dry season (7.16 mg/L). Talangama canal had similar patterns to Beira Lake.

The study found microplastic contamination in urban and semi-urban surface waters at levels comparable to some industrialized countries, highlighting a concerning issue.

KEYWORDS: *Microplastic pollution, Seasonal impact, Sri Lanka, Urban, Colombo*

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1 INTRODUCTION

Plastics are utilized in a wide range of items, and production of them has dramatically increased in recent years (Shamskhany et al., 2021). Plastic waste can be found everywhere (from mountaintops to seafloors) due to inefficient or nonexistent end-of-life plastic management. Stormwater, rivers, wastewater discharge, and wind are just a few of the different ways that plastic is conveyed to freshwater and marine habitats. Plastics can persist in aquatic environments for centuries, or millennia, due to their sluggish degradation processes. (Shamskhany et al., 2021)

Microplastics, which are microscopic fragments of plastic less than 5 mm (0.2 inch) long that are found in the environment because of plastic pollution, have gotten a lot of attention in the last ten years (Manzoor et al., 2021). Microplastics are classified into two types: main and secondary. Primary microplastics are microfibers shed from clothing and other materials, such as fishing nets, as well as minuscule particles produced for commercial use, such as those found in cosmetics. Secondary microplastics are created when larger plastic objects, such as water bottles degrade. The primary environmental elements that contribute to its disintegration are the sun's rays and ocean waves. Many of these goods quickly contaminate the environment as they travel through rubbish. To make microplastics, carbon and hydrogen atoms are linked together in polymer chains (Stanley and Morgan, 2022). The USGS (The United States Geological Survey) currently classifies materials into five categories: fibers, foam, fragments, beads/pellets, and film.

Furthermore, due to its protracted decomposition, which varies depending on the kind, plastic is a significant cause of pollution in the air, water, and land. Some plastics disintegrate quickly, while others take years or decades to do so. Plastic degradation has been categorized into photo-oxidative degradation, thermal degradation, ozone degradation, catalytic degradation, mechano-chemical degradation, and biological degradation depending on the physical, chemical, or biological agents that caused it (Manzoor et al., 2021).

Density is one of the physical characteristics that is commonly linked to the distribution and mobility of microplastics. The density of plastic in freshwater and marine settings varies depending on the type of polymers used, and biofouling, or the development of biofilms on the surfaces of particles, can have a substantial impact (Lagarde et al., 2016).
Physical and chemical toxicity may be caused by microplastics. This may lead to bodily harm that causes stress and inflammation, or it may obstruct the digestive tract, which would restrict food intake or breathing (Kolemans et al., 1970).

The increased quantity of microplastics in these habitats, combined with their distinguishing characteristics, has allowed them to access marine biota such as phytoplankton and other species at the bottom of the food chain before rising the food chain. When these compounds enter these organisms, they accumulate in all their organelles and tissues, causing a variety of negative effects, notably oxidative stress. However, due to the rate at which microplastics are accumulating in the environment and the intricacy of the numerous species in the food chains, the various scientific initiatives aimed at lowering the detrimental effects of microplastics on life forms have not been as effective as hoped. Another significant impediment has been identified as the timescale required to establish microplastic biodegradation. As a result, to analyze the possible environmental dangers and toxicological impacts of microplastics across different trophic layers, more efficient scientific methodologies must be implemented. This is owing to a lack of understanding about the ecotoxicological effects and environmental fate of microplastics derived from either primary or secondary sources. Researchers must precisely quantify the rates at which large plastic particles disintegrate into microplastics, as well as the mechanisms underlying these degradative processes. However, in recent years, an increasing number of micropollutants have been found in the water cycle, which are known to have long-term effects on the ecosystem (Lagarde et al., 2016).

There are several rivers, lakes, and canals in Sri Lanka, and they offer drinking water as well as being important for human daily activities. Microplastics are an increasing issue as a pollutant capable of damaging aquatic species in Sri Lanka. While freshwater microplastic research has grown in recent years, much about the sources and delivery pathways of microplastics in aquatic settings remains unknown.

The goal of this project is to investigate the contamination caused by microplastics in southwest Beira Lake, the Talangama canal, and the Dutch canal in Colombo. To assess microplastic contamination in inland water bodies in and around Colombo, as well as to investigate the seasonal impact on microplastic pollution. (Wet season vs. dry season) Only three large bodies of water will be sampled. This research looks at the relationship between the amount of microplastic and seasonal changes. The samples will be taken twice, once during the wet season and once during the dry season. Representative samples will only be collected from lake/canal inlets and the water's surface.

2 MATERIALS AND METHODOLOGY

Water bodies from urban and suburbs were selected. It was expected to sample from the Talangama canal, Dutch canal, and Beira Lake. All water bodies were sampled once in the dry season as well as once in the wet season. Surface water and lake/canal inflow samples were collected. After collecting the samples all the laboratory tests were done and at the end, the analytical data was taken.

2.1 Study area

Beira Lake - The Sri Lanka Land Reclamation and Development Corporation Beira Lake is an important feature in Colombo's downtown. The Beira Lake is divided into four primary basins due to its distribution around the city: East Lake (containing the floating market), West Lake, South-west Lake, and the Galle Face Lake. (Karunarathne et al., 2022) The South-West side of Beira Lake (Figure1) was chosen for sampling in this study because the sewage network and wastewater treatment facilities on the west side of Beira Lake are ancient and inefficient. As a result, polluted water immediately enters the lake, resulting in poor water quality in the southwest lake.

Figure 1 Location of Sampled Southwest Beira Lake (a-b) View of Beira Lake (c-d)

Dutch canal - The Dutch Canal (Figure 2) is a network of many canals, with several locally including five canals. They are,

1. Heen canal
2. Kinda Canal

3. Dematagoda Canal
4. Kirulapone canal
5. Dehiwala Canal

Figure 2 Locations of sampled water ways(a-b), Heen Canal(c), Kinda Canal(d), Dematagoda Canal(e), Kirulapone Canal(f) and Dehiwala Canal(g)

Talangama canal – Talangama Canal (Figure 3) is a man-made canal in Sri Lanka western province that connects the Talangama Lake estuary to the Kelani River estuary through the Chandrika Kumarathunga Road. As a result, the water quality of the Talangama canal has been polluted, and the surrounding land has become extremely contaminated due to the increasing trend in anthropogenic activities. The area near the CINEC junction and roughly 800m were chosen for sample since it is a heavily inhabited region with one of the best and well-maintained jogging tracks on the island. There is also an outdoor gym and a large parking lot. The track is over 2.5km long and provides plenty of space. It is located along the lake canal and provides beautiful views.

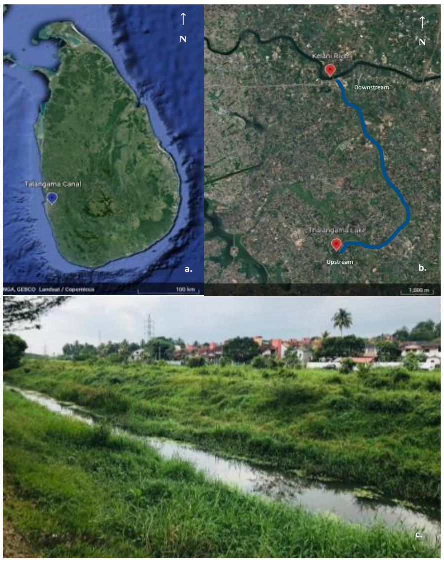


Figure 3 Locations of sampled water way (a-b) and view of Talangamam Canal near the Malabe CINEC Junction

2.2 Rainfall Data

For define the wet season and the dry season the recent 4 years were selected. After plotting the maximum daily rainfall in a month vs month, the dry season and the wet season were defined. Rainfall data were collected from the Meteorology Department of Sri Lanka (https://www.meteo.gov.lk).

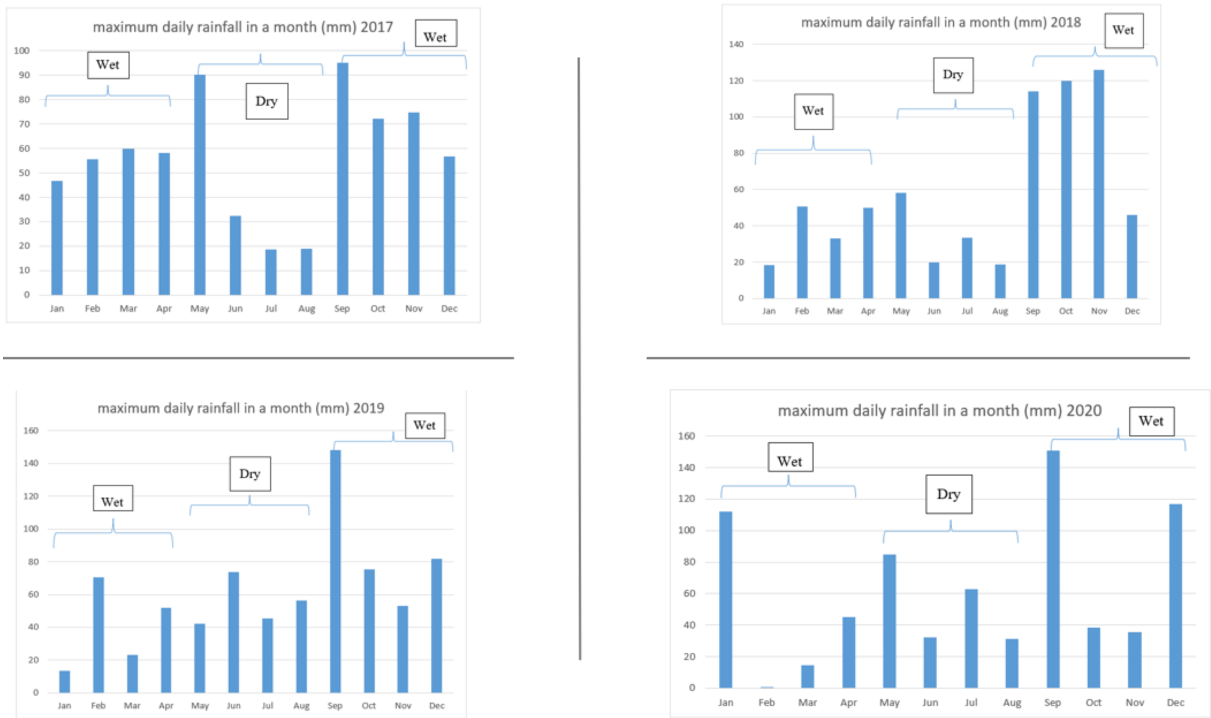


Figure 4. Maximum Rainfall in a month (mm) per year; 2017,20118,2019,2020

The data of maximum daily rainfall recorded monthly for each year display some key features of rainfall distribution in Colombo. The month will highest daily rainfall can be observed to be September for 3 of the 4 years where only in 2018, the maximum daily rainfall was recorded in November. The lowest recorded maximum daily rainfall is far less predictable as results show July, August, January, and February for years 2017, 2018, 2019, and 2020, respectively. Another interesting feature about the minimum daily rainfall monthly value is that for 2017 and 2018, respectively in July (18.7mm) and August (18.8mm) falls in the dry season while for 2019 and 2020 respectively January (13.3 mm) and February (0.1mm) falls in the wet season. This deviation highlights the somewhat unpredictable nature of rainfall. However, these deviations are far less scattered when evaluating from an overall perspective. Rainfall data of 2021 is not taken due to the deviation compared to last five years. As present in the graphs **May to August** duration is the **dry season** of the year and **rest of months** are in the **wet season**.

2.3 Sampling

When collecting water samples, a rope with a bucket (a plastic 4liter bucket) was utilized, and 1L well-cleaned water bottles were used to store water samples. Freshwater samples (1L) were collected at each sampling station. These samples were transported to the Sri Lanka Institute of Information Technology environmental Laboratory and stored at room temperature for further examination. For calculating reasons, the drains were believed to be a point source entry to the main lake. There were multiple inlets in a specific area that connected directly to the west Beira Lake.

Samples are taken from water surface and lake/canal inlets. The sampling for dry season was done in June (Beira Lake, Talangama Canal) and in August (Dutch Canal). Sampling for wet season was done in October. Representing the Dutch canal, 25 samples were taken from 5 different canal of the Dutch canal. Surface water samples were collected in densely populated areas and at every 100m-by-100m distance. This could not be done with Hume pipes since they could not be found in a 100m-by-100m area.

Table 1 Sampling details

Location	No of samples from Canal/Lake inlets	No of samples from Surface water	Total samples	Sampling conducted Month for dry season	Sampling conducted Month for wet season
Southwest Beira Lake	13	12	25	June	October
Dutch Canal	9	16	25	August	October
Talangama Canal	5	5	10	August	October

2.4 Laboratory Analysis (Determination of Microplastics)

Wet sieving: The water samples were sieved through 5mm and 0.3mm steel mesh, respectively. Following that, the water sample was rinsed with distilled water. It aids in the removal of all remaining solids from the sieve as well as the removal of salt from the sample. The steel mesh was then rinsed with distilled water, and any items that remained in the 5mm steel mesh were removed. Microplastic containing organic solids consists of materials that pass through a 5mm mesh but remain in 0.3mm.

Transferring Sieved Solids: It was measured in 250ml beakers and weighted to the nearest 0.1 milligrams. The solids from the 0.3mm mesh were put into the beaker with a spatula. The remainder was rinsed with distilled water and put to the beaker. The solids-containing beaker was placed in a dry oven at 90°C for 24 hours or more to eliminate all moisture from the sample.

Wet Peroxide Oxidation (WPO): The beakers containing microplastic and natural materials received 20ml of aqueous 0.05 M Fe (II) solution. The same beaker was then filled with 20 ml of 30% hydrogen peroxide. The mixture was then allowed to cool for five minutes before proceeding to the next phase. The dish was then covered and roasted to 75°C on a hot plate. The combination was removed off the hot plate when gas bubbles were visible on the surface of the solution. Another 20 cc of 30% hydrogen peroxide was added if natural materials were visible. If necessary, repeat the operation until no organic materials are visible. To raise the density of the solution, 6g of salts were added to the sample. The mixture was then placed back on the hot plate until all the salt had been dissolved.

Density Separation: After cooling down, the mixed sample of Wet Peroxide Oxidation (WPO) solution was put to the 100ml funnel (with a rubber tube sealed the bottom of the funnel) and covered the funnel top. It was kept overnight. Then, all floating materials were collected into a 250ml beaker. The floating material was filtered using filtration equipment and allowed to air dry.

Gravimetric Analysis: To determine the mass of microplastics, Eq. 1 was utilized, where m_{mp} is the mass of microplastics, m_{fpp} is the mass of dried filter paper with particles, and m_{efp} is the mass of empty filter paper.

Equation (1) → $m_{mp} = m_{fpp} - m_{efp}$

Microscope Exam: A microscope is a device that was used to examine small objects on filter papers. This lens bends light toward the eye, causing an item to look larger than it is. 4X/0,10 zooming was used to identify the microplastic particles and for qualitative analysis.

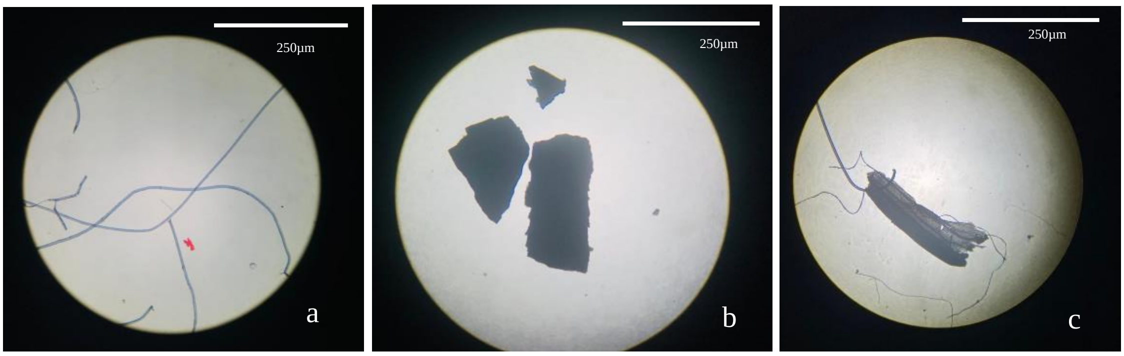


Figure 4. Microscope view of founded microplastic particles, Fiber (a), Fragment (b), Films (c)

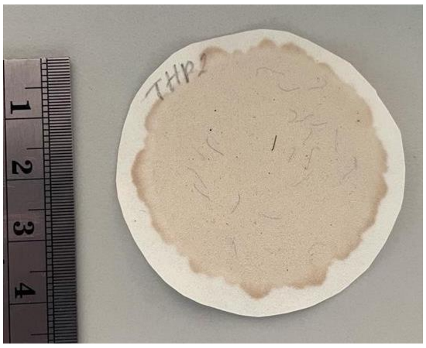


Figure 5. Visible Microplastics particles on Filter papers

2.5 Determination of water quality parameters

A turbidity meter was used to measure the turbidity (HACH 2100Q portable turbidity meter). Water samples were diluted with distilled water to determine the turbidity of water in the high turbidity range. Because the working solution is ten times as dilute as the stock, it is sometimes referred to as a "10X" dilution. In this situation, the dilution factor is 10. Using this calculation, combine 100 mL of stock with 900 mL of pure water.

The pH of water samples was determined using a pH meter (HACH HQ411D laboratory single input pH meter). pH value of a sample was evaluated by utilizing pH paper to see if it was acidic, alkaline, or neutral. This was performed by dipping the pH paper into a sample and watching the paper's color change. A color-coded scale is included in the publication, with different hues denoting different values.

2.6 Data Analysis

Using IBM SPS software, significant differences between two groups and more than two groups were discovered using the t-test and one way ANOVA (IBM SPSS Statistics 21). For all statistical analyses, $P < 0.05$ or $P < 0.1$ was selected as the significant level.

3 RESULTS

3.1 Microplastic Concentration vs Season

According to the graph (Figure 11), the highest average microplastic concentration (12.725 ± 5.122 mg/L) was found in Dutch Canal during the wet season and the lowest (4.183± 4.092 mg/L) was found in Dutch Canal during the dry season.

The bivariate correlations with Pearson's coefficient were used to examine the relationship between the microplastics concentrations of these three water sources and the seasonal changes. A correlation was observed between microplastic concentrations and the season. (Pearson's coefficient =1)

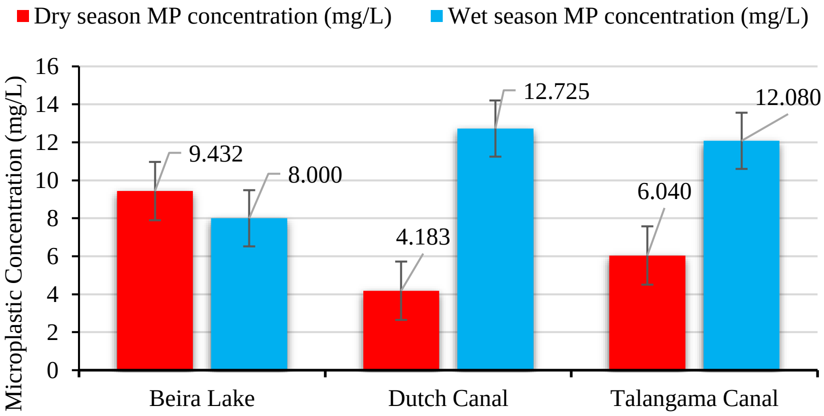


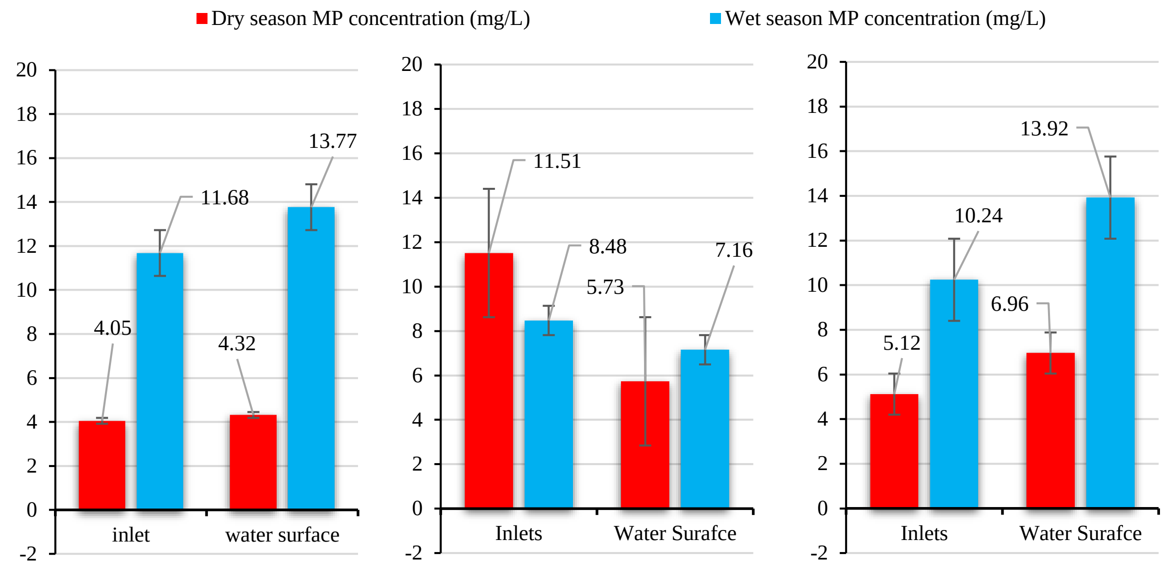
Figure 5 Microplastic Concentration vs Seasonal variation in Beira Lake, Dutch Canal, Talangama Canal

In Dutch canal (wet; 12.725 mg/L, dry; 4.183 mg/L) and Talangama canal (wet; 12.08 mg/L, dry; 6.04 mg/L) the microplastic concentration was increased in wet season than dry season. This may happen due to the ground surface microplastic will be washed and collected to those sources when the rainfall starts because the water that will be collected in the cannels, culverts, and drains will be at a greater level. But in Beira Lake (wet; 8 mg/L, dry; 9.432 mg/L) opposite happens. This may be due to the industrial wastage coming from culverts and drains in wet season are lower than in dry season and it may be due to accumulation of microplastic in water and low flowrate of water to the ocean in dry season.

3.2 Spatiotemporal Variation of Microplastic

For Beira Lake, as evidenced in Fig. 3a, in microplastic concentration in water surfaces (dry – 4.32 mg/L, wet-13.77 mg/L) is higher than the concentration in point sources (dry- 4.05 mg/L, wet-11.68mg/L) in both dry and wet seasons. Furthermore, a statistically significant ($p<0.05$) microplastic concentration was observed in both point sources and water surfaces during the wet season compared to the dry season. The reason for this may be all the surface runoff comes to water surface during the rainy season since the Beira Lake is in urban area.

For the Dutch Canal, as evidenced in Fig. 3b, the microplastic concentration of point sources was higher during the dry season (8.47 ± 4.91 mg/L) than the wet season (11.51 ± 5.46 mg/L), while in contrast the microplastic concentration of water surfaces was higher during the wet season (5.73 ± 3.67 mg/L) than the dry season (7.16 ± 4.56 mg/L). In both sources, a statistically significant difference was not observed during the two seasons ($p>0.05$). The reason for this may be all the surface runoff comes to water surface during the rainy season since the sampled area is highly pollutant. According to Yang and Cheng (Yang and Cheng, 2017), higher summer temperatures have a greater negative impact on output in low-temperature regions than in high-temperature regions, implying that adaptation to warming may have been actively undertaken in high-temperature regions. Lower industrial waste may come through point sources in the dry season than in the wet season.



(a) Beira Lake **(b) Dutch Canal** **(c) Talangama Canal**

Figure 6. Microplastic Concentration in Wert season and Dry season of (a) Beira Lake, (b) Dutch Canal, and (c) Talangama Canal

For Talangama Canal, as evidenced in Fig. 3c, in microplastic concentration in water surfaces (dry – 6.96 ± 3.26 mg/L, wet-13.92 ± 6.51 mg/L) is higher than the concentration in point sources (dry-5.12 ± 2.33 mg/L, wet- 10.24 ± 4.67 mg/L) in both dry and wet seasons. Furthermore, there was no statistically significant variation in microplastic concentration ($p>0.05$) between the wet and dry seasons in both point sources (0.065>0.05) and water surfaces (0.059>0.05). The reason for this may be all the surface runoff comes to water surface during the rainy season since the sampled area is densely populated.

4 DISCUSSION AND CONLUSION.

Microplastics have emerged as a significant contributor to the pollution caused by plastic. The water, the soil, and the air all contain trace amounts of microplastic. The air and the water are two of the primary mediums via which microplastics are transported. Toxic components that are contained in microplastic have the potential to be absorbed by environmental components as the microplastic is being transported. It poses a threat to a wide variety of plant and animal species. The majority of microplastics came into being because of man-made processes. Most of the plastic Urban water bodies are subject to pollution, and there is a pressing need for a great deal more research to be carried out to discover the forms, origins, and availability of microplastic in densely populated places.

Microplastic concentrations in the Dutch and Talangama canals were higher during the wet season than during the dry season. This may occur because when the rainstorm begins, the ground surface microplastic will be washed and gathered to those sources since the water collected in the cannels, culverts, and drains will be at a higher level. In Beira Lake, however, the opposite occurs. This could be because industrial waste from culverts and drains is lower in the wet season than in the dry season, or it could be due to the accumulation of microplastic in water and the low flowrate of water to the ocean in the dry season.

Microplastic concentrations in water surfaces of Beira Lake are higher than concentrations in point sources in both dry and wet seasons. Because Beira Lake is in an urban region, all surface runoffs may reach the water's surface during the rainy season. In both dry and wet seasons, turbidity at water surfaces is higher than concentration at point sources. The increase in turbidity during the wet season can be attributed to the increase in turbidity, which causes runoff and solids collection from the urban surroundings.

In both dry and wet seasons, the concentration of microplastics on water surfaces of Talangama Canal is higher than the concentration in point sources. Because the sampled area is densely populated, all surface runoffs may come to the water surface during the rainy season. In both the dry and wet seasons, the turbidity of the Talangama canal was higher on the water's surface than at point sources. The increase in turbidity during the wet season can be attributed to run off and solids collection from the surroundings.

The Dutch Canal and the Beira Lake are both in urban areas, but they have two different variations of microplastic pollution with seasonal variations because the Beira Lake is cleaned once a month and the Dutch Canal system has not been introduced with a microplastics treating or removal system. When compared to Beira Lake, all five canals sampled in the Dutch canal system are highly polluted.

It may investigate the microplastic content of aquatic life and sediment samples from the canal/lake to improve this study and evaluate the impact of microplastic contamination on the environment.

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