Microplastic abundance in sediments of the artificial ponds at Mulawarman University, Samarinda, East Kalimantan

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ABSTRACT

Microplastics present in the environment, particularly in sediments, pose potential threats to aquatic organisms, as they can impair organ function when ingested. This study aims to assess the abundance, types, and colors of microplastics in the sediments of the artificial pond at Mulawarman University, Samarinda. The research employed a purposive sampling method. The Faculty of Agriculture pond had a higher microplastic abundance compared to the UNMUL HUB pond. Nonetheless, statistical analysis using a t-test showed no significant difference in microplastic levels between the two sites at Mulawarman University, Samarinda (p-value > 0.05). Overall, the artificial ponds at Mulawarman University, East Kalimantan, contained an average of 275 particles of microplastic per kilogram of dry sediment. Specifically, the Faculty of Agriculture pond had 161.25 particles/kg, while the UNMUL HUB pond had 113.75 particles/kg. The microplastics found consisted of fibers, fragments, films, and pellets, with colors including black, blue, red, brown, yellow, and white.

INTRODUCTION

Waste is the residual output of daily human activities and natural processes, typically in solid form. Indonesia is estimated to be the second-largest contributor to plastic pollution in the world among 129 countries (Jambeck et al., 2015). According to the Ministry of Environment and Forestry, the average amount of waste generated in Indonesia reaches approximately 175,000 tons per day, equivalent to 64 million tons per year, with an individual daily waste output of around 0.7 kg (Ministry of Environment and Forestry, 2019).

Plastic waste that enters aquatic environments breaks down into small plastic fragments known as microplastics (UNEP, 2012). Microplastics are defined as plastic particles with a diameter of less than 5 mm (Cole et al., 2011). These particles are further classified by size into large microplastics (1–5 mm) and small microplastics (<1 mm). Microplastics vary in size, shape, color, composition, density, and other physical and chemical properties (Victoria, 2017). Their accumulation in sediments can alter light penetration in water bodies, thereby affecting sediment characteristics as well as the organic and inorganic content of sediments (Zhao et al., 2018). In recent years, microplastics have also been detected in various freshwater ecosystems such as rivers, lakes, and ponds (Castaneda et al., 2014; Earkes et al., 2015; Da Le et al., 2022). The issue of microplastic pollution has become a pressing environmental concern that warrants serious attention.

Mulawarman University in Samarinda hosts several artificial ponds, primarily constructed for aesthetic enhancement of the campus landscape. These ponds are surrounded by various campus activities, making them vulnerable to the influx of anthropogenic materials, including plastic waste in both macro and micro forms. At the same time, these ponds serve ecological functions by providing habitat for a variety of aquatic organisms, including fish and invertebrates. To date, no scientific data are available regarding the extent of microplastic contamination in these artificial aquatic ecosystems. The absence of such information has prompted this study, which aims to scientifically assess the abundance of microplastic particles in the sediments of artificial ponds within the Mulawarman University campus.

METHODOLOGY

Time and study location

This study was conducted on sediment samples collected from the artificial ponds located at Mulawarman University in Samarinda, specifically at the artificial ponds of the Faculty of Agriculture and UNMUL HUB. The research was carried out from March to May 2023. Microplastic analysis was conducted at the Water Quality Laboratory, Faculty of Fisheries and Marine Science, Mulawarman University.

Figure 1. Map showing the study site for microplastic contamination in sediments

Tools and materials

The tools and materials used in both fieldwork and laboratory analysis in this study are listed in Table 1.

Table 1. Tools and materials used in the study

Tools	Materials
1. Thally seat	1. Vacuum filter
2. Stationery	2. Tray
3. Mortar and pestle	3. Tweezers
4. Sediment grab	4. Oven (100 °C)
5. Secchi disk	5. Stereo microscope
6. DO meter	6. Apera Instrument A1480 DO 850
7. pH meter	7. Apera Instrument SX823-B multiprobe
8. Refractophotometer	8. Ziplock plastic bags
9. Measuring tape	9. Beaker glass
10. Camera	10. Scale
11. Aluminum sample container	11. Sediment samples
12. Aluminum foil	12. Distilled water
13. Wire sieve (125 µm mesh)	13. NaCl (salt)

Research procedure

Sample collection was conducted using a purposive sampling method. Purposive sampling involves selecting samples that align with the research objectives, thus expected to effectively address the research problem. Sediment samples were collected from five points proportionally at each site. Samples were collected using a sediment grab and then transferred into ziplock plastic bags. The collected sediment samples were subsequently analyzed at the Water Quality Laboratory, Faculty of Fisheries and Marine Science, Mulawarman University.

Microplastic abundance calculation

The calculation of microplastic abundance in sediment was based on the method described by Dewi et al. (2015), which involves comparing the number of microplastic particles to the weight of dry sediment samples. The microplastic abundance data were analyzed using descriptive statistics with Microsoft Excel.

Microplastic abundance was calculated using the following formula:

$$Microplastic\ Abundance\ \left(\frac{particles}{kilogram}\right) = \frac{Number\ of\ Microplastic\ Particles\ in\ Sediment\ \text{(particles)}}{Dry\ Sedimen\text{t (grams)}}$$

In addition, the types and colors of microplastics were observed at each sampling site. Microplastics can be categorized into several types, including pellets, fragments, fibers, and films. They also come in various colors, such as black, blue, white, transparent, red, green, and others.

The analysis of microplastic types and colors was conducted by calculating both the number and percentage of particles. The percentage of each type and color was calculated using the following formula:

$$Percentage\ (\%) = \frac{Number\ of\ Particles\ of\ a\ Specific\ Type\ or\ Color\ \ \text{(particles)}}{Total\ Number\ of\ Particles\ (particles\ \text{(particles)}} x100\%$$

RESULT AND DISCUSSION

Identification and classification of microplastics

Observations revealed four types of microplastics present in the sediment samples from the artificial ponds: fibers, fragments, films, and pellets. Additionally, six colors of microplastic particles were identified, namely red, yellow, black, blue, brown, and white. Below are examples of the colors and images of microplastic particles observed in the test samples under a stereo microscope at 20x magnification:

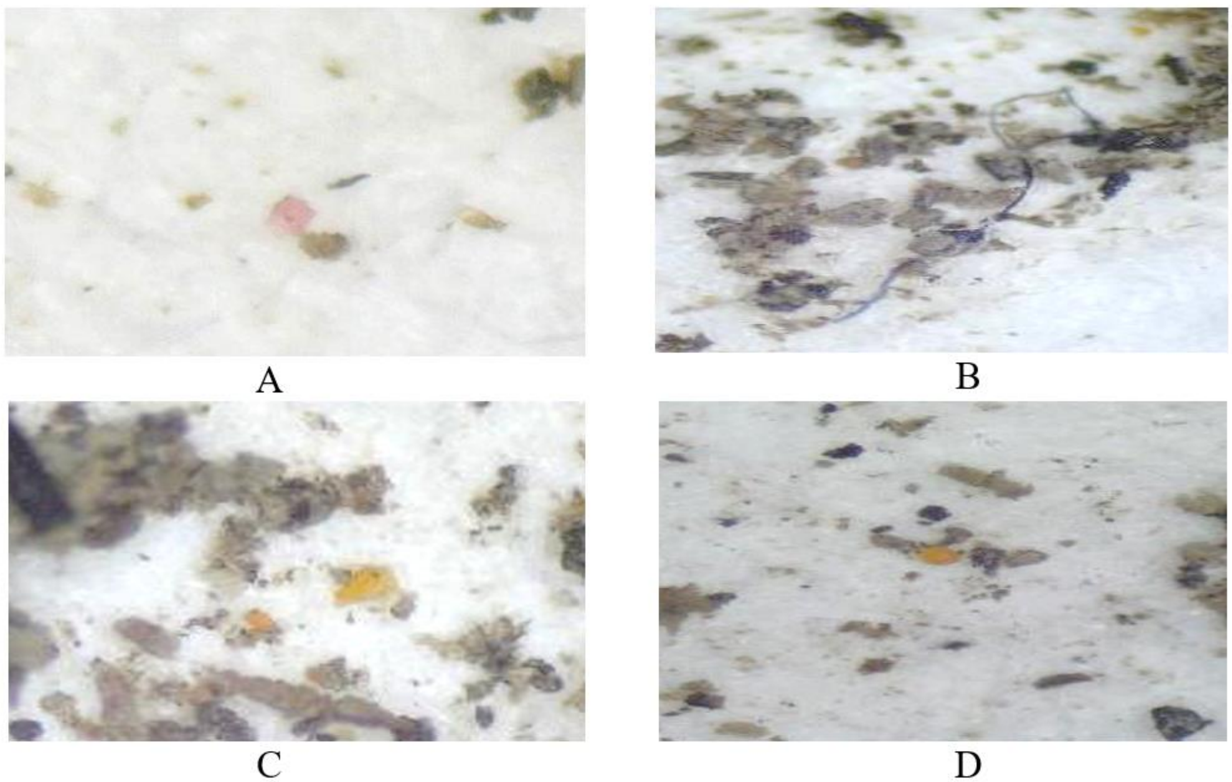

Figure 2. Illustration of microplastic particles identified: A. Film (red); B. Fiber (black); C. Fragment (yellow); D. Pellet (yellow).

Identification of Microplastic Types

The figure below shows that the dominant type of microplastic found in sediment samples from the artificial ponds at Mulawarman University is film. Among the various types, film microplastics were the most prevalent, with an average of 430 particles/kg of dry sediment. According to Dewi et al. (2015), film-type microplastics originate from fragments and degradation of plastic bags and are characterized by their thin sheet-like structure and low density. Despite their low density, these particles can still settle and accumulate in bottom sediments.

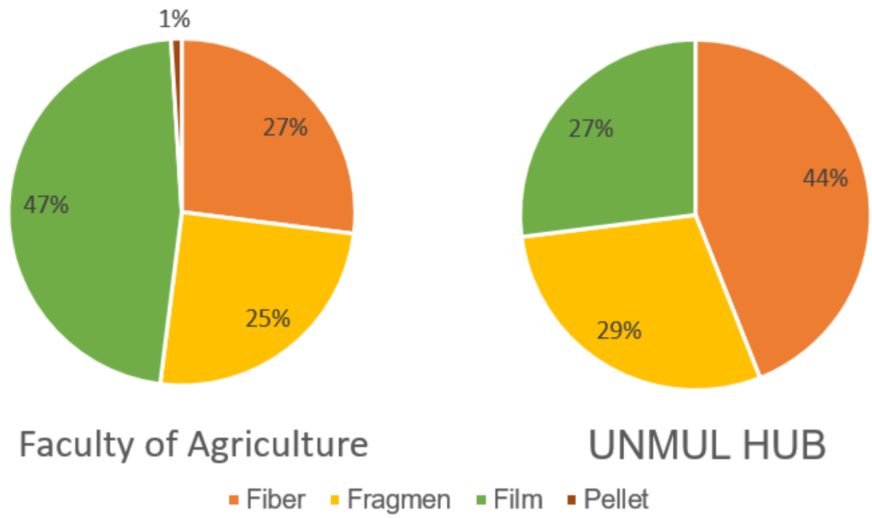

Figure 3. Percentage of microplastic types at each pond

At the Faculty of Agriculture Pond, as shown in Figure 3, film microplastics were found to be the most abundant, with an average of 305 particles/kg of dry sediment, accounting for 47% of the total. Fiber-type microplastics were the second most prevalent, with an average of 175 particles/kg of dry sediment (27%), followed by fragments at 160 particles/kg (25%). Pellet-type microplastics were the least abundant, with an average of only 5 particles/kg of dry sediment, contributing just 1%.

In contrast, at the UNMUL HUB pond, fiber-type microplastics were the most dominant, with an average of 200 particles/kg of dry sediment, accounting for 44%—a higher percentage than at the Faculty of Agriculture Pond. However, other microplastic types showed a decrease in abundance at this location. Fragment-type microplastics averaged 130 particles/kg (29%), film-type averaged 125 particles/kg (27%), and no pellet-type microplastics were found.

Identification of microplastics based on color

Observations of microplastic particles in the artificial ponds—namely the Faculty of Agriculture pond and the UNMUL HUB pond—revealed several colors, including black, red, yellow, brown, blue, and white. The color of microplastics may change upon exposure to sunlight, which can cause discoloration (Browne, 2015).

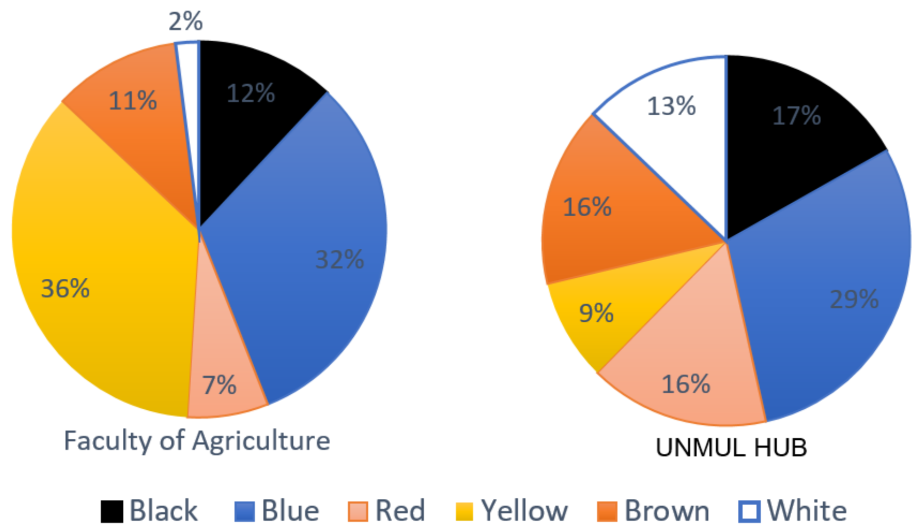

Figure 4. Percentage of microplastic colors at each pond location

Figures 4 illustrates the average number of microplastic particles by color and their respective percentages. Based on the analysis, yellow was the most dominant color found in the Faculty of Agriculture pond, with 235 particles/kg of dry sediment or 36%. Blue was the second most frequently observed color in the same pond, with 205 particles/kg or 32%. White microplastics were the least common, with only 10 particles/kg or 2%.

In contrast, the UNMUL HUB pond showed a different pattern. Blue microplastics were the most prevalent, with 135 particles/kg of dry sediment or 29%. Black was the second most common color, with 75 particles/kg or 17%. Yellow microplastics were among the least detected in this pond, with only 40 particles/kg or 9%.

Microplastic abundance in artificial ponds

Sediment samples from the artificial ponds at Mulawarman University showed varying levels of microplastic abundance across the sampling sites. The overall abundance was 275 particles/kg. The Faculty of Agriculture pond exhibited a higher total abundance, with 161.25 particles/kg of dry sediment, compared to 113.75 particles/kg at the UNMUL HUB pond. Film-type microplastics were most commonly found in the Faculty of Agriculture pond, with an average abundance of 76.25 particles/kg of dry sediment. In contrast, fiber-type microplastics were dominant in the UNMUL HUB pond, with an average abundance of 50 particles/kg.

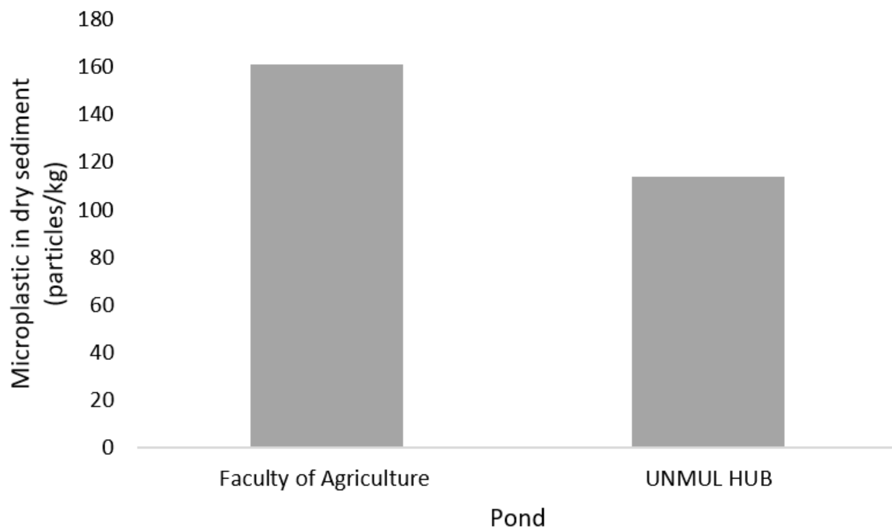

Figure 5. Microplastic abundance at each pond

The high abundance of film-type microplastics in the artificial pond at the Faculty of Agriculture is likely due to discarded plastic bags and food packaging entering the pond. This is supported by the proximity of a cafeteria near the pond, which is suspected to be a source of plastic waste. Pellet-type microplastics were found in low quantities, likely due to the absence of nearby industrial activities. The presence of pellet microplastics in this aquatic environment may be attributed to residual construction waste or improperly degraded plastic debris.

Table 2. Microplastic particles (particles/kg dry sediment) at five sampling stations in each pond

Pond	Station	1	2	3	4	5	Total (Type)
Faculty of Agriculture	Fiber	275	75	75	150	300	875
	Fragment	75	125	150	175	275	800
	Film	325	400	100	225	475	1525
	Pellet	0	25	0	0	0	25
UNMUL HUB	Fiber	125	250	200	175	250	1000
	Fragment	250	100	225	25	50	650
	Film	250	75	100	150	50	625
	Pellet	0	0	0	0	0	0

The high abundance of fiber-type microplastics in the UNMUL HUB artificial pond may be attributed to the degradation of plastic ropes and fishing activities that use fishing lines. Discarded fishing lines in the pond can degrade into fine microfibers that are microscopic in size. Pellet-type microplastics were not found in this location, likely because there are no anthropogenic activities that contribute pellets to the aquatic environment.

The widespread distribution and high abundance of microplastics in sediment—along with their size and coloration that resemble prey—increase the likelihood of ingestion by various aquatic organisms (Ramananda, 2023). In this study, the abundance of microplastics in sediment was lower compared to other studies, suggesting a relatively better environmental condition at the study site. However, the potential for microplastics to affect aquatic organisms, such as bottom-dwelling fish, remains. Microplastics that resemble natural prey in color may be mistakenly consumed by aquatic fauna.

To compare the two pond locations, a t-test was conducted between the Faculty of Agriculture pond and the UNMUL HUB pond to determine whether there was a significant difference in microplastic abundance. The result yielded a p-value of 0.1496, which is greater than the significance level of 0.05. This indicates that there is no statistically significant difference in microplastic abundance between the two pond locations. This result may be attributed to the similar environmental conditions and anthropogenic activities occurring at both sites.

The t-test result is consistent with findings reported by Putri (2022), who conducted a study in Kenanga Lake and Mahoni Lake in Depok, West Java, and also found no significant difference in microplastic abundance between the two study sites. According to Shafani et al. (2022), such non-significant differences suggest that microplastic abundance is not necessarily influenced by microplastic types. Furthermore, the findings imply that the distribution of microplastics in the sediment of artificial ponds tends to be relatively uniform.

CONCLUSION

The total microplastic abundance in the Faculty of Agriculture pond was higher than that in the UNMUL HUB pond. However, the t-test results indicated no significant difference in microplastic abundance between the two locations at Mulawarman University, Samarinda (p- value > 0.05). The overall microplastic abundance in the artificial ponds at Mulawarman University, East Kalimantan, was 275 particles/kg of dry sediment, with the Faculty of Agriculture pond and the UNMUL HUB pond showing abundances of 161.25 particles/kg and 113.75 particles/kg, respectively.

The types of microplastics identified included fibers, fragments, films, and pellets. The observed microplastic colors were black, blue, red, brown, yellow, and white.

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