JURNAL TEKNIK LINGKUNGAN
E-ISSN: 27146715
Journal homepage: www.envengjournal.com

Research Article

Identification Of The Microplastic Accumulation Potential in Lemna Minor Plant

Fachry Sihombing[1*], Dwina Roosmini[2]

[1]Faculty of Civil and Environmental Engineering, Bandung Institute of Technology, Indonesia
[2]Centre for Environmental Studies, Bandung Institute of Technology, Indonesia
*correspondence e-mail: 15321082@mahasiswa.itb.ac.id

Abstract

Microplastics are plastic particles smaller than 5 mm that pollute soil, water, and living organisms, and can carry toxic substances into environment. Therefore, efficient methods are needed to remove microplastics from the environment. Lemna minor is a small, fast-growing aquatic plant that is tolerant of pollution and is believed to be capable of absorbing microplastics from water bodies. This study aims to examine the potential of Lemna minor to absorb microplastics using water samples from the Citarum River, which contains microplastics with specific characteristics. The research focuses on analyzing microplastic accumulation, absorption efficiency, plant growth, characteristics of absorbed microplastics, and recommendations for ideal absorption conditions. The plants were incubated in the water samples for 14 days, with a 3-day acclimatization period to ensure optimal environmental adaptation. Observations were conducted periodically on days 1, 3, 5, 7, and 14 to measure microplastic accumulation and biomass changes. Results showed that the most effective absorption occurred between days 5 and 7, with a removal rate reaching 6% per gram of plant biomass (with 15 g biomass). Additionally, the plants exhibited rapid growth until day 7, with a growth rate of 25%. The most absorbed microplastics were fiber-shaped (87%), blue in color (54.5%), and sized 1001–3000 µm.

Keywords: *Lemna sp., microplastics, citarum river water, absorption*

ARTICLE INFO

Citation: *Sihombing, F., & Roosmini, D. (2026). Identification Of The Microplastic Accumulation Potential in Lemna Minor Plant. Jurnal Teknik Lingkungan, 32(1), 29-37. https://doi.org/10.5614/j.tl.2026.32.1.4*

Article History:
Received 11 Jan 2026
Revised 26 Apr 2026
Accepted 27 Apr 2026
Available online 30 Apr 2026

1. Introduction

Microplastics are pollutants commonly found in various ecosystems around the world. These particles are smaller than 5 mm and originate from different types of plastics discarded into the environment(Tanković et al., 2015). Microplastics are produced and dispersed in large quantities, making them a serious threat to ecosystem sustainability. One natural solution that can be implemented is the use of biotic components, such as aquatic plants. These plants have the potential to absorb and trap microplastic particles, allowing them to function as biofiltration agents to sustainably reduce microplastic concentrations in aquatic environments (Yin et al., 2025). Lemna minor, commonly known as duckweed, is a small aquatic plant that floats on the water surface and is widely distributed around the world. It has a simple structure without true stems or leaves, instead forming a thallus or leaf-like structure that floats on the surface. Its size usually ranges from 1–8 mm, with a distinct bright green color (Priya et al., 2012). Studies have shown that Lemna minor is frequently used for toxicity testing and as a bioindicator (Ziegler et al., 2015). It is also tolerant of microplastics and can function as both collectors and temporary reservoirs of microplastics through mechanisms. Microplastics may be intercepted from the water column or the atmosphere and subsequently adhere to the external surfaces of plants (Tang, 2023).

This study aims to analyze the level of microplastic accumulation in Lemna minor under different amount of biomass, identify biological changes in biomass development due to microplastic absorption, and evaluate the accumulation results to further analyze the plant's potential for microplastic uptake. The findings are expected to serve as a foundation for developing environmentally-based technologies, especially in freshwater ecosystems, to help create cleaner environments free from microplastic pollution.

2. Methodology

The research was conducted through several stages, beginning with the collection of experimental water samples. According to a 2024 report by the Indonesian Ministry of Environment and Forestry (KLHK), one of the highest microplastic contamination points in the Citarum River was identified in KOPO, specifically beneath the Soroja Toll Bridge, with a concentration of 32.6 particles/m³. Therefore, samples were collected from that location, including both riverbanks and directly beneath the bridge.

Water sampling was conducted only once, as the main objective of this study was to examine microplastic absorption by plants. Thus, only one sampling point, representing the highest concentration was required. The sampling focused solely on water from the Citarum River, using a grab sampling method. Samples were collected manually. This approach was chosen because the experimental plant used in the study lives on the water surface, and the research aimed to examine microplastic absorption under those conditions.

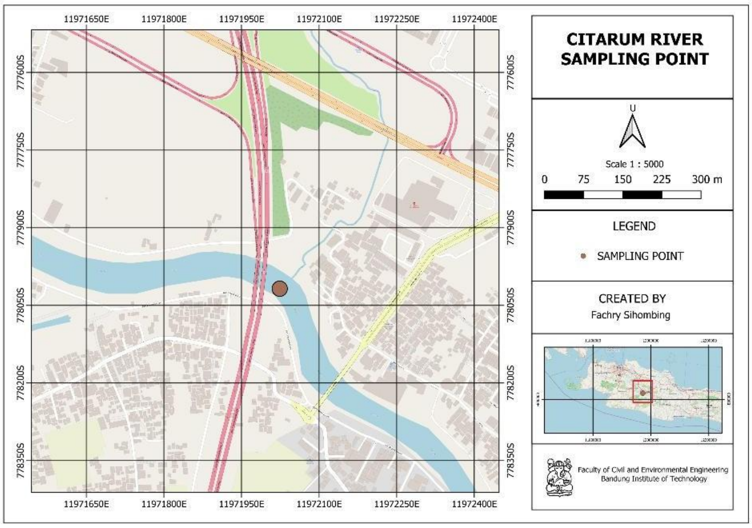


Figure 1. Sampling point at Citarum River

Once collected, the water samples were stored in a cooler box and kept in a refrigerator at the Environmental Health Lab (Lab HI) until the experiment began. During sampling, documentation was conducted, and permission from the local community was obtained to ensure the smooth running of the research.

A total of 200 grams of Lemna minor was ordered online from the marketplace and stored in a bucket containing water with neutral pH and appropriate lighting, without any added nutrients. Before the experiment started, characterization of both the plant and water samples was carried out to determine the initial microplastic levels in the plants and water prior to exposure. This characterization included total microplastic abundance in water and in plant samples with biomass variations of 5 grams, 10 grams, and 15 grams, according to the experimental design. Analysis of the shape, color, and size characteristics of microplastics in both the water and plant samples was also conducted.

The incubation phase began with the preparation of growth media using sterilized 500 mL beakers, each filled with 200 mL of Citarum River water. Lemna minor plants were then introduced into the beakers with three different biomass levels and grouped into five incubation groups based on observation times. Before incubation, plant samples underwent an adaptation test to ensure they could survive in the experimental environment. After an adaptation period of 3 days, the plants will be observed to determine whether they have acclimated, indicated by the plants retaining their green color or showing signs of blackening and yellowing, as well as the presence of dead plant tissue that has sunk to the bottom of the experimental beaker.

Observations were conducted periodically on days 1, 3, 5, and 7, with an additional observation on day 14 to assess long-term effects. The timing of observations was based on previous studies showing chronic effects of microplastic exposure on plants after seven days (Ceschin et al., 2023). Further observation after an additional seven days was used to evaluate plant conditions following prolonged exposure. At the end of each incubation period, laboratory tests were conducted on the plants to analyze the absorbed microplastic abundance, as well as the shape, color, size characteristics, and changes in plant biomass

3. Results and Discussion

3.1 Analysis of Microplastic Abundance in the Citarum River

The study was conducted by analyzing the abundance of microplastics present in the experimental water sample. Based on the identification results, a total of 76 microplastic particles were found in the water sample. The following is the analysis of the characteristics of microplastics found in the Citarum River water, based on their shape, color, and size.

Characteristics of Abundance, Shape, Color, and Size of Microplastics in the Water Sample

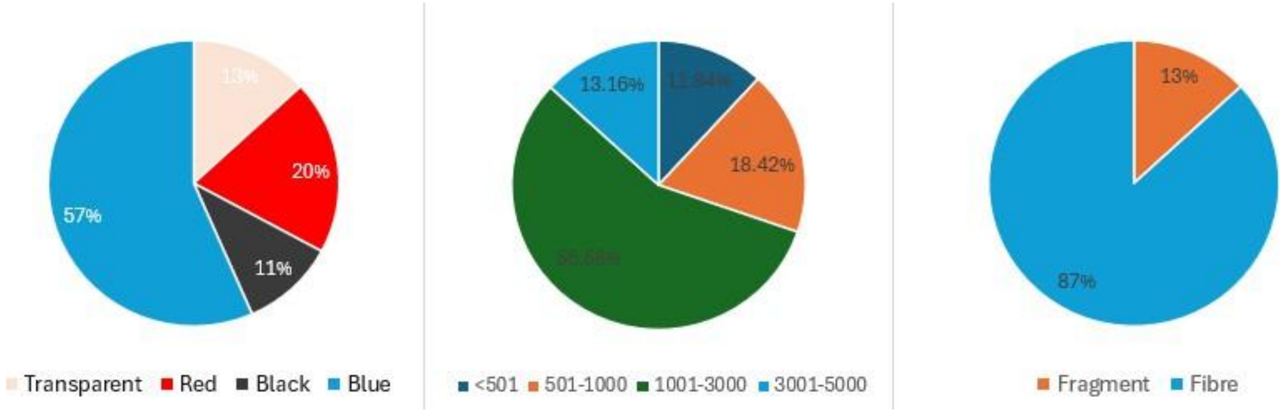


Figure 2. Characteristics (a) Shape, (b) Colour and (c) Microplastics size on water

Based on the analysis results shown in Figures 2, the distribution of microplastics in the water sample is dominated by several categories. In terms of shape, two dominant forms were identified: fibres, which accounted for approximately 87%, and fragments, comprising about 13%. Based on the color, blue microplastics were the most prevalent, making up around 57% of the total. In terms of size, the most commonly identified size range was 1001–3000 µm, representing 56.58% of the total microplastic abundance

Characteristics of Abundance, Shape, Color, and Size of Microplastics in Existing Plants.

The next step of the study involved analyzing the abundance, shape, color, and size of microplastics found in the existing plants. A total of 35 microplastic particles were detected in 5 grams of plants, 43 particles in 10 grams, and 47 particles in 15 grams of plants. The following are the characteristics of microplastics for each plant weight variation.

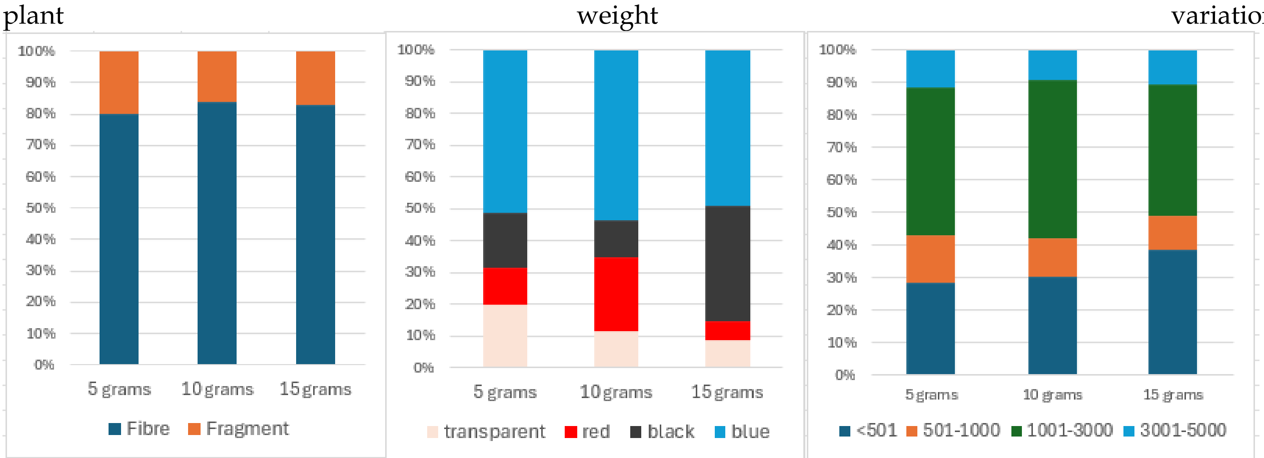


Figure 3. Microplastic (a) Shape, (b) Colour and (c) Size Characteristics Before Exposure

Based on the analysis results shown in Figures 3, the distribution of microplastics in the initial plant samples is dominated by several categories. In terms of shape, two dominant types were identified: fibre, which accounted for approximately 81%, and fragment, at 19%. When viewed by color, blue microplastics were the most dominant, making up about 51% of the total. Although blue microplastics consistently remained the most absorbed type, there was a noticeable shift in the proportions of other colors such as red and black across different plant biomass variations.

Overall, the most absorbed microplastics were, in order: blue, followed by black, red, and transparent. In terms of size, microplastics measuring 1001–3000 µm were the most absorbed, comprising around 54% of the total across all three plant biomasses. This was followed by microplastics measuring <501 µm (20%), 501–1000 µm (15%), and 3001–5000 µm (10%). Although the proportions varied slightly across different biomass levels, the tendency remained that microplastics sized 1001–3000 µm were the most commonly absorbed.

Identification of Growth Rate Plant

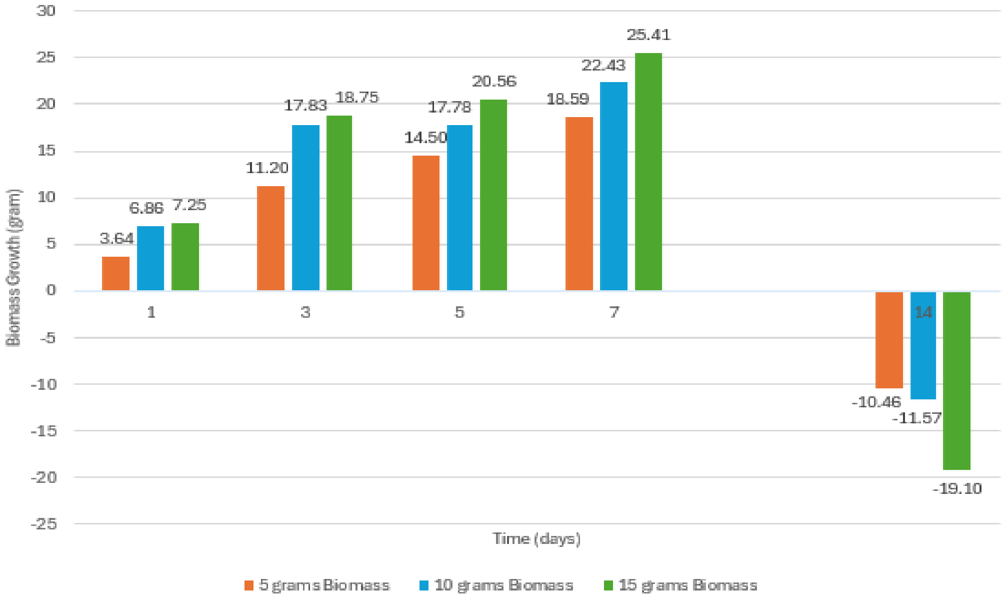


Figure 4. Lemna Biomass Growth (%) by time

In Figure 4, it can be observed that throughout the observation period up to day 7, the Lemna minor plants experienced a significant increase in biomass weight, particularly between day 1 and day 3. Growth appeared to slow down after day 3 and continued to decline until day 14, where the plant population even seemed to decrease. This was indicated by the shedding of several plant parts to the bottom of the incubation medium, forming a black sediment filled with plant tissue remains.

This phenomenon may be caused by the depletion of essential nutrients and the natural life cycle of the plant, which lasts approximately two weeks. The observations showed that the larger the initial biomass incubated, the higher the growth rate during the early phase of incubation. However, larger biomass also tended to experience a more significant reduction in mass by day 14. This decline is suspected to result from increased environmental stress due to higher plant population density within a single medium, leading to nutrient competition among individuals and resulting in physiological stress. This condition likely accelerates plant mortality in treatments with higher initial biomass compared to those with lower initial biomass.

Identification of Microplastic Abundance Absorbed by Plants

The results of the identification of microplastic abundance absorbed by the plants show that plants with higher biomass have a greater accumulation of microplastics, with absorption increasing over time. However, when compared based on absorption efficiency per unit of biomass, plants with a biomass of 5 grams tend to capture the most microplastics, with an average of up to 10 microplastics per gram of biomass. The absorption rate remains relatively stagnant by day 7 and then declines sharply by day 14. The microplastic absorption by Lemna plants is illustrated in Figure 5 and 6 below.

https://doi.org/10.5614/j.tl.2026.32.1.4

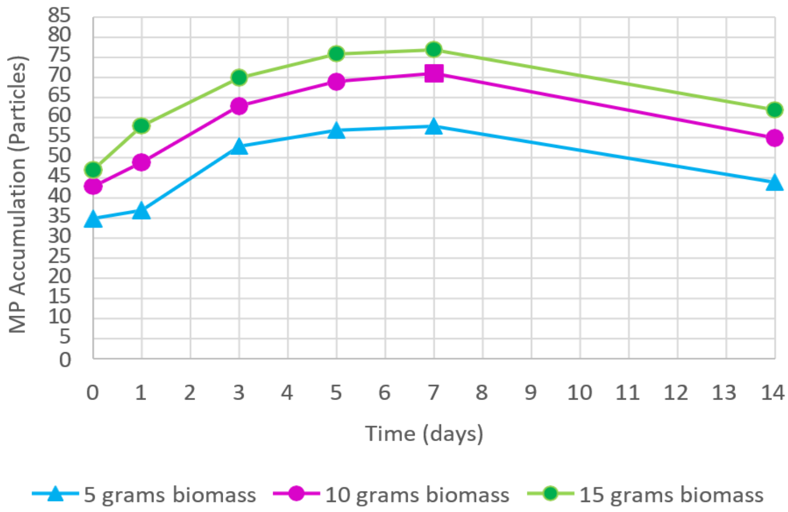


Figure 5. Microplastic Accumulation Based on Biomass

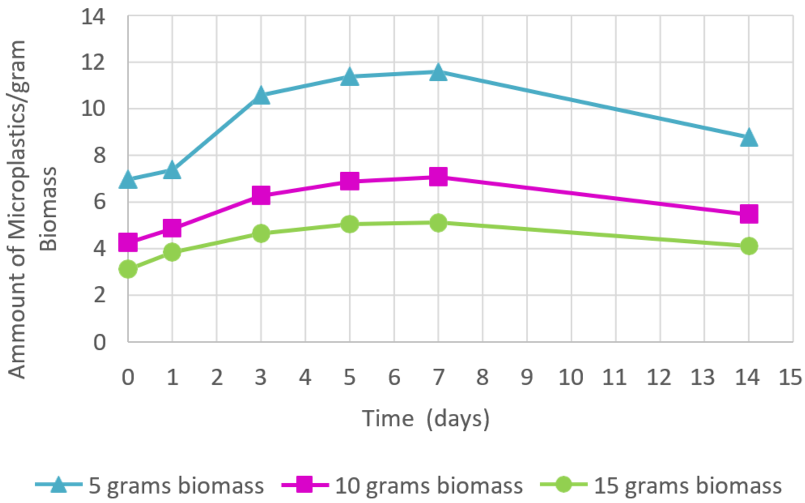


Figure 6. Number of Particles Absorbed per Gram of Plant Biomass

The accumulation of microplastic absorption by the plants showed a significant increase from day one to day three, then slowed until day seven. Day seven was identified as the optimal absorption point, followed by a decline on day fourteen. This decrease is suspected to be due to the plant reaching saturation in absorbing microplastics or as a result of environmental stress and biomass reduction. Microplastic accumulation was also found on day zero, originating from microplastics already absorbed before the experiment. Overall, the total accumulation of microplastics increased over time and biomass until reaching a certain limit.

However, the identification results show that plants with a biomass of 5 grams exhibit higher microplastic absorption efficiency, averaging 10 microplastic particles per gram of biomass over a 14-day incubation period, as shown in Figure 6. This finding indicates that a smaller amount of plant biomass may be more effective in absorbing microplastics. Nonetheless, the exact optimal biomass quantity for microplastic absorption per liter of water in this experiment cannot yet be definitively determined and requires further research.

Microplastics Removal Rate on Plants (%)

The results show that the larger the plant biomass, the higher the total accumulation of microplastics. However, when compared per gram of biomass, the smallest biomass actually has a higher removal rate per gram. A significant increase occurred on the third day, with removal percentages reaching around 20–25%. By the fifth day, the increase slowed down to about 5–8% compared to the previous day. On the seventh day, the increase was even smaller, around 1–3%, indicating that the plants were nearing saturation in absorbing microplastics.

On the fourteenth day, the removal percentage decreased quite drastically compared to the seventh day, although microplastic removal was still recorded at 11–19.74%. This decline is likely caused by several factors, such as saturation of absorption, re-release of microplastics back into the environment, or attachment of microplastics to new or aging plant tissue.

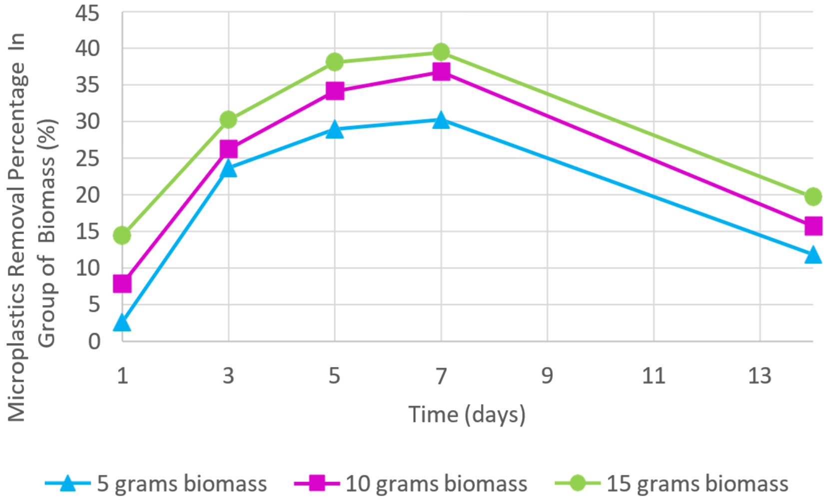
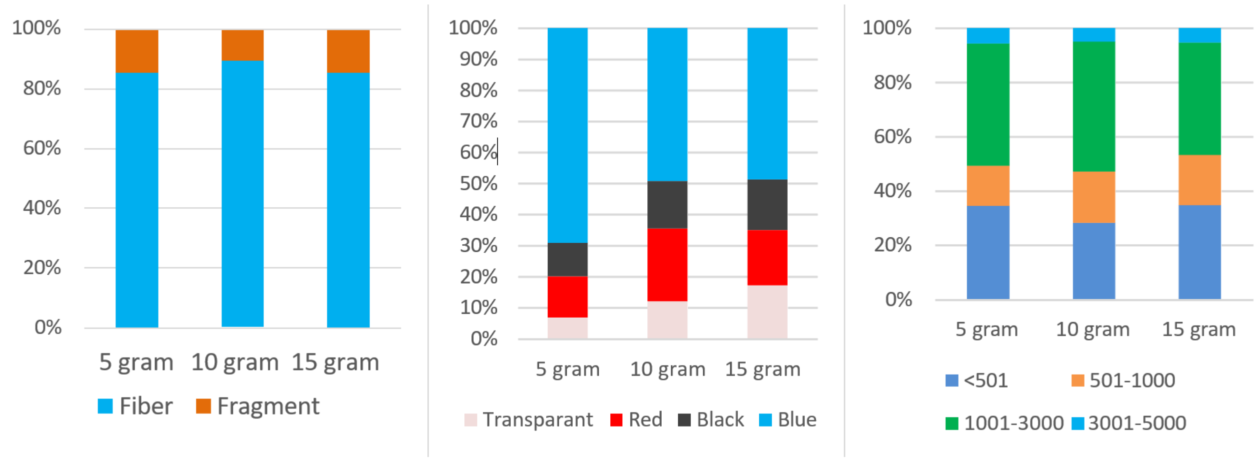


Figure 7. Microplastic Removal Percentage by Plant per Gram of Biomass.

Distribution of the Abundance by Shape, Color, and Size of Absorbed Microplastics

After incubation, an analysis was conducted on the shape, color, and size of the absorbed microplastics. The following are the identification results of the characteristics of microplastics absorbed for each variation of plant biomass.



(a) (b) (c)

Figure 8. Distribution of Microplastic (a) Shapes, (b) Colors, (c)z Sizes Absorbed by the Plants

It can be seen in Figure 8, that fiber and fragment shapes dominate, with approximately 87% fibers and 13% fragments. Based on the analysis, the abundance of fibers in the plants is 213 particles for plants with 5 grams biomass, 274 particles for 10 grams, and 292 particles for 15 grams. Thus, the total abundance of fibers from the accumulated microplastics is 779 particles.

It is also observed that blue particles dominate the color distribution of absorbed particles, accounting for 54.5% of the total identified particles, followed by red particles at 18.5%, black particles at 14.5%, and transparent particles at 12.6%. Based on the analysis, there are 490 blue microplastic particles, 130 black particles, 166 red particles, and 113 transparent particles out of a total of 899 microplastics. Regarding size, the microplastics are mostly dominated by the size range of 1001–3000 µm, while the least abundant size is 3001– 5000 µm. The abundance is 44.61% for the 1001–3000 µm size range and the smallest is 5.23% for the 3001–5000 µm size range.

Result Comparison

A. Microplastics Shape Based Comparison

After the microplastic accumulation analysis was conducted, a comparison of microplastic accumulation will be carried out to determine the absorption rate by the plant. Figure 10 below presents the results of the microplastic absorption analysis based on particle shape.

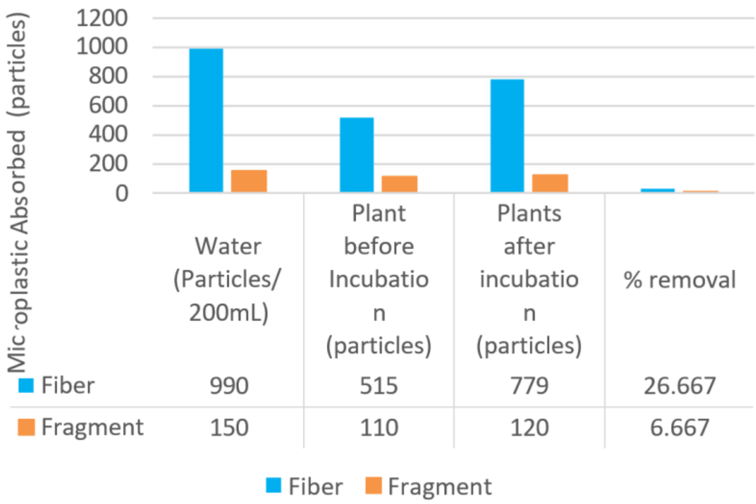


Figure 9. Comparison Between Water, Plants Before Exposure, and Plants After Exposure

Based on the comparison of removal efficiency between water, plants before exposure, and plants after exposure, the removal rate of fibre-type microplastics was 26.7%, representing an increase of 51% compared to the pre-exposure plant condition. In contrast, fragment-type microplastics had a removal rate of 6.7%, with a total accumulation increase of 9% from the pre-exposure condition. These findings indicate that Lemna minor tends to absorb microplastics in the form that is most abundant in the aquatic environment. The dominance of fibre-shaped particles in the plant tissues aligns with the high abundance of this form in both the water medium and the existing plants prior to exposure.

This result also suggests that the distribution of microplastic shapes in the environment is one of the key factors influencing microplastic accumulation in plants. These findings indicate that Lemna minor tends to absorb microplastics in the form that is most abundant in the aquatic environment. The dominance of fibre-shaped particles in the plant tissues aligns with the high abundance of this form in both the water medium and the existing plants prior to exposure. This result also suggests that the distribution of microplastic shapes in the environment is one of the key factors influencing microplastic accumulation in plants.

B. Microplastics Color Based Comparison

Based on the comparison between microplastic accumulation in water and in plants before exposure with that in plants after treatment (Figure 10), the data show that the removal rate of microplastics by Lemna minor varies depending on particle color. Red particles exhibited the highest removal rate at 36%, followed by blue particles at 26%, transparent particles at 22%, and black particles at -8%.

These findings indicate a tendency of the plant to absorb specific types of microplastics, with red-colored particles being the most absorbed. The dominance of blue particles in the plant tissues suggests that particles of this color have a strong tendency to adhere to or accumulate on the plant surface.

However, upon further analysis, red microplastics exhibit a higher absorption rate by the plant compared to other colors. Additionally, the negative result observed for black particles suggests that this type of microplastic is difficult for the plant to absorb and may be released back into the environment. This also indicates that the plant has varying absorption capabilities for different types of particles. Moreover, in addition to shape and size, the color of microplastics is an important factor influencing the absorption and accumulation mechanisms in aquatic plants.

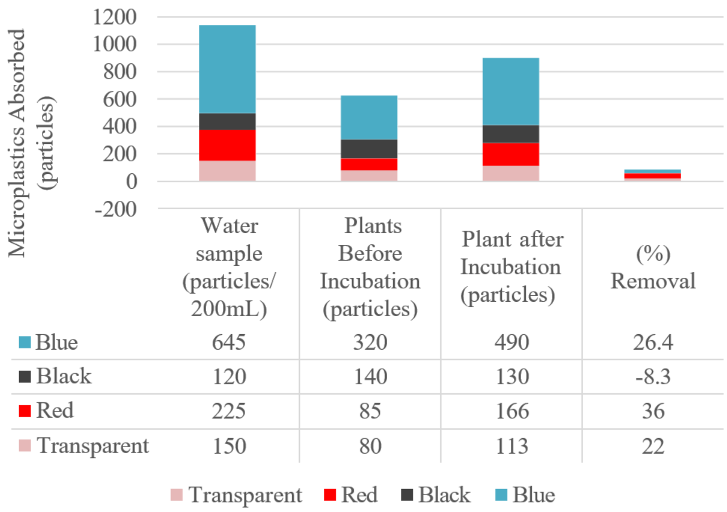


Figure 10. Comparison Between Water, Plants Before Exposure, and Plants After Exposure

C. Microplastics Size Based Comparison

Based on the comparison between microplastic accumulation in water and in plants before exposure with that in plants after treatment (Figure 11), the data show that the removal rate of microplastics by Lemna minor varies significantly depending on particle size. The analysis revealed that microplastics smaller than 501 µm had the highest removal rate from the water, accounting for 64% of the initial total accumulation. This was followed by particles sized 501–1000 µm with a removal rate of 40%, particles sized 1001–3000 µm at 18%, and the largest particles, sized 3001–5000 µm, with the lowest removal rate at -12%.

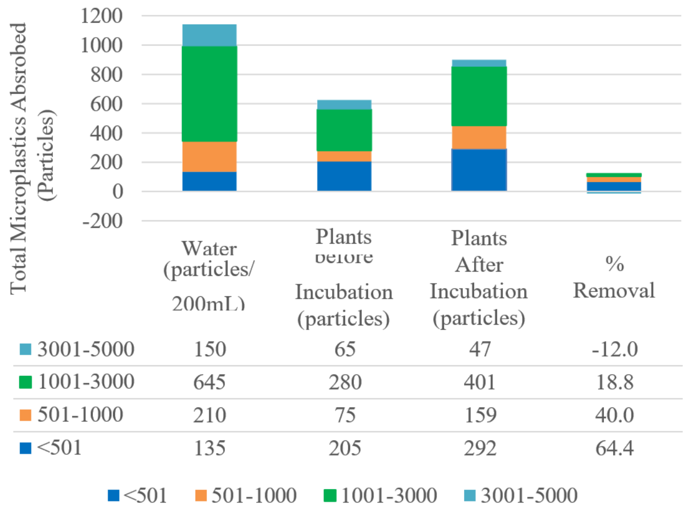


Figure 11. Comparison Between Water, Plants Before Exposure, and Plants After Exposure

In this finding, a negative result of -12% was observed for microplastics sized 3001– 5000 µm. This is suspected to be due to the limited mobility and relatively smaller surface area of larger particles (>3000 µm), which reduces their ability to be effectively trapped or accumulated on the surface of Lemna minor. These results indicate a higher tendency for the plant to absorb smaller microplastic particles, as the removal percentage appears to increase inversely with particle size. Overall, these findings also conclude that particle size is an important factor in the microplastic absorption process by the plant.

4. Conclusion

Based on the stages of analysis conducted, it can be concluded that Lemna minor has potential as a microplastic-absorbing agent. The study shows that Lemna minor can absorb approximately 5% of microplastics per gram for a 5-gram biomass over a 7-day period. This finding indicates that there is an optimal biomass-to-volume ratio for more effective microplastic absorption. Furthermore, the research also reveals that Lemna minor is capable of absorbing specific characteristics of microplastics, suggesting the need for further studies and treatment modifications to enhance its microplastic absorption efficiency.

The accumulation of microplastics in this plant reached 77 particles for a 15-gram biomass after 7 days. The absorbed microplastic accumulation showed a significant upward trend from day one to day three, peaking on day seven. These results suggest that there is an optimal time frame for the plant to absorb microplastics, which may be influenced by saturation limits or a decrease in absorption capacity due to environmental stress.

In terms of the characteristics of absorbed microplastics, the identification results show that the plant accumulates microplastics in line with their distribution in the environment. However, when considering the absorption rate, the plant exhibits varying levels depending on microplastic characteristics. In terms of shape, Lemna minor can absorb up to 26.7% of fibre-type microplastics, with a 51% increase compared to the pre-exposure condition. This indicates the plant's ability to absorb microplastics that are more dominantly distributed in water.

From the color, the plant demonstrated the highest removal rate for red microplastics, at 36%, while it actually released black microplastics back into the environment by 8%. This suggests that the plant has a greater capacity to accumulate red microplastics, which often originate from food packaging, plastic toys, or household products, while it is less effective at absorbing black microplastics, commonly associated with vehicles, tires, or electronic devices. Thus, the results indicate a limitation in the plant's microplastic absorption ability that warrants further investigation.

In terms of particle size, the analysis revealed that smaller microplastics had higher absorption rates, with particles under 501 µm being absorbed up to 64% of their initial accumulation. The absorption rate decreased progressively with increasing particle size. This demonstrates that smaller microplastics are more easily absorbed by the plant compared to larger ones. In fact, the analysis showed that the largest size range of microplastics tended to be released back into the environment. These results lead to the conclusion that Lemna minor has a specific size range capacity for microplastic absorption the smaller the microplastics, the more effectively they are absorbed. To optimize the microplastic absorption efficiency of Lemna minor in phytoremediation applications, specific conditions are highly recommended. Ensure the availability of essential nutrients in the aquatic medium to support the healthy growth and vitality of Lemna minor for optimal pollutant absorption. By focusing on appropriate biomass placement, sufficient contact duration, and understanding the types of microplastics that are most effectively absorbed (small size, fibre shape, red color), phytoremediation strategies using Lemna minor can be significantly enhanced.

Reference

Ceschin, S., Mariani, F., Di Lernia, D., Venditti, I., Pelella, E., & Iannelli, M. A. (2023). Effects of Microplastic Contamination on the Aquatic Plant Lemna minuta (Least Duckweed). *Plants*, *12*(1), 207. https://doi.org/10.3390/plants12010207

Priya, A., Avishek, K., & Pathak, G. (2012). Assessing the potentials of Lemna minor in the treatment of domestic wastewater at pilot scale. *Environmental Monitoring and Assessment*, *184*(7), 4301–4307. https://doi.org/10.1007/s10661-011-2265-6

Indonesian Ministry of Environment and Forestry (KLHK). (2024). Study of microplastic content in the Citarum River (water, sediment, and fish).

Tang, K. H. D. (2023). Phytoremediation of Microplastics: A Perspective on Its Practicality. *Industrial and Domestic Waste Management*, *3*(2), 90–102. https://doi.org/10.53623/idwm.v3i2.291

Tanković, M. S., Perusco, V. S., Godrijan, J., Pfannkuchen, D. M., & Pfannkuchen, M. (2015). Marine plastic debris in the north-eastern Adriatic . In A. Kržan & P. Horvat (Eds.), *Proceedings of the MICRO2015 Seminar on microplastics issues, Book of Abstracts* (p. 26).

Yin, J., Zhu, T., Li, X., Wang, F., & Xu, G. (2025). Phytoremediation of microplastics by water hyacinth. *Environmental Science and Ecotechnology*, *24*, 100540. https://doi.org/10.1016/j.ese.2025.100540

Ziegler, P., Adelmann, K., Zimmer, S., Schmidt, C., & Appenroth, K. -J. (2015). Relative in vitro growth rates of duckweeds (Lemnaceae) – the most rapidly growing higher plants. *Plant Biology*, *17*(s1), 33–41. https://doi.org/10.1111/plb.12184