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Characteristics of microplastics in the surface water of Lake Singkarak and their relationship with microplastics in bilih fish (*Mystacoleucus padangensis*)

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ABSTRACT

Microplastic pollution in freshwater ecosystems has become a pressing global environmental health issue, given potential to accumulate in aquatic food chain and pose health risks to aquatic organisms and to humans who consume fishery products. Microplastics are among the most commonly found pollutants in freshwater and have the potential to affect aquatic organisms. Lake Singkarak is potentially exposed to microplastic pollution from various surrounding anthropogenic activities. This study aimed to analyze the abundance and characteristics of microplastics in surface water and to compare them with the characteristics of microplastics in bilih fish based on secondary data. Water samples were collected in triplicate from three locations representing a river inlet, a residential area, and a tourism area. Samples were analyzed using chemical extraction and visual identification under a microscope. The parameters observed included the number and shape of microplastics. Microplastics were detected at all sampling locations, with abundance ranging from 9.33±1.15 to 11.67±4.51 particles/L. The microplastics found were dominated by fiber and fragment shapes, with fiber being the most dominant. The highest abundance was found at the river inlet and tourism area locations. Comparison with microplastic data on bilih fish showed consistent characteristics, particularly the dominance of the fiber shape. This indicates a potential link between the presence of microplastics in the water and exposure in aquatic biota. Thus, Lake Singkarak functions as a medium for the transport and accumulation of microplastics, highlighting the need for improved plastic waste management to reduce potential pollution and its impact on the aquatic ecosystem.

Keywords: *Microplastics, Surface Water, Lake Singkarak, Bilih Fish*

1. Introduction

Plastic pollution, particularly microplastics, has become an environmental health issue receiving serious global attention because of its potential impact not only on aquatic ecosystems but also on human health. Microplastic particles that pollute water bodies can enter the food chain through aquatic organisms such as fish, and subsequently move to humans through the consumption of fishery products (trophic transfer), potentially causing various health problems such as oxidative stress, endocrine disruption, and the accumulation of toxic compounds in the body (Rashid et al., 2026). Given that fish are one of the main sources of animal protein for the community, including in the Lake Singkarak area, this issue of microplastic pollution is of critical importance to study in depth in order to protect public health and the sustainability of local fishery resources.

According to data from the National Waste Management Information System (SIPSN), plastic waste generation in Indonesia reaches tens of millions of tons per year, with plastic waste comprising nearly 20% of total national waste generation. In 2023, approximately 10.8 million tons of plastic waste were recorded across Indonesia. Most of this waste has not been properly managed and has the potential to become a source of pollution, particularly in aquatic ecosystems such as rivers and lakes (Dzihninafira et al., 2023). The National Oceanic and Atmospheric Administration (NOAA) defines microplastics as plastic particles smaller than 5 mm in size, which are widely recognized as one of the most concerning pollutants in aquatic ecosystems due to their widespread distribution, persistence, and potential ecological impacts (Du et al., 2021; Elizalde-Velázquez & Gómez-Oliván, 2021). Microplastics originate from primary sources, such as particles directly manufactured in small sizes, as well as secondary sources formed from the fragmentation of larger plastic items, which are then distributed in the aquatic environment through river flow and hydrodynamic processes connecting terrestrial, riverine, and lake ecosystems (Rashid et al., 2026). Microplastic pollution has become part of a broader global environmental issue that is receiving increasing attention because of its persistence and its potential impact on aquatic ecosystems and organisms. In Indonesia, Lake Singkarak in West Sumatra is one of the important water resources potentially exposed to microplastic pollution from various surrounding anthropogenic activities, such as agriculture, fisheries, and tourism (Ad'hani et al., 2024). A previous study reported the presence of microplastics in bilih fish *(Mystacoleucus padangensis)*, one of Lake Singkarak's endemic fish species with high ecological and economic value. That study found microplastics in the organs of bilih fish, dominated by fiber and fragment shapes, indicating exposure to microplastics from the surrounding aquatic environment (Ad'hani et al., 2024). Microplastics are a group of persistent pollutants that are difficult to degrade and widely distributed, making them a global concern, since their presence can adversely affect various organisms and contaminate diverse ecosystems, ranging from freshwater and marine environments to terrestrial areas and remote regions such as the Arctic. Their identification and characterization across various environmental matrices are therefore important for obtaining reliable data on their toxicity levels (Ali et al., 2024).

Although the presence of microplastics in bilih fish has been confirmed, information on the characteristics of microplastics in the water as part of the lake ecosystem where the fish live remains limited (Ad'hani et al., 2024). Yet water is the primary medium responsible for distributing microplastics to aquatic organisms. Analyzing microplastics in water to understand the potential link between microplastics in the aquatic environment and those found in organisms is considered important, particularly in lake areas with a high intensity of human activity (Chen et al., 2024). Therefore, this study aimed to analyze the characteristics of microplastics, including type, size, and concentration, in the surface water of Lake Singkarak across several human activity zones, such as river inlet areas, residential settlements, and tourist destinations, as well as to explore their relationship with the microplastic content in bilih fish (Benson et al., 2022). This approach is expected to provide preliminary insight into the relationship between microplastic exposure in lake water and the presence of microplastics in aquatic organisms in Lake Singkarak, as well as mitigation recommendations for the conservation of Lake Singkarak (Dong et al., 2025).

2. Research Methods

This study is a descriptive-analytical study with an observational approach aimed at identifying and describing the characteristics of microplastics in the surface water of Lake Singkarak. Primary data were obtained through water sampling and laboratory analysis, while secondary data on the characteristics of microplastics in bilih fish (*Mystacoleucus padangensis*) from a previous study were used as comparative data.

The study was conducted at Lake Singkarak, specifically in the Jorong Mutiara area, Nagari Batu Taba, South Batipuh District, Tanah Datar Regency. Sampling locations were selected based on the potential input of plastic waste from anthropogenic activities, namely the river inlet, residential, and tourism areas (Deswati et al., 2025). Sample preparation was carried out at the Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang (UNP), while microplastic identification using a microscope was carried out at the LLDIKTI Region X Laboratory, Padang. The study population was the surface water of Lake Singkarak. Surface water samples were taken from three locations representing the river inlet, residential, and tourism areas, hereafter coded as S1 (River Inlet), S2 (Residential Area), and S3 (Tourism Area), respectively; these codes are used consistently throughout the tables and figures in this article. Sampling was carried out at a depth of 0–10 cm using a *plankton net* towed from a bilih fish platform (bagan) over a distance of ±1 km toward the lake shore. At each location, 1 L samples were taken with three replicates (triplicate).

The instruments used included a *plankton net*, sieve, glass storage bottles, a camera, a beaker, an analytical balance, a 1 L volumetric flask, a measuring pipette, a *hot plate*, *magnetic stirrer*, a measuring cylinder, a stirring rod, 250 mL and 500 mL Erlenmeyer flasks, a Buchner funnel, a vacuum pump, a spatula, and an

Optika B-350 microscope. The materials used included surface water samples from Lake Singkarak, 30% H_2O_2 solution, 0.05 M $FeSO_4 \cdot 7H_2O$, 30% NaCl solution, Whatman No. 42 filter paper, and other supporting materials.

Surface water samples were collected using a direct filtration method to isolate microplastic particles from the water samples. The filtered water was separated from macro-debris using a 50 mm sieve, then stored in glass bottles and taken to the laboratory for further analysis. Microplastic extraction was carried out using a method adapted from the NOAA protocol (Nousheen et al., 2022). A total of 1 L of the water sample was placed into a beaker, then 10 mL of 30% H_2O_2 was added and stirred for 5 minutes. Next, 10 mL of 0.05 M $FeSO_4 \cdot 7H_2O$ was added and stirred for 30 minutes, followed by the addition of 10 mL of 30% NaCl, which was stirred again for 30 minutes. The entire process was carried out using a *magnetic stirrer* at a temperature of ±70°C and a speed of 180 rpm. The mixture was then filtered using Whatman No. 42 filter paper with the aid of a vacuum pump.

Microplastic identification was carried out visually on the residue on the filter paper using an Optika B-350 microscope at 100× magnification. The parameters observed included particle shape, color, and number. Image documentation was carried out using MoticPlus software to support the morphological analysis of microplastics.

Microplastic data on bilih fish (*Mystacoleucus padangensis*) were obtained from a previous study (Ad'hani et al., 2024). The data included the characteristics of microplastics based on particle shape and number from 16 fish sampling points in Lake Singkarak. This data was used for comparison without re-analyzing the fish samples. Data analysis was carried out descriptively by comparing the characteristics of microplastics in surface water with the microplastic data on bilih fish. The comparison was carried out qualitatively and using simple quantitative methods to identify the consistency of microplastic shape and number between the two media, thereby providing insight into the potential link between microplastic pollution in the water and exposure in aquatic organisms.

3. Results

3.1 Number of Microplastics in Surface Water

The number of microplastics identified in the surface water samples of Lake Singkarak is presented in Table 1.

Table 1. Abundance of microplastics in the surface water of Lake Singkarak

Sampling Location	Location Characteristics	Microplastic Abundance* (Particles/L)
S1 (River Inlet)	Area near the river inlet	11.67 ± 4.51
S2 (Residential Area)	Domestic activity area	9.33 ± 1.15
S3 (Tourism Area)	Tourism activity area	11.67 ± 2.52

Note (*): Microplastic abundance values are expressed as mean ± standard deviation (mean ± SD) from three sampling replicates (triplicate), each with a volume of 1 L.

The abundance of microplastics in the surface water of Lake Singkarak varied across sampling locations. The highest abundance was found at the river inlet and tourism area locations, at 11.67 ± 4.51 particles/L and 11.67 ± 2.52 particles/L, respectively, while the residential area showed a lower abundance of 9.33 ± 1.15 particles/L.

3.2 Characteristics of Microplastic Shapes

Based on visual identification using an Optika B-350 microscope at 100× magnification, the microplastics found in the surface water of Lake Singkarak were classified into several shapes, namely fiber and fragment (Figure 1).

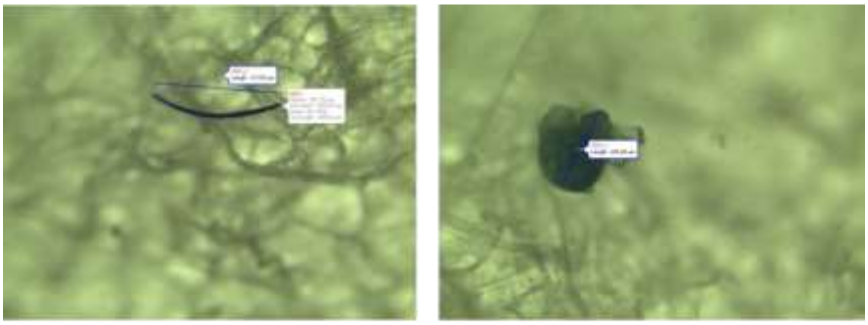

Figure 1. Microplastic shapes in the surface water of Lake Singkarak (a. fiber and b. fragment)

The microplastic shapes visually identified in Figure 1 were subsequently quantified and are presented in detail in Table 2 to show the abundance of microplastics by shape at each sampling location.

Table 2. Characteristics of microplastic shapes in the surface water of Lake Singkarak

Sampling Location	Fiber (particles/L)	Fragment (particles/L)	Total (particles/L)
S1 (River Inlet)	6.67 ± 3.06	5.00 ± 1.73	11.67 ± 4.51
S2 (Residential Area)	6.67 ± 3.21	2.67 ± 2.08	9.33 ± 1.15
S3 (Tourism Area)	8.33 ± 1.53	3.33 ± 1.15	11.67 ± 2.52

Note (*): Values presented are the mean ± standard deviation from three sampling replicates (triplicate).

Table 2 presents the number of microplastics by shape (fiber and fragment) at each sampling location, obtained from three sampling replicates. This data was then visualized in Figure 2 to clarify the comparison of the dominance of microplastic shapes across sampling locations. Presenting the data as a graph makes it easier to observe the distribution pattern of microplastics and the difference in numbers between fiber and fragment at each location.

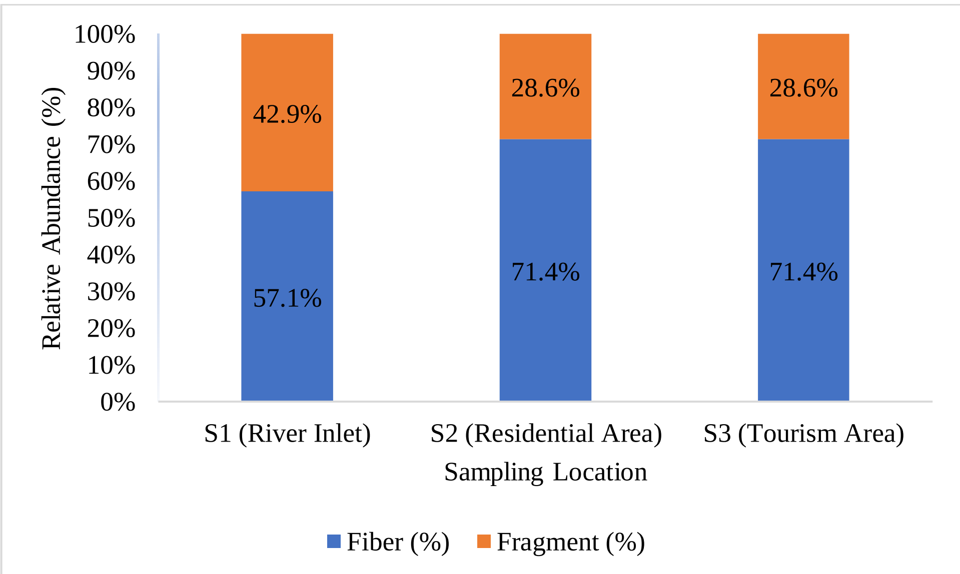

Figure 2. Relative abundance (%) of fiber and fragment microplastics at each sampling location. Data labels indicate the percentage contribution of each microplastic shape to the total microplastics collected at each site.

Based on the analysis, fiber was the dominant microplastic shape at all sampling locations, accounting for a greater proportion than fragments. The tourism area (S3) contained the highest number of fiber-shaped microplastics (25 particles/L), followed by the river inlet (S1) and residential area (S2), with 20 particles/L each. In contrast, fragment-shaped microplastics were less abundant at all sites, with the highest count observed at the river inlet (15 particles/L), followed by the tourism area (10 particles/L) and residential area (8 particles/L). In terms of relative abundance, fibers accounted for 57.1% of the total microplastics at the river inlet (S1), 71.4% at the residential area (S2), and 71.4% at the tourism area (S3), whereas fragments comprised 42.9 %, 28.6%, and 28.6%, respectively. These findings quantitatively confirm the predominance of fiber-shaped microplastics across all sampling locations.

3.3 Comparison of Microplastic Characteristics in Water and Bilih Fish

Table 3 presents a comparison of the characteristics of microplastics found in the surface water of Lake Singkarak with microplastics in bilih fish *(Mystacoleucus padangensis)* based on the results of a previous study. This comparison focused on the similarity of microplastic shape and dominance patterns to provide a preliminary picture of the relationship between microplastics in the aquatic environment and biota.

Tabel 3. Comparison of microplastic characteristics in surface water and bilih fish in Lake Singkarak

Parameter	Surface Water of Lake Singkarak (This study)	Bilih Fish (Previous study (Ad'hani et.al., 2024)
Location	Lake Singkarak (3 points: inlet, residential, tourism)	Lake Singkarak (16 points)
Media	Surface water	Aquatic organism (Fish digestive and respiratory tract)
Presence of Microplastics	Detected at all locations	Detected in the fish digestive and respiratory tract
Dominant Shape	Fiber	Fiber
Minor Shape	Fragment	Fragment

4. Discussion

4.1 Characteristics of Microplastics in the Surface Water of Lake Singkarak

The results showed that microplastics were detected at all surface water sampling points in Lake Singkarak. The microplastic particles found were dominated by fiber and fragment shapes. This finding is consistent with a previous study reporting that all sampling points in Lake Singkarak tested positive for microplastics, with fiber and fragment as the main shapes, although the quantities varied across locations (Ad'hani et al., 2024).

The dominance of fiber and fragment-shaped microplastics indicates a significant contribution from anthropogenic activities around the lake. Fiber shapes generally originate from domestic waste, such as textile fibers from clothes-washing activities, as well as from fishing equipment, while fragments result from the degradation of larger plastic items exposed to physical, chemical, and biological factors in the aquatic environment. Poorly managed plastic waste on land has the potential to be carried by surface runoff into the lake's water body (Rohaningsih et al., 2022).

The presence of microplastics in surface water indicates that the water column of Lake Singkarak functions as a medium for the transport and distribution of microplastics. This condition is particularly evident in areas adjacent to the river inlet, residential areas, and tourism areas, which are locations with relatively high intensity of human activity. This is consistent with findings stating that freshwater bodies receiving input from their catchment areas are prone to microplastic accumulation due to inflows from various land-based sources (Henny et al., 2022).

Based on Table 1, the highest microplastic abundance was found at the river inlet and tourism area locations, while the residential area showed relatively lower abundance. The high abundance of microplastics at the river inlet indicates that plastic waste from land carried by river flow is a major contributor to microplastic pollution in Lake Singkarak. In addition, intensive tourism activity also has the potential to increase microplastic input due to the high use of single-use plastic products and suboptimal waste management.

Lake Singkarak has a relatively long water retention time, giving it the potential to function as a long-term accumulator of microplastics. This condition can increase the risk of microplastic exposure to aquatic organisms, including endemic fish in the lake. Previous studies have shown that lakes with similar characteristics are prone to significant microplastic accumulation and may pose an ecological threat to aquatic biota (Henny et al., 2022).

In addition, the dominance of fiber-shaped microplastics in this study reinforces the indication of domestic waste input from the population around the lake. Human activities such as textile production, clothes washing, and the use of synthetic equipment are known to contribute to the release of microplastic fibers into the aquatic environment. A single wash of synthetic clothing has been reported to release up to thousands of microplastic fibers, which then flow through drainage systems and rivers before eventually accumulating in the lake's waters (Yuranda et al., 2024).

4.2 Comparison of Microplastic Characteristics in Water and Bilih Fish

A comparison of microplastic characteristics between surface water and bilih fish in Lake Singkarak is presented in Table 3. The table shows that the dominant microplastic shapes in surface water, namely fiber and fragment, are consistent with the microplastic shapes reported in bilih fish in a previous study (Ad'hani et al., 2024).

This similarity in microplastic shape characteristics indicates that microplastics present in the water column potentially serve as a source of exposure for bilih fish. Although the present study used only three surface water sampling locations (S1, S2, and S3), compared with the sixteen sampling locations used to characterize microplastics in bilih fish (Ad'hani et al., 2024)**,** the selected water sampling sites were intentionally chosen to represent the major anthropogenic settings around Lake Singkarak, namely the river inlet, residential area, and tourism area. These three locations encompass the principal pathways of microplastic input into the lake and therefore provide representative environmental conditions for evaluating microplastic characteristics. Moreover, the comparison presented in this study is intended to qualitatively assess the consistency of microplastic shape composition between surface water and bilih fish rather than to establish a statistically paired comparison or a causal relationship. Therefore, the difference in the number of sampling locations does not invalidate the observed similarity in the dominant microplastic shapes between the two studies.

The main material of microfiber microplastics is textile, which can enter water through wastewater, surface runoff, and atmospheric deposition. The fibers that make up fabric can easily break down into microplastics during washing or even during normal use, and ultimately enter the environment (Xiong et al., 2022), while fragments result from the degradation of larger plastic items accumulated in the aquatic environment. This is consistent with bilih fish tissue, where fiber similarly dominated, with an average abundance of 67.38% compared to 32.62% for fragment across the digestive and respiratory tracts (Ad'hani et al., 2024).

Although the datasets were collected independently and therefore cannot be used to infer a direct cause-and-effect relationship, the consistent predominance of fiber-shaped microplastics in both surface water and bilih fish supports the hypothesis that surface water represents an important exposure pathway for microplastic uptake by bilih fish. However, this comparison is not intended to demonstrate a cause-and-effect relationship, given that the microplastic data on fish were obtained from a secondary source and were not analyzed concurrently with the water samples in this study. This similarity in microplastic shape characteristics indicates that microplastics present in the water column potentially serve as a source of exposure for bilih fish. Fiber-shaped microplastics generally originate from domestic activities such as textile washing, while fragments result from the degradation of larger plastic items accumulated in the aquatic environment.

It is acknowledged that the three water sampling points (S1, S2, and S3) used in this study are fewer than the sixteen sampling points used to characterize microplastics in bilih fish. (Ad'hani et al., 2024). However, the three points in this study were deliberately selected to represent the main categories of anthropogenic pressure around the lake (river inlet, residential, and tourism activity), which together encompass the range of human activity zones covered by the sixteen fish sampling points reported in the previous study. Because this comparison is intended only to provide an indicative, qualitative picture of the consistency of microplastic shape composition between water and fish, rather than a statistically paired site-by-site comparison, the difference in the number of sampling points does not undermine the validity of the comparison. Nonetheless, future studies with a denser water sampling grid matching the fish sampling points would allow a more rigorous, quantitatively paired assessment of the relationship between microplastics in water and in bilih fish.

4.3 Implications of Microplastics in Water for Exposure in Bilih Fish

The presence of microplastics in surface water, particularly the predominance of fiber and fragment shapes, increases the likelihood that these particles are ingested by bilih fish through feeding and respiratory activities. As a pelagic species that inhabits the water column throughout its life cycle, bilih fish (*Mystacoleucus padangensis*) are continuously exposed to microplastics suspended in the aquatic environment. Although this study did not directly analyze microplastics in fish, the consistency of microplastic characteristics observed in surface water and those previously reported in bilih fish suggests that the water column may represent an important exposure pathway for this species. Because bilih fish is an endemic species of Lake Singkarak and is widely consumed by local communities, the occurrence of microplastics in its tissues may also raise concerns regarding potential human exposure through fish consumption. Although the health effects of dietary microplastic exposure are still being investigated, microplastics may act as carriers of chemical contaminants and other toxic substances, highlighting the importance of continued monitoring and further risk assessment. These findings further emphasize the need to control microplastic pollution sources in the Lake Singkarak catchment to protect both aquatic ecosystems and public health (Ad'hani et al., 2024; Yuranda et al., 2024).

Physiologically, microplastic exposure in fish can cause various health effects, including physical damage to the gills and digestive tract due to obstruction or mechanical irritation, oxidative stress due to an imbalance between reactive oxygen species (ROS) production and the antioxidant defense system, as well as chemical toxicity arising from pollutants such as heavy metals and persistent organic compounds adsorbed onto the surface of microplastic particles, which can be released after ingestion (Banaee et al., 2025). These impacts can ultimately disrupt the respiratory, metabolic, and growth functions of bilih fish. Given that bilih fish are an economically valuable food commodity and an important source of animal protein for communities around Lake Singkarak, the presence of microplastics in this fish also poses a risk of *trophic transfer*, namely the transfer of microplastics along with their associated pollutants from fish to humans through consumption (Habumugisha et al., 2024). Human exposure to microplastics through this fish consumption pathway has the potential to cause health problems such as oxidative stress, endocrine disruption, and other long-term toxic effects (Köktürk et al., 2024). Therefore, the findings on the presence of microplastics in water and bilih fish in Lake Singkarak are not only relevant to the health of the aquatic ecosystem but also carry important implications for the food safety and health of communities who consume bilih fish.

5. Conclusion

This study showed that microplastics were detected at all surface water sampling locations in Lake Singkarak, with abundances ranging from 9.33 ± 1.15 to 11.67 ± 4.51 particles/L. Fiber was the dominant microplastic shape, accounting for 57.1% of the total microplastics at the river inlet and 71.4% at both the residential and tourism areas, whereas fragments comprised 42.9%, 28.6%, and 28.6%, respectively. The highest microplastic abundance was observed at the river inlet and tourism area, indicating that anthropogenic activities and catchment area inputs are important contributors to microplastic contamination in the lake.

Comparison with secondary data on microplastics in bilih fish (*Mystacoleucus padangensis*) showed consistent characteristics, particularly the dominance of fiber and fragment shapes. Although it does not demonstrate a direct cause-and-effect relationship, this consistency indicates that microplastics in surface water potentially serve as a source of exposure for bilih fish as an organism living in the Lake Singkarak ecosystem. This microplastic exposure has the potential to cause physiological disturbances in fish, such as damage to the respiratory and digestive systems, oxidative stress, and metabolic disruption resulting from the physical and chemical properties of microplastic particles. In addition, given that bilih fish are one of the animal protein sources widely consumed by the community, the presence of microplastics also has the potential to increase the risk of transferring microplastics along with their adsorbed pollutants through the food chain (*trophic transfer*), making it a concern for food safety and public health.

The findings of this study show that Lake Singkarak functions as a medium for the transport and accumulation of microplastics, highlighting the need for more effective plastic waste management, particularly through controlling pollution sources from domestic activities, river catchment areas, and tourism. These efforts are important to reduce microplastic pollution, protect the aquatic ecosystem, and support the sustainability of fishery resources and public health.

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Bibliography

Ad'hani, C. D., Zulkarnaini, Z., Silvia, S., & Yuranda, F. (2024). Analysis of Microplastics of Bilih Fish (Mystacoleucus padangensis) in Lake Singkarak, West Sumatra Using FT-IR Spectroscopy. *Elkawnie*, *10*(2), 205. https://doi.org/10.22373/ekw.v10i2.22336

Ali, S. S., Elsamahy, T., Al-Tohamy, R., & Sun, J. (2024). A critical review of microplastics in aquatic ecosystems: Degradation mechanisms and removing strategies. In *Environmental Science and Ecotechnology* (Vol. 21). Editorial Board, Research of Environmental Sciences. https://doi.org/10.1016/j.ese.2024.100427

Banaee, M., Multisanti, C. R., Impellitteri, F., Piccione, G., & Faggio, C. (2025). Environmental toxicology of microplastic particles on fish: A review. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, *287*, 110042. https://doi.org/https://doi.org/10.1016/j.cbpc.2024.110042

Benson, N. U., Agboola, O. D., Fred-Ahmadu, O. H., De-la-Torre, G. E., Oluwalana, A., & Williams, A. B. (2022). Micro(nano)plastics Prevalence, Food Web Interactions, and Toxicity Assessment in Aquatic Organisms: A Review. In *Frontiers in Marine Science* (Vol. 9). Frontiers Media S.A. https://doi.org/10.3389/fmars.2022.851281

Deswati, D., Tetra, O. N., Ahzammi, M. R., Lubis, A. S., & Suparno, S. (2025). Spatial-temporal distribution and polymer characterization of microplastics in surface waters of Lake Singkarak (Solok Region, Indonesia): A baseline study. *Regional Studies in Marine Science*, *91*, 104508. https://doi.org/https://doi.org/10.1016/j.rsma.2025.104508

Du, S., Zhu, R., Cai, Y., Xu, N., Yap, P.-S., Zhang, Y., He, Y., & Zhang, Y. (2021). Environmental fate and impacts of microplastics in aquatic ecosystems: a review. *RSC Advances*, *11*(26), 15762–15784. https://doi.org/10.1039/d1ra00880c

Dzihninafira, H., Hamdan, A. M., & Razi, F. (2023). Microplastic Removal in Krueng Aceh River Water Using Ultrafiltration Membrane from Polyethersulfone Polymer (PES). *IJCA (Indonesian Journal of Chemical Analysis)*, *6*(2), 151–163. https://doi.org/10.20885/ijca.vol6.iss2.art7

Elizalde-Velázquez, G. A., & Gómez-Oliván, L. M. (2021). Microplastics in aquatic environments: A review on occurrence, distribution, toxic effects, and implications for human health. *Science of The Total Environment*, *780*, 146551. https://doi.org/https://doi.org/10.1016/j.scitotenv.2021.146551

Habumugisha, T., Zhang, Z., Uwizewe, C., Yan, C., Ndayishimiye, J. C., Rehman, A., & Zhang, X. (2024). Toxicological review of micro- and nano-plastics in aquatic environments: Risks to ecosystems, food web dynamics and human health. *Ecotoxicology and Environmental Safety*, *278*, 116426. https://doi.org/https://doi.org/10.1016/j.ecoenv.2024.116426

Henny, C., Rohaningsih, D., Suryono, T., Santoso, A. B., & Waluyo, A. (2022). Microplastic pollution in the surface water of Lake Singkarak, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *1118*(1). https://doi.org/10.1088/1755-1315/1118/1/012050

Köktürk, M., Özgeriş, F. B., Atamanalp, M., Uçar, A., Özdemir, S., Parlak, V., Duyar, H. A., & Alak, G. (2024). Microplastic-induced oxidative stress response in turbot and potential intake by humans. *Drug and Chemical Toxicology*, *47*(3), 296–305. https://doi.org/10.1080/01480545.2023.2168690

Li, J., Liu, H., & Paul Chen, J. (2018). Microplastics in freshwater systems: A review on occurrence, environmental effects, and methods for microplastics detection. *Water Research*, *137*, 362–374. https://doi.org/https://doi.org/10.1016/j.watres.2017.12.056

Nousheen, R., Hashmi, I., Rittschof, D., & Capper, A. (2022). Comprehensive analysis of spatial distribution of microplastics in Rawal Lake, Pakistan using trawl net and sieve sampling methods. *Chemosphere*, *308*. https://doi.org/10.1016/j.chemosphere.2022.136111

Rashid, K., Ali, S., Chaudhry, A. H., Sial, N., Akram, M. R., & Aslam, M. (2026). A comprehensive review on microplastics: Their presence in surface and ground water, environmental distribution, and impact on human and aquatic systems. *Science of The Total Environment*, *1020*, 181547. https://doi.org/https://doi.org/10.1016/j.scitotenv.2026.181547

Rochman, C. M., Brookson, C., Bikker, J., Djuric, N., Earn, A., Bucci, K., Athey, S., Huntington, A., McIlwraith, H., Munno, K., De Frond, H., Kolomijeca, A., Erdle, L., Grbic, J., Bayoumi, M., Borrelle, S. B., Wu, T., Santoro, S., Werbowski, L. M., … Hung, C. (2019). Rethinking microplastics as a diverse contaminant suite. *Environmental Toxicology and Chemistry*, *38*(4), 703–711. https://doi.org/10.1002/etc.4371

Rohaningsih, D., Henny, C., Suryono, T., & Santoso, A. B. (2022). Macroplastic abundance at Lake Singkarak riparian, West Sumatera. *IOP Conference Series: Earth and Environmental Science*, *1062*(1). https://doi.org/10.1088/1755-1315/1062/1/012025

Setälä, O., Fleming-Lehtinen, V., & Lehtiniemi, M. (2014). Ingestion and transfer of microplastics in the planktonic food web. *Environmental Pollution*, *185*, 77–83. https://doi.org/https://doi.org/10.1016/j.envpol.2013.10.013

Wright, S. L., Thompson, R. C., & Galloway, T. S. (2013). The physical impacts of microplastics on marine organisms: A review. *Environmental Pollution*, *178*, 483–492. https://doi.org/https://doi.org/10.1016/j.envpol.2013.02.031

Xiong, X., Tappenbeck, T. H., Wu, C., & Elser, J. J. (2022). Microplastics in Flathead Lake, a large oligotrophic mountain lake in the USA. *Environmental Pollution*, *306*. https://doi.org/10.1016/j.envpol.2022.119445

Yuranda, F., Zulkarnaini, Z., Silvia, S., & Ad'hani, C. D. (2024). Analysis of Microplastics on Digestive and Respiration System of Horse-Eye Jack Fish (Caranx latus) in Coastal Bungus Bay, West Sumatra. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 2687–2695. https://doi.org/10.29303/jppipa.v10i5.7099