E-ISSN 2549-8703 I P-ISSN 2302-7282

BIOTROPIKA *Journal of Tropical Biology*

https://biotropika.ub.ac.id/

Vol. 11 | No. 2 | 2023 | DOI: 10.21776/ub.biotropika.2023.011.02.06

MICROPLASTIC CONTAMINATION IN WATERS AND SEDIMENTS IN THE SELOREJO RESERVOIR, MALANG REGENCY, EAST JAVA

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Submitted : April, 12 2023
Accepted : September, 13 2023

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How to cite:
Prahardika, BA, Akbar IF, Muzammil MI. 2023. Microplastic contamination in waters and sediments in the Selorejo Reservoir, Malang Regency, East Java. *Biotropika: Journal of Tropical Biology* 11 (2): 106-114.

ABSTRACT

Microplastic waste particles are a new contamination material in aquatic and terrestrial ecosystems. Heaps of garbage and fishing activities around residential areas are examples of anthropogenic activities around the Selorejo Reservoir and can potentially become sources of microplastic contamination. This research aims to observe the presence of microplastic contamination type and its abundance in water and sediment samples taken from the Selorejo Reservoir. The purposive sampling method was applied at five different stations, including the Konto River inlet, Kwayangan River inlet, residential area (kauman hamlet), tourism area, and reservoir outlets. Each station has three transects (as replicates), and about 100 liters of water and 1000 grams of sediment were taken. Water and sediment samples were then destruction using 30% H_2O_2 acid and 30% H_2SO_4 to remove organic components that were still attached and later facilitated observation under a stereo microscope with a magnification of 400X to make it clearer. All types of microplastics found were then counted based on their respective numbers. The analysis results showed that there was microplastic contamination in the reservoir water samples at each station. The highest abundance of microplastics was successively found in the Konto River inlet with a total abundance value of 39.27x101 particles/liter, then in the residential area (kauman hamlet) a number of 35.34x101 particles/liter, tourist areas 33.67x101 particles/liter, outlet 30.36x101 particles/liter and Kwayangan river inlet 29.67x101 particles/liter. Meanwhile, the presence of microplastics was also found in reservoir sediment samples. The highest abundance of microplastics was also found in sediments in the Selorejo Reservoir originating from the Konto River inlet with a total abundance value of 3.68 particles/gram, then in the tourist area 2.08 particles/gram, in the Kwayangan River inlet 1.56 particles/gram, in the residential area a number of 1.2 particles/gram and outlets 1.12 particles/gram. The types of microplastic found in the waters of the Selorejo Reservoir include fibers, fragments, and filaments. While the types of microplastics found in Selorejo Reservoir sediments include fibers, fragments, filaments, and films. This result is related to the existence of various community activities which are sources of microplastic contamination.

Keywords: *microplastics, sediments, Selorejo Reservoir, waters*

INTRODUCTION

Ecosystems in the world are constantly faced with the complexity of pollution problems, including water pollution. One of the environmental issues currently developing is the threat of new contaminants in the form of microplastics [1]. In recent decades, there has been an explosion in the use of plastics as plastics are considered practical, durable, and multi-purpose. At present, plastic has become of public interest [2]. Initially, plastic was used because it has the characteristics of a material that is durable, flexible, and does not rust, but lately, more and more single-use plastics are being used [3]. The threat of plastic to the environment is not only in the form of a large amount of plastic waste that has accumulated in aquatic and terrestrial environments but can also occur due to fragmentation or plastic shards that are large in size to become smaller due to environmental conditions and weathering. The results of this fragmentation are generally referred to as microplastics [4]. Microplastics are plastic waste that comes from the fragmentation of large plastic particles and has a size smaller than 5 mm [5, 6]. So far, microplastics identified in the environment are divided into several types, including fibers, filaments, fragments, films, and granules [7]. Factors that influence the breakdown of large-size plastics into microplastics are aquatic activities such as waves and currents in the waters [8].

Studies regarding microplastic waste particles in aquatic ecosystems have been carried out in various parts of the world, one of which was carried out in Lake Hovsgol, Mongolia. This study found several types of microplastic waste, namely films and fragments, which were the most common, with a percentage of up to 78% [9]. In addition, research on microplastic waste in sediments has also been carried out, indicating that microplastics have been found in St. Lawrence sediments in Canada [10]. The results of a study conducted by Hidalgo-Ruz et al. [11] showed that sediment samples had a higher abundance of microplastics than surface water samples. Most of the microplastics are at the bottom and settle in sediments because the transport of microplastics in sediments tends to be slower than in water [12]. Sediments are part of aquatic ecosystems that originate from the disintegration and decomposition of rocks and the accumulation of waste and other decomposition products in these ecosystems [13].

Selorejo Reservoir is one of the famous water tourism spots in Malang Regency, East Java. The flow of water from the surrounding rivers has the potential to carry waste from the residential and agricultural sectors to the Selorejo Reservoir area [14]. It is also feared that tourist visiting activities will cause the potential for waste piles around the Selorejo Reservoir area to increase. In addition, the Selorejo Reservoir also has a stream of water originating from a tributary of the Brantas River, where resident activities such as industry around the Brantas River Basin are also increasing [15]. Based on preliminary studies that have been carried out at several points of the Brantas River in the Malang City area, there are several piles of plastic waste. This condition is feared to be a source of microplastic contamination and can accumulate in standing water such as reservoirs.

Therefore, research on the type and distribution of microplastics needs to be carried out further to see the presence of microplastic contamination in the Selorejo Reservoir ecosystem, both in its waters and in the bottom sediments of the ecosystem. So, through this research, it is hoped that results will be obtained regarding the presence and abundance of microplastic waste found in waters and sediments in the Selorejo Reservoir, Malang Regency.

METHODS

Time and study area. This research was conducted for two months, from August to September 2021, in the Selorejo Reservoir, Malang Regency, East Java. The sampling location points were determined using a purposive sampling method, which was adjusted based on the characteristics of the activities of the surrounding community. In this study, there were five observation stations, including Station 1 at the Konto River inlet, Station 2 at the Kwayangan River inlet, Station 3 in a residential area (Kauman hamlet), Station 4 in a tourism area, and Station 5 at the Selorejo Reservoir outlet and carried out three repetitions for each observation station (Figure 1).

Water and sediment sampling. A sampling of water using tools in the form of a plankton net mesh size 140 (106 µm) diameter 30 cm and a bucket. According to Hidalgo-Ruz et al. [11], the volume of water taken from each station is 100 liters at the water surface (0 – 1 meter depth). Meanwhile, sediment sampling was carried out using a tool in the form of a hoe. The number of sediment samples taken was 1000 grams. A sampling of both water and sediment was carried out at a distance of 1 meter from the edge of the reservoir. The total number of sediment sampling points was 15 station points (five sampling points and two sub-points, each within 10 meters to the right and left) (Figure 2). Each water and sediment sampling were repeated three times.

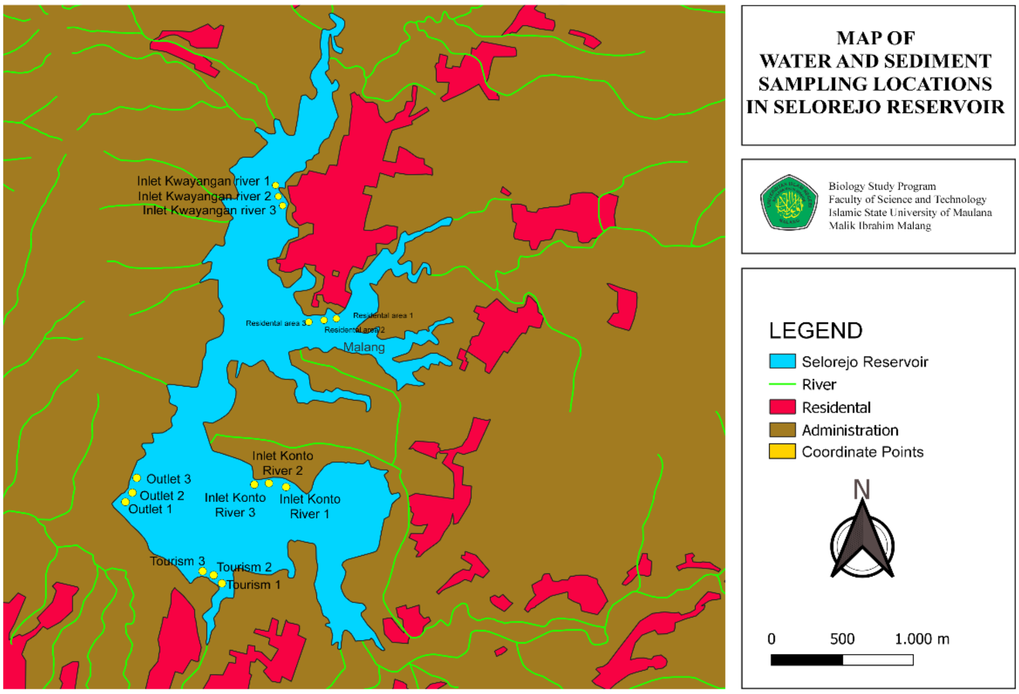

Figure 1. Map of water and sediment sampling locations

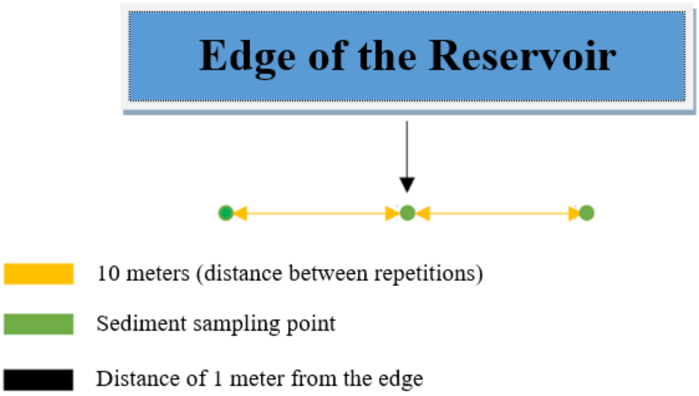

Figure 2. Distance between repetitions in sampling

Identification of types and calculation of microplastic abundance in water samples. The initial step was to test for the presence of the microplastics on water samples by adding 100 ml of 30% H_2O_2 [16] to separate the microplastics from the nylon filter cloth (using nylon type T165 mesh 420 mm). Water samples were then added with H_2O_2, left at room temperature for 24 hours, and covered with aluminium foil [17]. The water sample was then stirred using a magnetic stirrer for 30 minutes. After stirring, the water samples were filtered (using Whatman filter paper no. 40 with a diameter of 110 mm) and rinsed with distilled water. Furthermore, the water sample was put into a petri dish to be identified with a microscope. The microscopes stereo (Nikon SMZ1500) used in the observations generally use a magnification of 40-400x and use a reference book on Microplastics on Seafood on the North Coast of Java [18] and Microplastic Pollutants [19].

Identification of types and calculation of microplastic abundance in sediment samples. Separation of microplastic particles in sediment samples was carried out in the laboratory. There were several stages conducted, including (1) drying, (2) density separation, (3) microplastic extraction, (4) sample heating, (5) filtering and (6) visual sorting stage. Sediment was dried in the oven at 70°C to a constant weight. Two hundred fifty grams of dried sediment from each sample was weighted for the next stage. The next stage was density separation by adding saturated NaCl solution (300 g/L) to a 1 L beaker glass that contained the dried sediment sample. The extraction stage was carried out by adding 20 mL of mixed solution/diluent, made from 344 ml H_2SO_4 and 166 ml H_2O_2 (or in a ratio of 3:1). The sediment samples were then immersed in a diluent at room temperature (±27°C) for 24 hours. Then, the sediment sample was heated for 24 hours at 60°C using a water bath. Then, the sediment samples were rinsed with distilled water while filtered using nylon type T165 mesh 420 mm. The filtered sample was placed into a petri dish to be identified under the microscope stereo (Nikon SMZ1500) using a magnification of 40-100x [11]. Reference books on Microplastics in Seafood from the North Coast of Java [18] and Microplastic Pollutants [19] were used as guidance for microplastic identification.

Data analysis. Microplastic abundance was calculated by the formula [11, 20]:

$$\text{Microplastic abundance in water} = \frac{\text{number of microplastic (particles)}}{\text{volume of filtered water (liter)}}$$

$$\text{Microplastic abundance in sediment} = \frac{\text{number of microplastic (particles)}}{\text{weight of dry sediment (gram)}}$$

The abundance of microplastic at five different locations in the water and sediment samples of the Selorejo Reservoir was then subjected to statistical analysis using the one-way ANOVA test. This analysis was carried out to determine the significant differences in microplastic waste in both water and sediment samples at each observation station.

RESULTS AND DISCUSSION

Total abundance of microplastics in Selorejo Reservoir waters and sediments. Microplastic contamination was found at each observation station in the waters of the Selorejo Reservoir. Based on observations of microplastic waste findings, it was shown that the average total abundance of microplastics in reservoir water samples was 33.5 x 101 particles/liter. Similar results were also found in the sediment samples. The average total abundance of microplastics was 1.92 particles/gram. The existence of abundant plastic waste will make the abundance of microplastics last longer in aquatic ecosystems [21]. In addition, microplastic waste can also sink due to several reasons, including changes in density and the degradation process itself. The existence of a biofouling process can also make the density of microplastics higher than the density of water [22].

Based on the study results, it showed that there were differences in the abundance of the five observation stations. The highest microplastic abundance was successively found in the inlet area of the Konto River (Station 1) with a total abundance value of 39.27 x 101 particles/liter, then in the residential area (Station 3) with a total of 35.34 x 101 particles/liter, tourist area (Station 4) 33.67 x 101 particles/liter, outlet (Station 5) 30.36 x 101 particles/liter and Kwayangan river inlet (Station 2) 29.67 x 101 particles/liter.

Meanwhile, the highest abundance of microplastic waste in sediment samples was also found at the inlet of the Konto River with a total abundance value of 3.68 particles/gram, followed by the tourist area (2.08 particles/gram), Kwayangan River inlet (1.56 particles/gram), residential area (1.2 particles/gram), and Selorejo Reservoir outlet (1.12 particles/gram). Overall, the findings of total microplastic abundance in both water and reservoir sediment samples can be seen in Figure 3.

Microplastics found in various ecosystems can come from several sources of pollution, such as from larger pieces of plastic waste, which are then carried away by rivers, runoff, tides, and wind. In addition, large plastic waste can also be carried away from various community activities around the aquatic ecosystem area, including using various aquaculture tools, fishing gear, and clothing fibers originating from household wastewater [23]. Apart from inputs from land, the large concentration of microplastics is due to the fact that ships passing by significantly contribute to microplastic pollution [24]. This also happened in the waters of the Selorejo Reservoir. In this area, with the naked eye, garbage can be found floating on the water surface or reservoir body. In addition, this reservoir is used by fishermen to catch fish using nets.

The presence of microplastics in the water and sediment samples of the Selorejo Reservoir indicated another negative impact caused by the accumulation of plastic waste in the surrounding ecosystem. Microplastics can leach into air, water, food, and potentially enter human body tissues [25]. Microplastics have been detected in benthic and sedimentary environments. Benthic aquatic biota can ingest microplastics in the waters in the form of microbeads and microfibers [26]. Organisms that eat or accidentally ingest microplastic particles can affect the overall food chain in the ecosystem. For example, when phytoplankton or zooplankton absorb microplastics (either accidentally eaten or ingested), this will threaten energy production at the next trophic level. Thus, low-level organisms that absorb this microplastic waste will then affect the reduction in the total energy produced and can threaten the population of all other organisms involved in the food web. In addition, microplastic particles can accumulate various pollutants and are home to pathogenic bacteria in aquatic environments [27].

Microplastics pose risks to the health of living organisms, reproduction, growth, and destruction of invertebrate and vertebrate species [28]. Microplastics can be harmful to biota in an ecosystem. This is because microplastics can be distributed in food webs from the lowest to highest trophic level [29]. The distribution of microplastics is thought to originate from producers at the level of the food web. However, microplastics did not significantly negatively impact anatomic macrophytes. In a study, microplastics can attach to the roots of macrophytes and can even be absorbed in nano-size [30]. Previous research stated that duckweed (*Lemna minor*) plants experienced impaired viability and growth due to exposure to microplastics up to 30–600 µm of plastic particles [31].

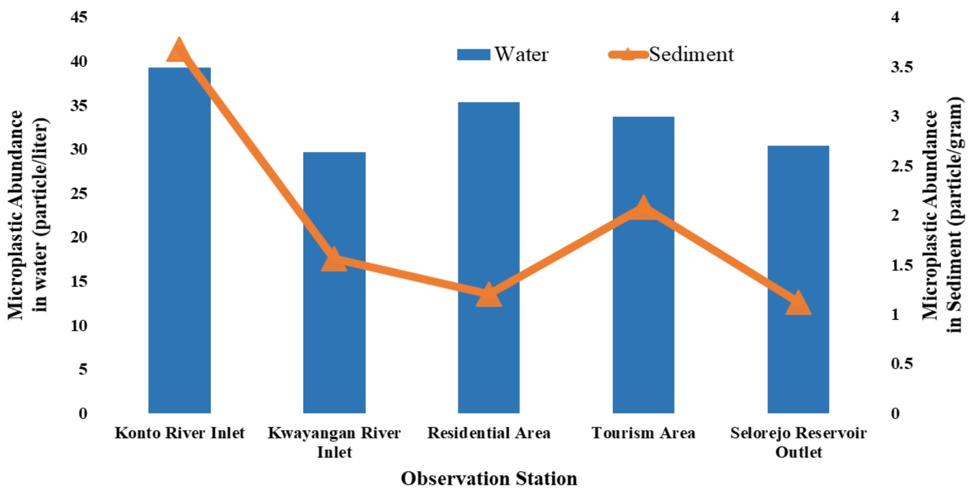

Figure 3. Total abundance of microplastics in the waters and sediments of the Selorejo Reservoir

The microplastics found at the Konto River inlet, in water and sediment samples, had the highest abundance compared to other stations. This condition is possibly derived from the many activities of the surrounding community. Based on the field survey results, it was known that many fishermen were looking for fish using fishing gear in the form of nets. These activities were thought to have led to the discovery of several microplastic abundances in this area. In addition, the Konto River inlet, a connecting area of two rivers, namely, the Konto and Pijal Rivers, has more waste piles than other stations. This can be seen from the results of a field survey, which found contamination in the form of scattered piles of garbage in the body of the reservoir. The community commonly used the area of the Kwayangan river inlet station to catch fish with nets. Apart from being used as a fishing spot, this area was also used as a fishing ground for shrimp. The fishing gear used was suspected as a source of microplastics at this station. This condition is in accordance with what was conveyed by Law et al. [23].

The Residential station is an area that is in direct contact with residents. In addition, many community activities were also found, such as the use of boats, fishing areas, places to dock fishing boats, and several floating cages managed by the community. This station was found to have a higher abundance of microplastics than the Kwayangan River inlet station. Increasing community activities are likely to be the cause of the growing abundance of microplastics in the area. This was in accordance with the opinion of Nugroho [32], which stated that the large number of microplastics found was suspected to be due to the influence of anthropogenic activities that occur around water bodies so that many piles of plastic waste consisting of plastic bags, food packaging, toiletries, direct disposal of plastic waste and fishing and fishing activities. This also happened at the Residential area.

The microplastic abundance at tourist stations did not differ much from that at residential stations. This condition is due to the existence of tourist attractions used as places for various tourist boats to dock, and some of the operational ships of Perusahaan Umum Jasa Tirta (PJT). The existence of used plastic bottle waste, which was increasingly being found floating in these waters, was also the cause of the high abundance of microplastics at this station. According to Dewi et al. [33], the findings of microplastics can originate from the breakdown of large plastics and form smaller plastic particles.

The abundance of microplastics found at the Kwayangan River inlet station was significantly different from that of the Konto River inlet station. This condition is affected by the domination of the mountainous area around the Kwayangan River and its flow, and then this river also did not pass through the residential areas. However, the flow of the Kwayangan River that enters the Selorejo Reservoir is one of the areas around the reservoir that people usually use to catch fish with nets. Apart from being used as a fishing spot, this area is also used as a fishing ground for shrimp. It is the existence of community activities that allow microplastic contamination to occur. The finding of microplastics in ecosystems can come from various fishing activities originating from fishing gear, for example, fishing lines and damaged nets [34].

The outlet area of the reservoir is the area of the reservoir body far from residential areas and has minimal community activity around it. Despite this, microplastics can still be found at this station. This condition is possible because the outlet area of the reservoir is an accumulation of water from all over the Selorejo Reservoir, thus allowing microplastics to accumulate in this area. Based on the opinion of Ayuningtyas [20], who stated that the presence of strong currents in the waters would be able to make microplastic particles move from one place to another. In addition, Nugroho also stated that the large number of microplastics found was allegedly due to the influence of activities that occur in water areas, which can see piles of plastic waste consisting of plastic bags, food packaging, toiletries, direct disposal of plastic waste and fishing and fishing activities [32].

Microplastic types in Selorejo Reservoir waters and sediments. Grouping and identifying the microplastic types were carried out visually using a stereo (macro) microscope. The identification results were then classified based on several types, such as filaments (thin, transparent, and from cylindrical particles), fiber (thin, straight), fragments (asymmetrical shapes), films (thin flexible, irregular), granules (spherical shapes), and foam (light particles, sponge texture) (Figure 4). Each type of microplastic was then counted based on the amount found [35].

The types of microplastic found in the waters of the Selorejo Reservoir include fibers (74.5 %), fragments (20.8 %), and filaments (4.7 %). While the types of microplastics found in Selorejo Reservoir sediments include fibers (46 %), fragments (40.6 %), filaments (10.9 %), and films (2.5 %). Fiber microplastic was the highest type found in water and sediment samples at all observation stations (Figure 5). This condition was related to various community activities, which act as sources of microplastic contamination.

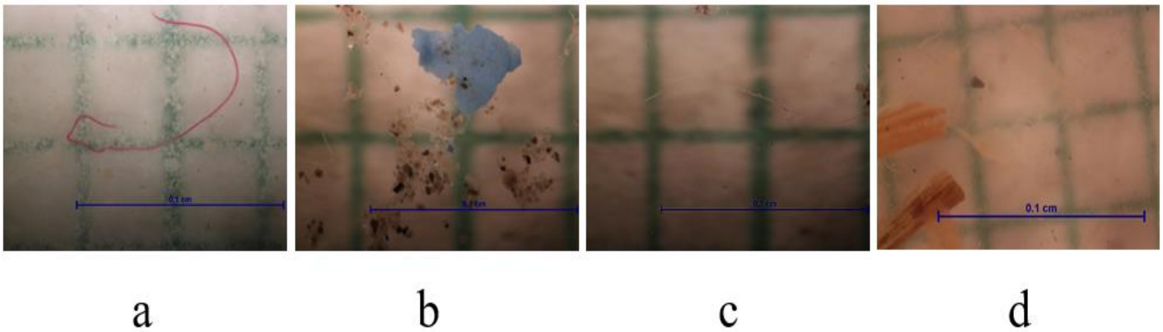

Figure 4. Microplastic fiber particles (a), fragments (b), filaments (c), and films (d), 400x magnification.

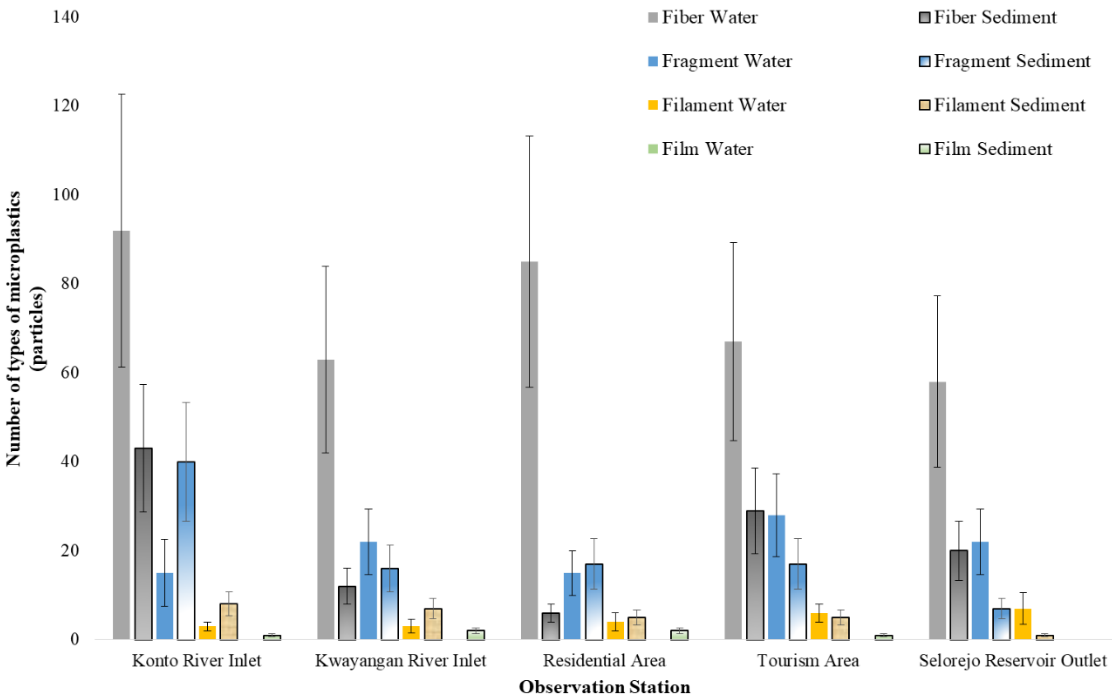

Figure 5. Comparison of the number of microplastic types at five different station locations in the Selorejo Reservoir

Fiber is one of the types of microplastics most often found in aquatic ecosystems. The presence of microplastic fiber waste can mostly come from various activities of the surrounding community, including from the process of destroying various fishing equipment such as fishing lines and nets, or from clothing fibers originating from household waste around aquatic. According to Nor & Obbard [36], fiber is a microplastic type comes from the fragmentation of ship ropes then decomposed and accumulated in water and sediments. This was observed to occur in the Selorejo Reservoir, which fishermen commonly use to catch fish with nets, which is suspected to be the cause of microplastic fiber contamination in this water body. Fiber is the most abundant type of microplastic particle, its size can be short or long, with different thicknesses and colors [37]. The microplastic fiber found in the Selorejo Reservoir ecosystem consisted of several colors. In general, the color of microplastics indicated the properties of microplastics capable of absorbing various types of pollutants with varying levels. The color differences shown by the various microplastics can be used to identify the polyethylene polymers that make up them. In addition, it can also be used to determine the density and explain its abundance on the water surface [38]. This condition is shown by the existence of a very significant comparison between the amount of fiber in the water sample which is far more than that found in the sediment sample.

Microplastics fragment were also found in all research stations. Plastic bottles floating on water surface were thought to be one of sources for this microplastic pollution in the water and sediment samples. Based on Dewi et al. [33], large plastic containers can be degraded into very small plastic pieces and are then referred to as fragment type microplastics. Microplastic fragments found at the study site had the characteristics of being asymmetrical, jagged, hard, angular, and resembling broken pieces of plastic. The types of fragments are stiff, thick, irregular in shape, and have a variety of different colors [37]. The fragment-type microplastics found in this study have red and blue colors. However, the microplastics found do not always have the same color as the original plastic [39].

The microplastic filaments found have transparent, thin characters. This filament-type microplastic is suspected because it is used as a place for fishing activities with nets by fishermen at the water and sediment sampling locations. Figure 3 showed that filaments were dominantly found in the water samples. Based on information [33], the presence of filament types in the waters came from fishing gear in the form of nets or ropes used by fishermen. Various fishing gear can be found around the area study, and some of them are piled up in garbage found around the observation station, both floating on the water surface and buried in sediments. In addition, it was also found the activities of fishermen who were looking for fish with tools in the form of nets. The filament type can also come from pieces of plastic bags with a low enough density to break down easily into small pieces [24]. Most of the most common characteristics of filaments are their transparent colors. Various types of transparent-colored microplastics are one way of early identification of polypropylene (PP) polymer. PP polymer is one of the most common plastic waste polymers found in aquatic ecosystems [40]. In addition, the transparent color indicated when microplastics that have been in the waters for a long time had been photodegraded by UV light [41].

Film is a type of microplastic that has thin and clear characteristics. According to Ayuningtyas et al. [20], this type of microplastic film had the characteristics of being thin and irregular. Disposable plastic bags, which are currently widely used by the community, are an example of an activity that is the biggest contributor to the presence of film-type microplastics in various ecosystems. According to Claessens et al. [42], sources of film-type microplastics could come from human activities, such as plastic bags, plastic wraps, and plastic bottles that were not recycled. This type of microplastic was only found in small abundance in sediment samples, whereas it was not found in water samples.

Selorejo Reservoir ecosystem is a type of aquatic ecosystem that is relatively stagnant (lentic). This condition causes an accumulation of microplastic contamination that can potentially occur in this reservoir. Furthermore, this condition is in accordance with what was conveyed by Law et al. [23]. Apart from input from land, the large concentration of microplastics is caused by boat activities, both fishermen and tourists passing by can also make a major contribution to microplastic contamination [24].

CONCLUSION

The results of research that has been carried out in the Selorejo Reservoir, Ngantang District, Malang Regency, yielded several conclusions, including:

1. The findings of microplastic waste found in both water and sediment samples of the Selorejo Reservoir had different abundances at each observation station.
2. The types of microplastic found in the waters of the Selorejo Reservoir include fibers, fragments, and filaments. While the types of microplastics found in Selorejo Reservoir sediments include fibers, fragments, filaments, and films.

The suggestions for the next study are that it is necessary to research the presence of microplastic contamination in biota that live both in the waters and sediments of the Selorejo Reservoir.

ACKNOWLEDGMENT

The author would like to thank LP2M (Lembaga Penelitian dan Pengabdian kepada Masyarakat) UIN Maulana Malik Ibrahim Malang who has provided assistance through competitive grants in the 2021 Litapdimas Program through DIPA 2021 with contract number SP DIPA-025.04.2.423812/2021 as well as to the Waduk Selorejo contamination exploration team in Malang Regency.

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