

## **Analysis of Microplastics in Water and Biofilm Matrices in Metro River, East Java, Indonesia**

Safitri Permata Sari<sup>1</sup>, Hartati Kartikaningsih<sup>2</sup>, Adi Tiya Yanuar<sup>3</sup>, Andi Kurniawan<sup>2\*</sup>

<sup>1</sup>Postgraduate Program, Faculty of Fisheries and Marine Science, University of Brawijaya, Malang, Indonesia

<sup>2</sup>Department of Water Resources Management, Faculty of Fisheries and Marine Science, University of Brawijaya, Malang, Indonesia

<sup>3</sup>Coastal and Marine Research Centre, University of Brawijaya, Malang, Indonesia

### **Abstract**

The Metro River flows from upstream to downstream across East Java to support several human activities such as household, toilets, or agriculture. The utilization of water rivers must be balanced with water quality monitoring so that the quality of the water can be monitored. This study aims to analyze the abundance of microplastic in the Metro River. Moreover, the water parameters (pH, dissolved oxygen, temperature, flow velocity) were also measured. Sampling was carried out at three different stations, namely station 1 representing the agricultural activity area, station 2 representing the household activity area, and station 3 representing industrial activity. This study shows the abundance of microplastics in biofilm matrices and surrounding river water. The types of the microplastics are fibers, fragments, and films. The total abundances of microplastics in river water ranged from 0.8 - 1.61 particle.mL<sup>-1</sup>, while the biofilm matrices ranged from 7.4 to 9.5 particle.gram<sup>-1</sup>. The results of water quality parameters at all stations are still relatively good compared to quality standards. To the best of our knowledge, this study was the first study that reports the microplastics in the water of and inside biofilm formed on Metro River.

**Keywords:** aquatic ecology, biofilm, Metro River, microplastics, water pollution.

### **INTRODUCTION**

Economic growth and an increase in population, primarily in big cities, can harm the environment. Environmental pollution can occur everywhere, including in the aquatic ecosystem. If directly discharged into the waters, various wastes from human activities such as households, industry, and agriculture can increase the concentration of pollutants and reduce the quality of the waters [1]. Meanwhile, water has a crucial role in the survival of humans, animals, and plants. Therefore, this problem requires proper handling.

Open and flowing waters such as rivers have the potential to be polluted. River pollution may occur due to waste from various human activities. The presence of pollutants will change the river's physical, chemical, and biological conditions [2]. Solid waste or garbage is the primary pollutant material intentionally or unintentionally carried by runoff water into the watershed. One of the most common types of waste is plastic waste which can be degraded into microplastics. Although it has been seen as one of the substances that can become emerging pollutants, studies on microplastics in rivers in

Indonesia are rarely reported. Nevertheless, studies on the content of microplastics in river ecosystems in Indonesia are an essential part of managing river ecosystems [3-6].

Microplastic is plastic waste that has a size of less than 5 mm. The change of plastic waste into microplastics takes a long time through the degradation process. Therefore, microplastics in waters are a severe problem because of their persistence, harming aquatic biota. Microplastics have various shapes, colors, sizes and are widely distributed in waters worldwide [7]. Microplastic pollution cannot be easily removed from the waters because of its persistent nature. The level of contamination of microplastic pollution can impact the food chain in marine waters, ranging from microorganisms such as plankton, various species of fish, and marine mammals [8]. The use of rivers for various human activities allows the presence of contaminants in the form of microplastics. However, research is rarely done to analyze the abundance of microplastics in river ecosystems.

Microplastics can be adsorbed into biofilms which are the dominant habitat of microbes in aquatic ecosystems. Microplastics in biofilms can be a problem in aquatic ecosystems because biofilms are actively involved in the food chain process. In this food chain process, microplastics in the biofilm can move and accumulate in fish that eat the biofilm. If humans consume these

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\* Correspondence Address:

**Andi Kurniawan**

Email : andi\_k@ub.ac.id

Address : Dept. Water Resources Management, University of Brawijaya, Veteran Malang, 65145.

fish, these microplastics can be accumulated in the human body.

The Metro River is a subsidiary of the Brantas Watershed, which flows throughout Malang City and ends in Kepanjen District, Malang Regency, with a river length of 54.55 km. This river has many benefits to support various human activities, especially for residential residents in watersheds. Based on its designation, the Metro River is a class II water class. It means water designation can be used for water recreation infrastructure/facilities, freshwater fish cultivation, animal husbandry, water for irrigating crops, or others that require the same water quality as that use [9].

This study aims to analyze the content of microplastics in water and biofilms growing in the Metro River. This study provides essential knowledge to develop bioassessment technology for aquatic environment management. This study was the first that reports the microplastics in the water and biofilm formed on Metro River.

## MATERIAL AND METHOD

### Sampling Area

This research was conducted in the Metro River, Malang City, in September 2021. Water and biofilm sampling was carried out at three different stations, each station representing an area of agricultural, household, and industrial activity. The sampling method used in this research is purposive sampling. A sampling at each station was also repeated three times. The

sampling location of this research can be seen in Figure 1.

Station 1 is the Metro River located near Tirtomulyo Street, Tlogomas Village, Lowokwaru District. The coordinates of station 1 for sampling this research are 7°56'17" S and 112°35'51" E. This location is a watershed affected by waste from household and agricultural activities.

Station 2 is the Metro River located on Klayatan Street, Bandungrejosari Village, Sukun District. The coordinates of 7°59'58" S and 112°37'04" E were for Station 2 sampling. This watershed is affected by waste from household activities. Station 3 is the Metro River located at Raya Kebonagung Street, Karang Sono Village, Pakisaji District. The coordinates of station 3 are 8°02'13" S and 112°36'41" E. This watershed area is affected by waste from household activities and several industrial activities.

### Sampling Procedure

The water parameters measured in this study were pH, dissolved oxygen, temperature, and water flow velocity. Measurement of physical and chemical water quality parameters was carried out in situ. Temperature (°C) was measured using a digital thermometer. The pH was measured using a pH meter (Lutron PH-201), the water flow velocity ( $m \cdot s^{-1}$ ) was measured using a current meter (JDC Flowatch FL-03). The dissolved oxygen (ppm) was measured using a DO meter (Lutron DO-5509) [10].

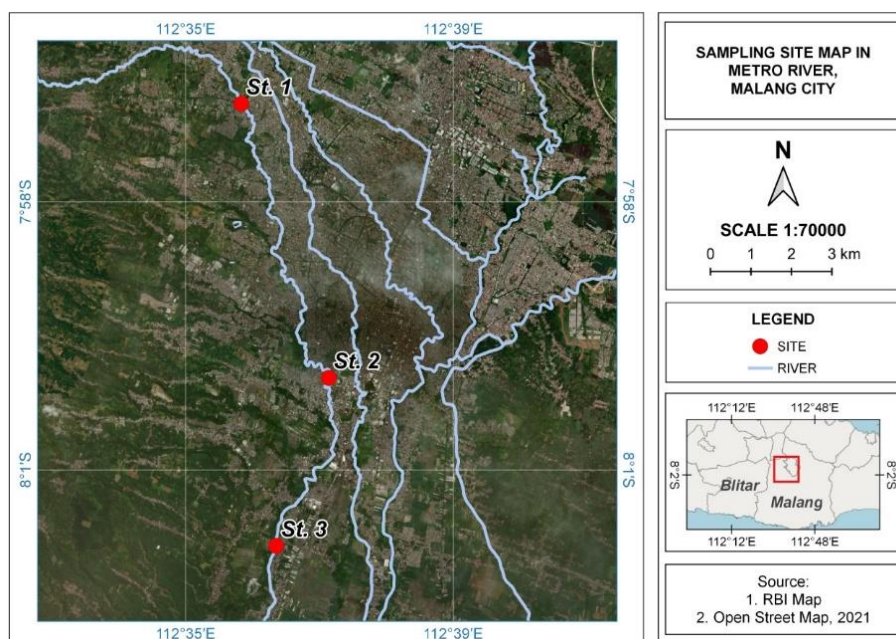


Figure 1. Sampling location

River water (16 L) was taken and filtered using a plankton net to 250 mL of sampling bottle. The filtered water was placed in a plastic bottle and then brought to the laboratory in a coolbox with a temperature of approximately 4°C. The biofilm used in this study is a biofilm that grows naturally on rocks in the Metro River. The biofilm was removed from the rock surface by gently brushing the biofilm into 50 mL distilled water. The biofilm suspension obtained was collected in a plastic container and put into a coolbox (4°C) and then brought to the laboratory.

### Microplastic Analysis

The biofilm suspension or river water was filtered using a 5 mM and 0.1 mm stainless steel mesh sieve to obtain microplastics. The resulting particles were then dried using an oven (90°C) for 24 hours. A total of 20 mL of a solution of 0.05 M Fe and 30% H<sub>2</sub>O<sub>2</sub> were added to a glass beaker containing the dried particles. Next, 6 g reagent grade NaCl was added to every 20 mL of suspension obtained. Then, the suspension was put into a density separator. The resulting precipitate was discarded, while the supernatant was used to analyze the microplastic content. The supernatant was filtered using Whatman filter paper, and then the presence of microplastics on the filter paper was observed using a microscope (Olympus BX50).

## RESULT AND DISCUSSION

### Water parameters

Measurement of water quality parameters was carried out in this study included temperature, pH, dissolved oxygen, and flow velocity. These physicochemical parameters affect the distribution and abundance of microplastics in the waters. The results of measuring water quality parameters can be seen in Table 1.

This study's water quality measurement suggested that the pH value at each station ranged from 7.5-7.6. The pH value of waters is influenced by temperature, dissolved oxygen, the biological activity of aquatic organisms, and ions. The biological activity of aquatic organisms such as respiration will increase CO<sub>2</sub> in the waters. The pH will decrease due to increased H<sup>+</sup> ions released into the waters [11].

The dissolved oxygen in this study ranged from 6.5-7.7 ppm. Aquatic organisms need dissolved oxygen for metabolic processes. Aerobic oxidation of organic and inorganic matter in waters also requires the presence of dissolved oxygen. The primary source of dissolved oxygen is diffusion from the air and photosynthetic products of aquatic organisms [12].

The temperature at each station ranged from 25-26°C. Factors that cause temperature differences are currents and turbulence in the river's upstream, middle, and downstream areas. The downstream area gets a high intensity of sunlight. The heat exchange process between water and air downstream is more remarkable, increasing temperature [13]. Water temperature will affect the process of plastic degradation into microplastics (thermal degradation). The high-temperature value will accelerate the degradation process so that the abundance of microplastics in the waters is high [14]. However, plastic degradation is not only triggered by plastic damage as a result of high temperatures but also due to thermodynamic effects such as being in running water at a temperature of 15°C to 28°C [15].

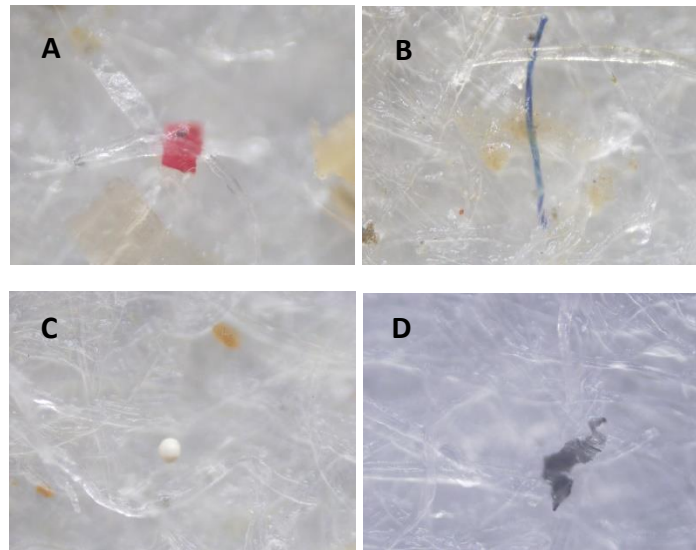
The current velocity at each station is different and ranges from 0.25-0.5 m.s<sup>-1</sup>. Water quality in the form of current velocity affects spreading organisms, minerals, and dissolved gases in the waters [14]. Several factors affect river flow speed, namely water discharge, materials, such as stones, mud, and sand found in the river body [16]. The relationship between current velocity and the abundance of microplastics in the waters is unidirectional. Hence, if the current velocity is high, the abundance value of microplastics also increases [17].

### Microplastics Abundance

The identification of microplastics that was carried out in this study found several types of microplastics, namely films, fibers, fragments, and beads. These types of microplastics come from different sources and amounts. The four types of microplastics in this study can be seen in Figure 2.

Table 1. The results of water quality parameter measurement

Station	pH	DO (mg.L <sup>-1</sup> )	Temperature (°C)	Water Flow velocity (m.s <sup>-1</sup> )
Station 1	7.5 ± 0.007	7.7 ± 1.2	25 ± 1.4	0.5 ± 0.1
Station 2	7.5 ± 0.007	6.5 ± 0.4	25 ± 1.4	0.5 ± 0.1
Station 3	7.6 ± 0.7	6.7 ± 0.5	26 ± 0.7	0.25 ± 0.1



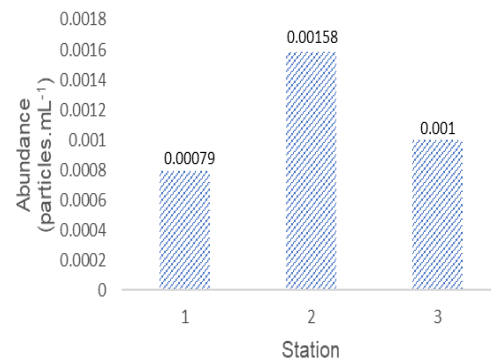
**Figure 1.** Types of microplastics found in this study (A: Fragments, B: Fiber, C: Beads, D: Film)

Microplastic films have thin and flexible characteristics [18]. The film was formed due to the degradation or pieces of plastic bags [19]. Microplastic fragments are the most commonly found in waters. The highest abundance after fragments is the type of film. The abundance is due to the low density of the film so it was easy to be distributed carried by the current [20].

Fiber has a physical shape resembling a thread and consists of various colors such as black, red, and blue. Fragments have an irregular rectangular physical shape that originates from a larger piece of plastic. Fragments are found in several colors, namely blue, red, green, and brown. Black and white film type microplastics in the form of a plastic sheet [21]. Microplastic beads come from the cosmetic industry and body care products such as soap, shampoo, toothpaste, face masks [22].

Sources of microplastic pollution at station 1 are from household activity waste and runoff from agricultural activities. Microplastics fiber types come from clothing, cloth, raffia, plastic sacks, and others waste disposal from settlements and agriculture [23]. The Station 2 river flow area contained plastic food packaging waste, crackle bags, baby diapers. The waste was intentionally or unintentionally entered the waters. Film-type microplastics have the physical form of thin sheets sourced from plastic bags or other materials made of single-use plastic [24]. Waste disposal at station 3 comes from household and various industrial activities, namely cigarette factories and sugar factories. The packaging or materials used during the

production process at the factory can be a source of fragments of microplastics contaminants. Microplastic fragments come from jars, buckets, plastic bottles, pieces of irrigation pipes, and others from human activities [25].



**Figure 2.** The abundance of microplastics in water

The abundance of microplastics in the water samples obtained in this study differed at each sampling station (Fig. 3). The abundance values of microplastics at each station were as follows; Station 1 was 0.00079 particles.mL<sup>-1</sup>, Station 2 was 0.00158 particles.mL<sup>-1</sup>, Station 3 was 0.001 particles.mL<sup>-1</sup>. The highest abundance of microplastics was at Station 2 because the location was influenced by waste from anthropogenic activities from densely populated settlements. The increasing human activity is directly proportional to the amount of waste produced. The existence of residential areas in the area around the river allows the waste from household activities to be directly discharged into the waters [26].

The abundance of microplastics inside the biofilm materices obtained in this study was different at each sampling station, as shown in Figure 4. The abundance values of microplastics at each station were as follows. Station 1 has as many as 9.5 particles.g<sup>-1</sup>, Station 2 as many as 9.8 particles.g<sup>-1</sup>, Station 3 as much as 9.5 particles.g<sup>-1</sup>. Biofilm is defined as a community of autotrophs and heterotrophs covered by an organic matrix and live on substrates in water. The biofilm-forming microbial community consists of bacteria, algae, fungi [27].

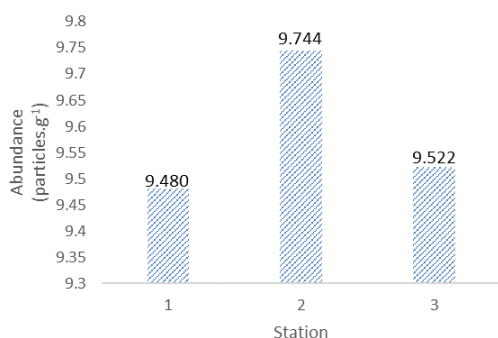


Figure 3. The abundance of microplastics in biofilm matrices

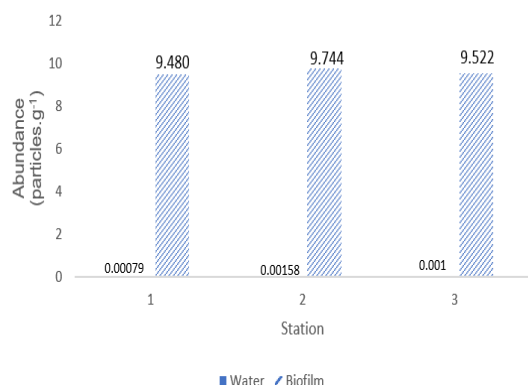


Figure 4. Comparison of microplastic abundance in water and biofilm (comparisons are made in grams assuming 1 mL of water is equivalent to 1 g of water)

In order to compare the abundance of microplastics in the biofilm matrix and water, the abundances of microplastics in the biofilm and river water around the biofilm were compared (Fig. 5). This comparison assumes that 1 mL of water is equivalent to 1 g of water. The results showed that the abundance of microplastics in the biofilm was ten times higher than the abundance of microplastics in water at each sampling station. This higher number may be because biofilms can adsorb microplastics in

adsorption. Because of this ability, biofilms can be used as biosorbents for various pollutants, including microplastics [28]. Biosorption can occur by involving physicochemical processes between pollutants and biofilm polymers through ion exchange mechanisms and electrostatic interactions [29].

This study shows that the biofilm matrix can withstand microplastics. This ability is also found in other biomass in aquatic ecosystems such as fish, aquatic invertebrates, and algae [30]. The results of this study strengthen knowledge to develop biofilms in eco-aquatic technology, especially in assessing the presence of pollutants in aquatic ecosystems.

Microplastic as an emerging pollutant should be monitored for its existence [31]. The monitoring requires agents that are relatively easy to find in all aquatic ecosystems, which is biofilm is an alternative [28,32]. Further studies related to the presence and interaction of microplastics with aquatic organisms are needed to a better understanding of the presence and impact of microplastics in aquatic ecosystems, especially on biofilms as the predominant habitat of aquatic microbes [33]. The interaction of aquatic microbes and microplastics as emerging pollutants will increase opportunities to use microbes to manage and conserve aquatic ecosystems.

### CONCLUSION

This study was conducted to identify the abundance of microplastics in the Metro River, Malang. This study showed that river water and biofilm in metro rivers contain microplastics. The types of microplastics at all sampling stations consisted of fiber, fragments, films, and beads. The abundance of microplastics in river water ranged from 0.8 - 1.61 particles.mL<sup>-1</sup> and inside the biofilm matrix ranged from 7.4 - 9.5 particles.g<sup>-1</sup>. Assuming 1 mL of water is equivalent to 1 gram of water, the microplastic content in biofilm is ten times higher than in river water. This study showed that microplastics, widely seen as emerging pollutants, must receive attention in managing river ecosystems in Indonesia.

### REFERENCES

[1] Djoharam, V., E. Riani, M. Yani. 2018. Analisis kualitas air dan daya tampung beban pencemaran Sungai Pesanggrahan di Wilayah Provinsi DKI Jakarta. *J. Nat. Resour. Environ. Manage. (Jurnal Pengelolaan*

- Sumberdaya Alam dan Lingkungan). 8(1). 127–133. DOI: 10.29244/jpsl.8.1.127-133.
- [2] Sahabuddin, H., D. Harisuseno, E. Yuliani. 2014. Analisa status mutu air dan daya tampung beban pencemaran sungai wangu kota kendari. *Jurnal Teknik Pengairan*. 5(1). 19–28.
- [3] Alam, F.C., E. Sembiring, B.S. Muntalif, V. Suendo. 2019. Microplastic distribution in surface water and sediment river around slum and industrial area (case study: Ciwalengke River, Majalaya district, Indonesia). *Chemosphere*. 224. 637e645.
- [4] Lestari, P., Y. Trihadiningrum, B.A. Wijaya, A. Yunus, M. Firdaus. 2020. Distribution of microplastics in Surabaya River, Indonesia. *Sci. Total Environ*. 726. 138560. DOI: 10.1016/j.scitotenv.2020.138560.
- [5] Sembiring, E., A.A. Fareza, V. Suendo, M. Reza. 2020. The presence of microplastics in water, sediment, and milkfish (*Chanos chanos*) at the downstream area of Citarum River, Indonesia. *Water Air Soil Pollut*. 231. 355.
- [6] Radityaningru, A.D., Y. Trihadiningrum, M. Sholihah, E.S. Soedjono, W. Herumurti. 2021. Microplastic contamination in water supply and the removal efficiencies of the treatment plants: A case of Surabaya City, Indonesia. *J. Water Process. Eng*. 43. 102195.
- [7] Zhang, W., S. Zhang, J. Wang, Y. Wang, J. Mu, P. Wang, X. Lin, D. Ma. 2017. Microplastic pollution in the surface waters of the Bohai Sea, China. *Environ. Pollut*. 231. 541–548. DOI: 10.1016/j.envpol.2017.08.058.
- [8] Stolte, A., S. Forster, G. Gerds, H. Schubert. 2015. Microplastic concentrations in beach sediments along the German Baltic coast. *Mar. Pollut. Bull*. 99(1–2). 216–229. DOI: 10.1016/j.marpolbul.2015.07.022.
- [9] Azmi, Z., Saniman, Ishak. 2016. Sistem penghitung pH air pada tambak ikan berbasis mikrokontroler. *Jurnal Ilmiah Saintikom*. 15(2). 101–108.
- [10] Kurniawan, A., L.N. Salamah, Y.A.D. Susanti, M.A. Damaika, Y.R.P. Guspinta, W.A. Lestari, S.M. Ulfa. 2018. Analysis of biofilms as biomonitoring agent for Cu<sup>2+</sup> and Pb<sup>2+</sup> pollution in the lotic ecosystem. *IOP Conference Series: Earth and Environmental Science*. 239.
- [11] Warman, I. 2015. Uji kualitas air muara Sungai Lais untuk perikanan di Bengkulu Utara. *Jurnal Agroqua*. 13(2). 24–33.
- [12] Saputri, A., Johny M.T.S., D. Rahayu. 2014. Analisis sebaran oksigen terlarut pada Sungai Raya. *Jurnal Teknologi Lingkungan Lahan Basah*. 2(1). 1–10. DOI: 10.26418/jtllb.v2i1.4618.
- [13] Asrini, N.K., I.W.S. Adnyana, I.N. Rai. 2017. Studi analisis kualitas air. *ECOTROPHIC: Jurnal Ilmu Lingkungan (J. Environ. Sci.)*. 11(2). 101–107.
- [14] Layn, A.A., Emiyarti, Ira. 2020. Distribusi mikroplastik pada sedimen di perairan Teluk Kendari. *Jurnal Sapa Laut (Jurnal Ilmu Kelautan)*. 5(2). 115–122. DOI: 10.33772/jsl.v5i2.12165.
- [15] Rummel, C.D., A. Jahnke, E. Gorokhova, D. Kuhnel, M. Schmidt-Jansen. 2017. Impacts of biofilms formation on the fate and potential effects of microplastics in the aquatic environments. *Environ. Sci. Technol. Lett*. 4. 258-267.
- [16] Mantaya, S., M. Rahman, Z. Yasmi. 2016. Storet model and pollution charges for the analysis of water quality Batu Kambing River, Mali-Mali River and Riam Kiwa River District of Aranio South Kalimantan. *Fish Scientiae*. 6(11). 35–52.
- [17] Bahriyah, N., S. Laili, A. Syauqi. 2018. Uji kualitas air Sungai Metro Kelurahan Merjosari Kecamatan Lowokwaru Kota Malang. *Biosaintropis*. 3(3). 18–25.
- [18] Ebere, E.C., V.A. Wirnkor, V.E. Ngozi, I.S. Chukwuemeka. 2019. Macrodebris and microplastics pollution in Nigeria: First report on abundance, distribution and composition. *Environ. Health Toxicol*. 34(4). 1–15. DOI: 10.5620/eaht.e2019012.
- [19] Horton, A.A., S.J. Dixon. 2018. Microplastics: An introduction to environmental transport processes. *WIREs Water*. 5(2). 1–10. DOI: 10.1002/wat2.1268.
- [20] Kovač Viršek, M., A. Palatinus, Š. Koren, M. Peterlin, P. Horvat, A. Kržan. 2016. Protocol for microplastics sampling on the sea surface and sample analysis. *J. Vis. Exp. : JoVE*. 118. 1–9. DOI: 10.3791/55161.
- [21] Laila, Q.N., P.W. Purnomo, O.E. Jati. 2020. Kelimpahan mikroplastik pada sedimen di Desa Mangunharjo, Kecamatan Tugu, Kota Semarang. *Jurnal Pasir Laut*. 4(1). 28–35.
- [22] Bhattacharya, P. 2016. A review on the impacts of microplastic beads used in

- cosmetics. *Acta Biomedica Scientia*. 3(1). 47–52.
- [23] Browne, M.A., P. Crump, S.J. Niven, E. Louise, A. Tonkin, T. Galloway, R.C. Thompson. 2011. Accumulation of microplastic on shorelines worldwide: sources and sinks. *Environ. Sci. Technol.* 45(21). 9175–9179. DOI: 10.1021/es201811s.
- [24] Azizah, P., A. Ridlo, C.A. Suryono. 2020. Mikroplastik pada sedimen di Pantai Kartini Kabupaten Jepara, Jawa Tengah. *J. Mar. Res.* 9(3). 326–332.
- [25] Tunggul, A., S. Haji, B. Rahadi, N.T. Firdausi. 2021. Analisis kelimpahan mikroplastik pada air permukaan di Sungai Metro, Malang Analysis of Abundance Microplastic in Surface Water in Metro River, Malang. *Jurnal Sumberdaya Alam dan Lingkungan*. 8(2). 74–84.
- [26] Dewi, I.S., A.A. Budiarsa, I.R. Ritonga. 2015. Distribusi mikroplastik pada sedimen di Muara Badak, Kabupaten Kutai Kartanegara. *Depik*. 4(3). 121–131. DOI: 10.13170/depik.4.3.2888.
- [27] Ferreira, L.M.H., G. Lara, W. Wasielesky, P.C. Abreu. 2016. Biofilm versus biofloc: Are artificial substrates for biofilm production necessary in the BFT system? *Aquac. Inter.* 24(4). 921–930. DOI: 10.1007/s10499-015-9961-0.
- [28] Kurniawan, A., T. Yamamoto. 2015. Biosorption of lithium using biofilm matrix of natural microbial consortium. *Microbiology Indonesia*. 9(3). 106–112. DOI: 10.5454/mi.9.3.2.
- [29] Kurniawan, A., T. Yamamoto, Y. Tsuchiya, H. Morisaki. 2012. Analysis of the ion adsorption-desorption characteristics of biofilm matrices. *Microbes Environ.* 27(4). 399–406. DOI: 10.1264/jsme2.ME11339/.
- [30] Suac, L., B. Nana, K.L. Hasellab, N. Craiga, V. Pettigrove. 2019. Microplastics biomonitoring in Australian urban wetlands using a common noxious fish (*Gambusia holbrooki*). *Chemosphere*. 228. 65-74.
- [31] Ayuningtyas, W.C. 2019. Kelimpahan mikroplastik pada perairan di Banyuurip, Gresik, Jawa Timur. *J. Fish. Mar. Res.* 3(1). 41–45.
- [32] Kurniawan, A. 2018. Biofilm matrices as biomonitoring agent and biosorbent for Cr(VI) pollution in aquatic ecosystems. *J. Environ. Eng. Sustain. Technol.* 5(2). 61-67.
- [33] Debroy, A., N. George, G. Mukherjee. 2021. Role of biofilms in the degradation of microplastic in aquatic environments. *J. Chem. Technol. Biotechnol.* DOI: 10.1002/jctb.6978.