Identification of Microplastic in Surface Column of Mahakam River Samarinda, Indonesia

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Abstract. The surface water from Mahakam River in Samarinda needs to fulfill the quality requirements because it is the main supply in the region. The microplastics in the water may negatively affect people in case they are not removed from the water. This study aimed to determine the abundance and type of microplastic in water from the Mahakam River, Samarinda City at a depth of 0.5 m based on size, specifically ≥500µm; 500µm> x ≥250µm, and 250µm > x ≥180µm. Samples were collected at Teluk Lerong Intake using grab and composite methods. The water sample was processed by filtering with 180µm nylon, eliminating organic substances using H_2O_2, density separator, second filtration with various nylon filters, and microscopic observation. Definitively, microplastic refers to various solid materials of the appropriate size, persist after undergoing the above process, and are microscopic. The results showed microplastic in all test samples with the highest abundance in size range of 250µm> x ≥180µm by 12.7 particles/500 mL sample. The size range of 500µm> x ≥250µm had an abundance value of 8 particles/500 mL and ≥500µm of 4.7 particles/500 mL. The predominant type was fiber, though the fragment and film microplastic were also found.

INTRODUCTION

MATERIAL AND METHODS

Sampling

Mahakam River water samples were taken at Teluk Lerong Intake, the Cendana WTP with the largest water supply. Water sampling was conducted three times in 24 hours, specifically every 8 hours at a depth of 0.5 meters. The cycle was carried out three times, collecting 9 liters of the sample [14]. Grab sampling was conducted using a water sampler to take 1 liter. The samples were categorized as composites, meaning that they were instantaneous mixtures from one location at different times [21]. The samples were then put into bottles and taken to the laboratory.

Sample Preparation

The water sample of 500 mL was filtered using a nylon size of 180 µm with a vacuum pump. The filter was then transferred to a porcelain dish, covered with aluminum foil, and heated in an oven at 90°C for 24 hours to reduce the moisture content. Furthermore, the solid sample filtered was transferred to a beaker with distilled water, followed by the addition of 20 mL of Fe (II) solution and 20 mL of 30% H_2O_2. The solution was allowed to stand for 5 minutes and transferred to a hot plate stirrer for heating. It was then stirred at a temperature of 75°C for ±30 minutes until the visible organic matter disappeared. Furthermore, 6 g of NaCl was added to 30 mL of sample and reheated at 75°C until the NaCl dissolved. It was then transferred to a density separator made of a glass funnel and a latex hose and allowed to stand for 24 hours. Suppose a precipitate is seen in the density separator, it is discarded, and the remaining solution transferred to a beaker. The tool was then rinsed using distilled water until all solids moved to the beaker [8]. Moreover, nylon was filtered with various sizes, including 500 µm, 250 µm, and 180 µm. Afterward, a nylon filter was placed in a petri dish and observed and before calculating the abundance of microplastic by comparing the total particles with the volume of the filtered water sample [22].

Microplastic Abundance Calculation

The microplastic abundance was calculated by calculating the total microplastic found divided by the volume of filtered water samples [22].

1. Microplastic abundance $= \frac{\text{total microplastic particle(particle)}}{\text{volume of the filtered water } (m^3)}$ 1)

The abundance values for each microplastic size category were divided into microplastic sizes of ≥500µm, 500µm>x≥250µm, and 250µm>x≥-180µm. The average calculation of the data was carried out three times, and the effect of variations in the size of the nylon filter on the microplastic abundance value was analyzed.

Identification of Microplastic Type

The identification of the types of microplastic was carried out based on the shape observed using a microscope. There were three types of microplastic, including fiber, film, and fragments. The ones categorized into fibers are shaped like elongated fibers, while films are transparent, thin, and soft [7]. The last category, fragments, is hard and rigid [23]. The predominant type was then identified, and the cause was studied.

RESULT AND DISCUSSION

Microplastic Abundance

The results showed microplastic contamination in all Mahakam River water samples with size categories ≥500µm, 500µm> x ≥250µm, and 250µm> x ≥180µm, as shown in Table 1. The highest microplastic value had a size range of 250µm> x ≥180µm with the average abundance of 12.7 particles/500 mL, 500µm> x ≥250µm with 8 particles/500 mL and ≥500µm with 4.7 particles/500 mL.

Smaller microplastics often have low densities and commonly appear on the surface. In contrast, those with higher densities often settle in sediments [24]. Sampling was carried out at a depth of 0.5 meters, which still represents the river surface area. For this reason, the smallest size range of 250µm> x ≥180µm has the greatest abundance value. This is in line with [25], which stated that the microplastic fraction with a small size (65-53 µm) dominated in raw water and WTP treated water. This aspect needs to be considered in the WTP efficiency while removing microplastic from raw water. Although WTP can reduce them, the small ones still pass to processed products. However, there is a need for further studies to provide a standard value of tolerance for the presence of microplastic in treated water and monitoring the level of contamination in raw water sources and their ptreatment. WTP needs to improve the capabilities of the units and enhance the efficiency of microplastic reduction.

TABLE 1. Data on Microplastic Abundance of Mahakam River Water at a Depth of 0.5 m

Filter Size	Microplastic Abundance	
First Running		
500 µm	5	/500 mL
250 µm	13	/500 mL
180 µm	18	/500 mL
Average	12,7	/500 mL
Second Running		

500 μm	5	/500 mL
250 μm	4	/500 mL
180 μm	10	/500 mL
Average	8	/500 mL
Third Running		
500 μm	4	/500 mL
250 μm	7	/500 mL
180 μm	10	/500 mL
Average	4,7	/500 mL

The presence of microplastic in surface water can be attributed to several factors, including movement from land, which is the main cause. Human habits, such as garbage disposal and recycling, weather including wind, rain, and flood phenomena, and topographic conditions contribute to this issue [24]. Some communities around the Mahakam River still throw garbage in water [26], leading to silting [19]. Also, the river has poor water quality in one of its tributaries surrounded by industrial and household activities. This is attributed to contamination of domestic waste that directly enters the river [20]. Data shows that the water quality of this river is categorized as moderately and heavily polluted [27].

The sampling process was carried out in mid to late August 2021, a period dominated by rain. In general, rain increases runoff into microplastic entryways from land directly to rivers or through drainage systems. Particles that are lighter float on the surface of the water, while heavier ones stay in the sediments or remain on land [28]

The Mahakam River is surrounded by urban areas, a condition that triggers microplastic contamination in rivers. Urbanization around the areas is one factor that significantly affects the presence and value of microplastic abundance in water bodies [24].

Microplastic Types

Microscopic observations showed three types of microplastic in Mahakam River water samples based on shape, including fiber, film, and fragments. Physically, fiber microplastic has a shape resembling lines. The film is irregular, thin, and transparent, while the fragments have jagged edges, are solid, and appear as pieces of larger plastics [29]. Fiber is the most common type of microplastic in the samples of sizes 500μm, 500μm> x 250μm, and 250μm> x 180μm. It can be sourced from greater damage to plastic materials, the release of fibers from synthetic clothing in the washing process, or degradation of fishing rods [30]. Generally, the polymers in fiber microplastic include polyester and nylon [24]. The level of fiber in water is determined by several factors, including runoff flow from land. Air can also be a medium for transferring very light microplastic, such as anthropogenic fiber, that easily moves in the air, especially in urban areas[24].

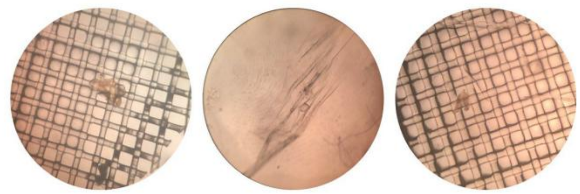
Fragments of microplastic were also found in the samples and were generally hard [23]. In surface water, they occur because the plastic on land is exposed to sunlight and hot temperatures, leading to rapid fragmentation. Fragments from dense polymers tend to remain and move to deeper soil layers, while those from lighter polymers move by the wind to surface waters. Fragmentation can also occur in waters due to exposure to UV rays from the sun and waves [24], similar to film microplastic. Table 2 and figure 1 show the types of microplastic found in the river.

TABLE 2. Microplastic Types in Mahakam River Water at a Depth of 0.5 m

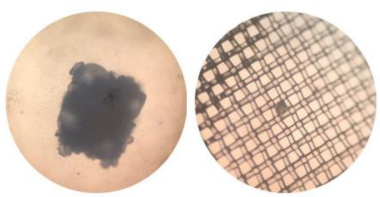
Sieve Size	Microplastic Type
First Running	
500 μm	fiber
250 μm	fiber
180 μm	fiber and fragment
Second Running	
500 μm	fiber

250 μm	fiber
180 μm	fiber
Third Running	
500 μm	fiber
250 μm	fiber
180 μm	fiber and film

(a)



(b)



(c)

Figure 1. Microplastic Types in Mahakam River Water at a Depth of 0.5 m (a) Microscopic observation of fiber microplastic, (b) Microscopic observation of film microplastic, (c) Microscopic observation of fragment microplastic

CONCLUSION

This study found that the microplastic content in all test samples with the highest abundance was in a size range of 250μm> x ≥180μm, 500μm> x ≥250μm, and ≥500μm. The average abundance were 12.7 particles/500 mL, 8 particles/ 500 mL, and 4.7 particles/500 mL, respectively. The predominant type of microplastic was fiber, which is attributed to domestic waste sources that enter the waters directly or due to the movement of microplastic on land through runoff, rain, wind, and flooding factors. The microplastic fraction with a small size (250μm> x ≥180μm) dominated in raw water. This aspect needs to be considered in the WTP efficiency while removing microplastic from raw water. However, there is a need for further studies to provide a standard value of tolerance for the presence of microplastic in treated water and monitoring the level of contamination in raw water sources and water treated WTP needs to improve the capabilities of the units and enhance the efficiency of microplastic reduction.

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REFERENCES

[1] P.L. Corcoran, Degradation of Microplastics in the Environment, in: T. Rocha-Santos, M. Coasta (Eds.), Handb. Microplastics Environ., Springer, 2021: pp. 1–12. https://doi.org/10.1007/978-3-030-10618-8_10-1.

[2] S. Klein, I.K. Dimzon, J. Eubeler, T.P. Knepper, Analysis, Occurrence, and Degradation of Microplastics in the Aqueous Environment, in: M. Wagner, S. Lambert (Eds.), Freshw. Microplastics Emerg. Environ. Contam., Springer Open, 2018: pp. 1–309. https://doi.org/10.1007/978-3-319-61615-5_3.

[3] S. Lambert, A. Boxall, C.J. Sinclair, Occuuence, Degradation, and Effect of Polymer-Based Materials in the Environment, in: D.M. Whitacre (Ed.), Rev. Environ. Contam. Toxicol., 1st ed., Springer International Publishing, 2014: pp. 1–53. https://doi.org/10.1007/978-3-319-01327-5.

[4] M. Wagner, S. Lambert, Microplastics are Contaminants of emerging Concern in Freshwater Environments: An Overview, in: M. Wagner, S. Lambert (Eds.), Freshw. Microplastics Emerg. Environ. Contam., Springer Open, 2018: pp. 1–309.

[5] D. Eerkes-Medrano, R.C. Thompson, D.C. Aldridge, Microplastics in freshwater systems: A review of the emerging threats, identification of knowledge gaps and prioritisation of research needs, Water Res. 75 (2015) 63–82. https://doi.org/10.1016/j.watres.2015.02.012.

[6] P. Lestari, Y. Trihadiningrum, B.A. Wijaya, K.A. Yunus, M. Firdaus, Distribution of Microplastics in Surabaya River, Indonesia, Sci. Total Environ. 726 (2020) 138560. https://doi.org/10.1016/j.scitotenv.2020.138560.

[7] P. Azizah, A. Ridlo, C.A. Suryono, Mikroplastik pada Sedimen di Pantai Kartini Kabupaten Jepara Jawa Tengah, J. Mar. Res. 9 (2020) 326–332. https://doi.org/10.14710/jmr.v9i3.28197.

[8] J. Masura, J. Baker, G. Foster, C. Arthur, Laboratory Methods for the Analysis of Microplastics in the Marine Environment: Recommendations for quantifying synthetic particles in waters and sediments, NOAA Marine Debris Division, 2015.

[9] N. Harpah, I. Suryati, R. Leonardo, A. Risky, P. Ageng, R. Addauwiyah, Analisa Jenis, Bentuk Dan Kelimpahan Mikroplastik Di Sungai Sei Sikambing Medan, J. Sains Dan Teknol. 20 (2020) 108–115. https://doi.org/10.36275/stsp.v20i2.270.

[10] E.A. Wicaksono, S. Werorilangi, T.S. Galloway, A. Tahir, Distribution and seasonal variation of microplastics in tallo river, makassar, eastern indonesia, Toxics. 9 (2021) 1–13. https://doi.org/10.3390/toxics9060129.

[11] F.C. Alam, E. Sembiring, B.S. Muntalif, V. Suendo, Microplastic distribution in surface water and sediment river around slum and industrial area (case study: Ciwalengke River, Majalaya district, Indonesia), Chemosphere. 224 (2019) 637–645. https://doi.org/10.1016/j.chemosphere.2019.02.188.

[12] M.R. Cordova, E. Riani, A. Shiomoto, Microplastics ingestion by blue panchax fish (Aplocheilus sp.) from Ciliwung Estuary, Jakarta, Indonesia, Mar. Pollut. Bull. 161 (2020) 111763. https://doi.org/10.1016/j.marpolbul.2020.111763.

[13] F.C. Alam, M. Rachmawati, Development of Microplastic Research in Indonesia, J. Presipitasi Media Komun. Dan Pengemb. Tek. Lingkung. 17 (2020) 344–352. https://doi.org/10.14710/presipitasi.v17i3.344-

352.

[14] M. Pivokonsky, L. Cermakova, K. Novotna, P. Peer, T. Cajthaml, V. Janda, Occurrence of microplastics in raw and treated drinking water, Sci. Total Environ. 643 (2018) 1644–1651. https://doi.org/10.1016/j.scitotenv.2018.08.102.

[15] M. Shen, B. Song, Y. Zhu, G. Zeng, Y. Zhang, Y. Yang, X. Wen, M. Chen, H. Yi, Chemosphere Removal of microplastics via drinking water treatment : Current knowledge and future directions, Chemosphere. 251 (2020) 126612. https://doi.org/10.1016/j.chemosphere.2020.126612.

[16] J.D. Meeker, S. Sathyanarayana, S.H. Swan, Phthalates and other additives in plastics: human exposure and associated health outcomes, Philos. Trans. R. Soc. B Biol. Sci. 364 (2009) 2097–2113. https://doi.org/10.1098/rstb.2008.0268.

[17] Badan Ousat Statisik, Badan Pusat Statistik Provinsi Kalimantan Timur., 2014, Tabel Nama dan Panjang Sungai Menurut Kabupaten dan Kota Tahun 2014, Kaltim.Bps.Go.Id. (2014).

[18] I.Y. Noor, S. Basuni, A.P. Kartono, D. Kreb, Kelimpahan dan Sebaran Populasi Pesut Mahakam Kalimantan Timur, J. Penelit. Hutan Dan Konserv. Alam. 10 (2013) 283–296.

[19] E. Tambunan, Dampak degradasi lingkungan terhadap transportasi sungai mahakam, in: 17th FSTPT Int. Symp., 2014: pp. 22–24.

[20] V. Pramaningsih, S. Suprayogi, I.L. Setyawan Purnama, Kajian Persebaran Spasial Kualitas Air Sungai Karang Mumus, Samarinda, Kalimantan Timur, J. Pengelolaan Sumberd. Alam Dan Lingkung. (Journal Nat. Resour. Environ. Manag. 7 (2017) 211–218. https://doi.org/10.29244/jpsl.7.3.211-218.

[21] Standar nasional Indonesia, SNI 03-7016-2004, Tata Cara Pengambilan Contoh Dalam Rangka Pemantauan Kualitas Air pada Suatu Daerah Pengaliran Sungai, 2004.

[22] W.C. Ayuningtyas, Kelimpahan Mikroplastik Pada Perairan Di Banyuurip, Gresik, Jawa Timur, JFMR-Journal Fish. Mar. Res. 3 (2019) 41–45. https://doi.org/10.21776/ub.jfmr.2019.003.01.5.

[23] K.H. Hanif, J. Suprijanto, I. Pratikto, Identifikasi Mikroplastik di Muara Sungai Kendal, Kabupaten Kendal, J. Mar. Res. 10 (2021) 1–6. https://doi.org/10.14710/jmr.v9i2.26832.

[24] A.A. Horton, A. Walton, D.J. Spurgeon, E. Lahive, C. Svendsen, Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities, Sci. Total Environ. 586 (2017) 127–141. https://doi.org/10.1016/j.scitotenv.2017.01.190.

[25] D. Kankanige, S. Babel, conventional water treatment plant (WTP) in Thailand, J. Water Process Eng. 40 (2021). https://doi.org/10.1016/j.jwpe.2020.101765.

[26] M.K. Dewi, Tthe People of The Vicinity of The River Mahakam Kutai, J. Gerbang Etam. 10 (2016) 75–83.

[27] B.P. Statisik, Badan Pusat Statistik., 2017, Status Kualitas Air Sungai 2007-2016, 2017.

[28] L. Nizzetto, G. Bussi, M.N. Futter, D. Butterfield, P.G. Whitehead, A theoretical assessment of microplastic transport in river catchments and their retention by soils and river sediments, Environ. Sci. Process. Impacts. 18 (2016) 1050–1059. https://doi.org/10.1039/c6em00206d.

[29] A.R. McCormick, T.J. Hoellein, M.G. London, J. Hittie, J.W. Scott, J.J. Kelly, Microplastic in surface waters of urban rivers: Concentration, sources, and associated bacterial assemblages, Ecosphere. 7 (2016) 1–22. https://doi.org/10.1002/ecs2.1556.

[30] P.K. Lindeque, M. Cole, R.L. Coppock, C.N. Lewis, R.Z. Miller, A.J.R. Watts, A. Wilson-McNeal, S.L. Wright, T.S. Galloway, Are we underestimating microplastic abundance in the marine environment? A comparison of microplastic capture with nets of different mesh-size, Environ. Pollut. 265 (2020) 1–12. https://doi.org/10.1016/j.envpol.2020.114721.