Vol. 15 No. 1 (2024) 15-20

Jurnal Riset
Teknologi Pencegahan Pencemaran
Industri

Journal homepage: https://www.jrtppi.id

The Effect of Sediment Texture on the Composition and Abundance of Microplastics in Banjaran River, Banyumas Regency, Indonesia

Andrie Yuliana, Nur Laila Rahayu*, Musyarif Zaenuri
Biology Study Program, Faculty of Science and Tecnology, Nahdlatul Ulama Purwokerto University, Indonesia

ARTICLE INFO
Article history:
Received August 04 2023
Received in revised form March 01, 2024
Accepted April 15, 2024
Available online May 31, 2024
Keywords:
Sediment Texture
Composition
Microplastic Abundance

ABSTRACT

Plastic waste is a serious environmental problem for all countries in the world, including Indonesia. Plastic waste of various sizes can have a negative impact, especially microplastics. Microplastic contamination can be found in aquatic sediments. One of the waters potentially polluted by microplastics is the Banjaran River, Banyumas Regency. This research was conducted to determine the composition and abundance of microplastics as well as the effect of sediment texture on the composition and abundance of microplastics in the sediments of Banjaran River, Banyumas Regency. The research location was determined using purposive sampling at four stations. At each station, samples were taken randomly at three different places with three repetitions. Analysis of the composition and abundance of microplastics in sediments was done in a laboratory using microscope observation. Sediment texture analysis was done using a dry sieve and pipetting method. Five types of microplastics were found in all sediment samples with a predominance of fiber (35%), followed by fragments (29%), films (19%), pellets (10%) and foam (7%). The abundance of microplastics in sediments ranged from 2.3 to 4.86 particles/50 grams of dry sediment. The sediment texture that dominated the four stations was sand, with an average fraction proportion value of 86.62%. Sediment texture had the strongest effect on the composition of fragment-type microplastic at 50.2% and had the same impact on the overall abundance at 56%, which indicated that the sediment texture had a significant effect on these two variables.

1. INTRODUCTION

The content of microplastics in the sea has reached 2.41 million tons of plastic every year from rivers. Based on the same study in Asia, 20 rivers are polluted with microplastics and account for more than two-thirds (67%) of global annual input while covering 2.2% of the continent's surface area and representing 21% of the global population. Rivers contaminated with microplastics include Serayu, Brantas, Progo, and Bengawan Solo, each river donating approximately 17,100 (range 13,300-29,900), 38,900 (range 32,300-63,700), 12,800 (range 9,800-22,900) and 32,500 (range 26,500-54,100) per ton of plastic per year. The increase in microplastics in waters is caused by population growth (Lebreton et al., 2017).

Sedimentary structures include sand, silt and clay components. Continuous accumulation of sediment or substrate and the presence of nutrients from living organisms and waste increase the organic matter content. The presence of microplastics has also been studied in sediments in several rivers in Indonesia. (Utami et al., 2022) found microplastics in the sediments of Progo River and Opak River in Bantul Regency ranging from 209 to 1,173 particles/kg and 315 to 3,730 particles/kg, respectively. Microplastics were also found in the sediments of Krukut River Jakarta (Azizi, Maulida, Setyowati, Fairus, & Puspito, 2022), Citarum River Jakarta (Sembiring et al., 2020), Jagir River Surabaya (Firdaus, Trihadiningrum, & Lestari, 2020), and several other rivers. One of the rivers potentially polluted by microplastics is

*Correspondence author.
E-mail: nurlailarahayu@gmail.com (Nur Laila Rahayu)

doi: https://10.21771/jrtppi.2024.v15.no.1.p15-20

Accreditation number: (Ristekdikti) 158/E/KPT/2021

Banjaran River located in Banyumas Regency, Central Java. Banjaran River is a tributary of Logawa River that flows from north to south, starting from the slopes of Mount Slamet precisely in Ketenger Village, Baturraden Subdistrict as the upstream area to Sidabowa Village, Patikraja Subdistrict as the downstream area Prayitno & Rukayah, 2019. Banjaran River flows through seven sub-districts, namely Baturraden, Kedungbanteng, North Purwokerto, West Purwokerto, South Purwokerto, East Purwokerto, and Patikraja (Bhagawati, Abulias, & Amurwanto, 2013).

Residential areas are dominating the landscape along the Banjaran River utilizing the stream for various activities such as bathing, washing, toilet, and household waste disposal (Samudra, Fitriadi, Baedowi, & Sari, 2022). These activities can contribute to various types of waste, especially plastic waste, which will then be carried by river currents, settle in sediments, and gradually degrade into microplastics. There is no prior study of microplastics in the Banjaran River, let alone on the sediment there. As we know, microplastic contamination can be an obstacle in the strategy of managing plastic waste and overcoming environmental pollution. Hence, research is needed to figure out the composition and abundance of microplastics in the sediment of Banjaran River in Banyumas Regency and one of the factors that influence differences in composition and abundance, namely sediment texture.

2. METHODS

This research was conducted from November 2022 to February 2023. Sediment sampling was carried out at Banjaran River, Banyumas Regency and sample analysis was carried out at the Integrated Science Laboratory, Faculty of Science and Technology, Nahdlatul Ulama University Purwokerto.

The method used in this study was the survey method, while the research location was determined by purposive sampling method at four stations based on land use. Each station was sampled by random sampling, that is, at each station three plots were made with three repetitions. The sampling points are listed in Table 1 and the research map is shown in Figure 1.

Table 1. Sampling locations

St.	Coordinate	Village	Land-use
1	7°36'87.09"S, 109°22'13.46"E	Kebumen, Baturraden District	Paddy field, farm, low-density residential area
2	7°39'17.72"S, 109°22'61.84"E	Beji, Kedung Banteng District	Paddy field, farm, mild density residential area
3	7°42'38.62"S, 109°22'42.08"E	Kober, West Purwokerto District	High-density residential area
4	7°45'77.81"S, 109°21'38.97"E	Sidabowa, Patikraja District	Paddy field and low-density residential area

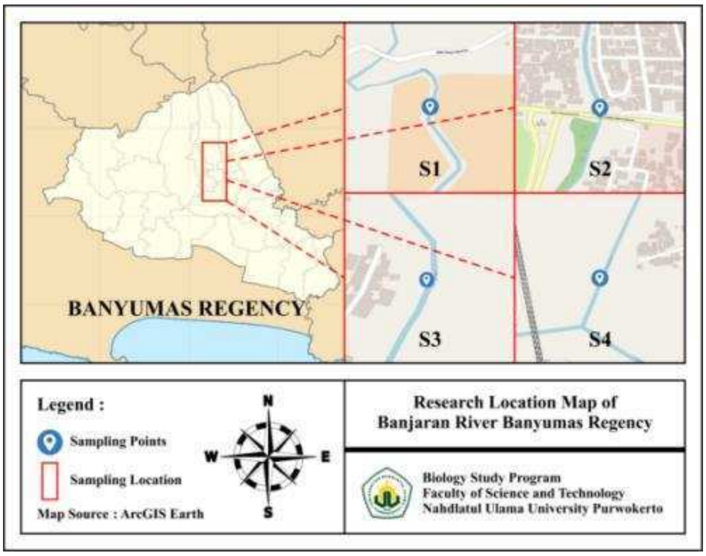

Figure 1. Map of research locations

2.1 Tools and Materials

This research required tools such as a stirring bar, 12 units of 250ml Beaker glass, 12 units of 500ml Beaker glass, aluminum foil, 12 aluminum dishes, 12 Petri dishes, an aluminum can (15cm in diameter), 100ml measuring glass, a camera, 36 transparent plastic bag 15x35cm, 36 transparent plastic bag 11x20cm, marking paper no 99, 36 Whatman filter paper no 42 (diameter 55mm, 2.5mcm pore), 12 Aluminium tray, binocular microscope, analytical scale, kitchen scale, oven, tweezer, 20ml pippete dropper, sieve shaker, stopwatch, hanging scale, tissue, stationery, GPS Map Camera apps.

Materials required in this research were clean water, 3600ml aqua dest, 1314g NaCl, and 36 sediment samples from Banjaran River, Banyumas Regency.

2.2 Analysis Procedure of Microplastic's Abundance and Composition

All analysis procedures were conducted in a laboratory adopting methods used by Yuwandita (2018) and Zientika et al. (2021) with minor adjustments.

1. Drying Phase
    a. Take 150g of wet sediment samples and place into oven
    b. Turn on the oven, set to 60°C for 24 hours

c. Weigh the dried samples

2. Density-based Sorting Phase
   a. Mix 50g of each dried sample with 150ml of saturated NaCl (a mixture of 36,5g NacL and 100ml aqua dest)
   b. Let them sit for 24 hours at room temperature
3. Filtering Phase
   a. Filter the supernatant from step 2 using Whatman paper no. 42
   b. Place the papers in Petri dishes and let them dry
4. Manual Selection Phase

Remove dried samples from Whatman paper then observe them under a microscope

Microplastic composition was analyzed using Microsoft Excel descriptive analysis and the result was presented in the form of percentages to determine the dominance of microplastic types at each station. Microplastic abundance analysis can be calculated using the formula used by Masura, *et al.* (2015) in their research.

$$K = \frac{n}{v}$$

Explanation:
K=abundance of microplastics (particles/50 gr)
n=microplastic count (particles)
v=dry weight of the sample (gr)

Sediment texture was analyzed using dry sieving and pipetting methods. Then, it was grouped based on their sizes following the classification guide from AGU (American Geophysical Union). The calculation of sediment weight percentage can be calculated using the formula used by Purnawan, *et al.* (2016) in their research. The analysis used to determine the effect of sediment texture on the composition and the abundance of microplastics is a simple linear regression test using SPSS 16.

3. RESULT AND DISCUSSION

3.1 Microplastic composition

Analysis results from four stations show that there are five types of microplastics found in the sediments of the Banjaran River in Banyumas Regency, namely fiber, film, foam, fragments, and pellets. The composition of microplastic types was obtained after analyzing under a microscope using a Nikon Type E-100, magnification 10x/0.25. The composition of microplastics found from sediment samples of Banjaran River, Banyumas Regency is presented in the form of a bar chart as shown in Figure 3.

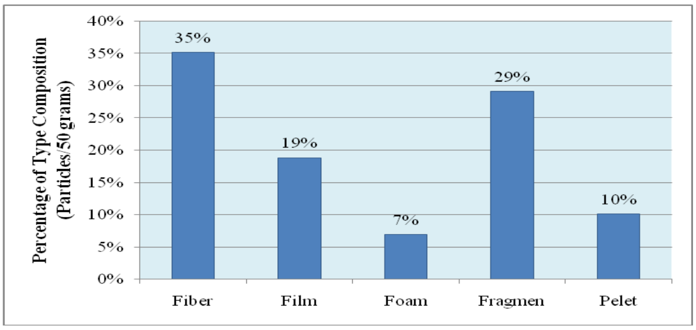

Figure 3. Microplastic composition percentage from all four stations (particles/50 grams)

The most dominant type of microplastic found is fiber, while the type of microplastic that is rarely found is foam. Research conducted by (Laila, Purnomo, & Jati, 2020) & (Alam et al., 2019) showed that fiber-type microplastics were found more in sediments. The high distribution of fiber-type microplastics comes from the fragmentation of nets used by fishermen or anglers to catch fish, textile material waste, and the process of washing clothes. Fiber-type microplastics mainly come from degraded plastic materials such as plastic sacks and various fishing gear but it is not rare to find such microplastics coming from textile industry waste, domestic waste, and construction waste (Ningsih, Yaqin, & Rahim, 2022) & (Migwi, Ogunah, & Kiratu, 2020).

The high fiber content found in sediments can harm aquatic biota. According to (Ta & Babel, 2020), fiber-type microplastics ingested by aquatic biota can form knots or clumps. This will be very dangerous for biota because fiber can close the digestive tract and block the entry of food. All aquatic life is likely to be contaminated with microplastics, especially fish. Several studies have shown that fiber is the most common type of microplastic found in fish (Nurwahyunani, Rakhmawati, & Cucianingsih, 2022) & (Choi et al., 2020).

The dominance of fiber in the fish digestive tract is thought to occur because the shape of the fiber can resemble its prey (Nie, Wang, Xu, Huang, & Yan, 2019). The dominance of fiber in the digestive tract and fish meat can also be attributed to its characteristics, which have the longest residence time in the stomach of the organism and have a larger aspect ratio than other types of microplastics. This causes fiber to attach to the digestive tract and fish tissues such as meat (Qiao et al., 2019).

In this study, foam-type microplastic was the least common type of microplastic found at all stations. This is also similar to research conducted by (Wu et al., 2020) where the density value of foam-type microplastics was found to be the lowest compared to other types of microplastics. In this study, foam-type microplastics will be seen floating on the surface of the supernatant during the filtering stage, but when the supernatant is poured into filter paper, the foam becomes the last particle to enter the filter paper and will even stick back with sediment. This is by the statement of (Wang, Wang, Ru, & Liu, 2019), where foam-type microplastics are less common because they have the lightest density compared to other types of microplastics, namely 0.05 g/cm^3. Foam will be more easily carried by water currents so the presence of foam is found more on the surface of the water than in the sediment.

3.2 Microplastic Abundance

The abundance of microplastics found in the four research stations is presented in histogram form as shown in Figure 5.

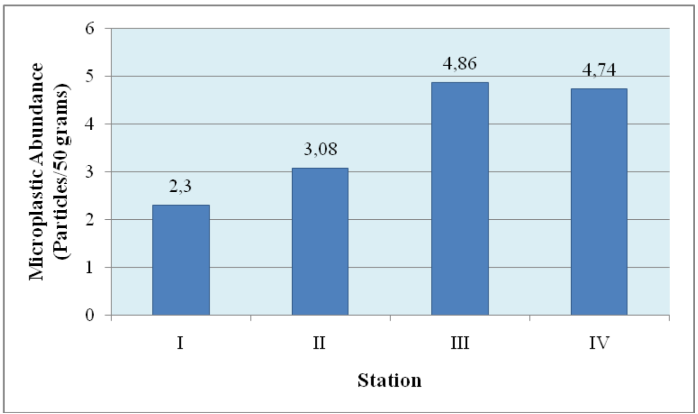

Figure 5. The abundance of microplastics found in each research station (particles/50 grams)

Based on Figure 5, it is known that the abundance of microplastics in the sediment of Banjaran River in Banyumas Regency ranges from 2.3 - 4.86 particles/50 grams of dry sediment. The results of the analysis of microplastic abundance in sediment samples obtained from the Banjaran River in Banyumas Regency showed that the abundance of microplastic particles was the highest at station III, which amounted to 4.86 particles/50 grams. This is because station III is located in an area with a high population density so the amount of microplastic accumulation is the highest compared to other stations. The lowest number of microplastic particles is found at station I, which is 2.3 particles/50 grams. This is because station I is the upstream part of the river with land use as rice fields, yards, and few settlements so the amount of microplastic accumulation is the least compared to other stations. In other words, the potential adverse effects of microplastics at station III on the environment, biota and humans are greater than other stations.

3.3 The Effect of Sediment Texture on Microplastic Composition and Abundance

The results of sediment texture analysis on sediment samples obtained from Banjaran River, Banyumas Regency the percentage value of sediment texture that dominates all four stations is sand. The percentage value of sand content in the sediment of each sampling point in Banjaran River in Banyumas Regency is between 85.71 - 87.42%. The effect of sediment texture on microplastic abundance in Banjaran River, Banyumas Regency was calculated using a simple linear regression test and the output result is $Y = -122{,}000 + 32{,}333X$. Based on the coefficients of the linear regression equation above, it is known that the constant is -122,000. This matter shows that if the sediment texture variable increases by 1 (one) unit, it will increase the abundance of microplastics by 32,333 units. The significance value is 0.005 or lower compared to 0.05, then the influence of sediment texture on the abundance of microplastics is significant.

A simple linear regression test on the effect of sediment texture on the composition of microplastics in Banjaran River, Banyumas Regency showed that sediment texture influences the abundance of microplastics by 56%. According to (Wahyuningsih, Bangun, & Muhtadi, 2018) & (Laila et al., 2020), which states that environmental conditions and sources of microplastic pollutants can affect the presence of microplastics in sediments, if there are more sources of pollutants, there will be more microplastics contained in sediments. Other factors can affect the difference in the presence of microplastics in sediments, namely the different experimental methods used in each study causing different data validation values. This makes each study difficult to compare.

Based on the results of the simple linear regression test on the effect of sediment texture on the five types of microplastic composition in Banjaran River, Banyumas Regency, it can be concluded that sediment texture contributes the highest level of influence on the composition of fragment types, which is 50.2%. This is by (Khatmullina & Isachenko, 2017) who stated that in addition to particle density and sedimentation rate, the type and size of microplastics are proven to play a role in the pattern of distribution and transportation in aquatic sediments. The research results of (He et al., 2021) confirmed that microplastics in sediments with lower particle density will have higher mobility, and vice versa. According to (Harris, 2020), fragments have the highest density compared to other types of microplastics. This high density causes fragments to easily sink in sandy sediments and settle to the bottom of the water.

4. CONCLUSION

Based on the result and discussion above, the following conclusions can be drawn from the composition of microplastic types found in the sediments of Banjaran River, Banyumas Regency were fiber (35%), fragments (29%), film (19%), pellets (10%) and foam (7%). The abundance of microplastics found in the sediments of Banjaran River in Banyumas Regency ranged from 2.3 - 4.86 particles/50 grams of dry sediment. Sediment texture had the strongest influence on fragment type composition at 50.2% with a correlation value of 0.709. Sediment texture also has a strong influence on the abundance of microplastics, which is 56% with a correlation value of 0.748.

ACKNOWLEDGMENT

The author would like to thank the supervisor of the Faculty of Science and Technology, Nadlatul Ulama Purwokerto University who helped in writing this article and the National Research and Innovation Agency (BRIN) as an institution that has allowed us to get Research Assistance for Research and Innovation Talents (BARISTA) in 2022 and Mr. Rofik Hananto, S.E., as the member of Commission VII of the House of Representatives of Central Java Electoral District VII who provided us with recommendations for said program (BARISTA) in 2022.

REFERENCE

Azizi, A., Maulida, N., Setyowati, W. N., Fairus, S., & Puspito, D. A. (2022). Microplastic pollution in the water and sediment of Krukut River, Jakarta, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *986*(1). https://doi.org/10.1088/1755-1315/986/1/012084

Choi, H., Lee, Y., Lim, C., Kim, Y., Lee, I., Jo, J., … Seo, D. (2020). Assessment of respiratory and systemic toxicity of Benzalkonium chloride following a 14-day inhalation study in rats. *Particle and Fibre Toxicology*, *17*(5), 1–19. https://doi.org/https://doi.org/10.1186/s12989-020-0339-8

Firdaus, M., Trihadiningrum, Y., & Lestari, P. (2020). Microplastic pollution in the sediment of Jagir Estuary, Surabaya City, Indonesia. *Marine Pollution Bulletin*, *150*(September), 110790. https://doi.org/10.1016/j.marpolbul.2019.110790

Harris, P. T. (2020). The fate of microplastic in marine sedimentary environments: A review and synthesis. *Marine Pollution Bulletin*, *158*(June), 111398. https://doi.org/10.1016/j.marpolbul.2020.111398

He, B., Smith, M., Egodawatta, P., Ayoko, G. A., Rintoul, L., & Goonetilleke, A. (2021). Dispersal and transport of microplastics in river sediments. *Environmental Pollution*, *279*, 116884. https://doi.org/10.1016/j.envpol.2021.116884

Khatmullina, L., & Isachenko, I. (2017). Settling velocity of microplastic particles of regular shapes. *Marine Pollution Bulletin*, *114*(2), 871–880. https://doi.org/10.1016/j.marpolbul.2016.11.024

Laila, Q. N., Purnomo, P. W., & Jati, O. E. (2020). Kelimpahan Mikroplastik Pada Sedimen Di Desa Mangunharjo, Kecamatan Tugu, Kota Semarang. *Jurnal Pasir Laut*, *4*(1), 28–35. https://doi.org/10.14710/jpl.2020.30524

Migwi, F. K., Ogunah, J. A., & Kiratu, J. M. (2020). Occurrence and Spatial Distribution of Microplastics in the Surface Waters of Lake Naivasha, Kenya. *Environmental Toxicology and Chemistry*, *39*(4), 765–774. https://doi.org/10.1002/etc.4677

Nie, H., Wang, J., Xu, K., Huang, Y., & Yan, M. (2019). Microplastic pollution in water and fish samples around Nanxun Reef in Nansha Islands, South China Sea. *Science of the Total Environment*, *696*, 134022. https://doi.org/10.1016/j.scitotenv.2019.134022

Ningsih, W., Yaqin, K., & Rahim, S. W. (2022). Microplastic contamination in coastal waters of South Larompong, Luwu, South Sulawesi, Indonesia. *Akuatikisle: Jurnal Akuakultur, Pesisir Dan Pulau-Pulau Kecil*, *6*(2), 101–108. https://doi.org/10.29239/j.akuatikisle.6.2.101-108

Nurwahyunani, A., Rakhmawati, R., & Cucianingsih, C. (2022). Kelimpahan Mikroplastik Pada Organ Pencernaan Ikan Mujair (Oreochromis mossambicus) di Waduk Malahayu Kabupaten Brebes. *Titian Ilmu: Jurnal Ilmiah Multi Sciences*, *14*(1), 18–22. https://doi.org/10.30599/jti.v14i1.1185

Qiao, R., Deng, Y., Zhang, S., Wolosker, M. B., Zhu, Q., Ren, H., & Zhang, Y. (2019). Accumulation of different shapes of microplastics initiates intestinal injury and gut microbiota dysbiosis in the gut of zebrafish. *Chemosphere*, *236*, 124334. https://doi.org/10.1016/j.chemosphere.2019.07.065

Samudra, S. R., Fitriadi, R., Baedowi, M., & Sari, L. K. (2022). Pollution level of Banjaran River, Banyumas District, Indonesia: A study based on the Saprobic Index of periphytic microalgae. *Biodiversitas*, *23*(3), 1527–1534. https://doi.org/10.13057/biodiv/d230342

Ta, A. T., & Babel, S. (2020). Microplastics pollution with heavy metals in the aquaculture zone of the Chao Phraya River Estuary, Thailand. *Marine Pollution Bulletin*, *161*(October), 111747. https://doi.org/10.1016/j.marpolbul.2020.111747

Wahyuningsih, H., Bangun, A. P., & Muhtadi, A. (2018). The relation of sediment texture to macro- and microplastic abundance in intertidal zone. *IOP Conference Series: Earth and Environmental Science*, *122*(1). https://doi.org/10.1088/1755-1315/122/1/012101

Wang, J., Wang, M., Ru, S., & Liu, X. (2019). High levels of microplastic pollution in the sediments and benthic organisms of the South Yellow Sea, China. *Science of the Total Environment*, *651*, 1661–1669. https://doi.org/10.1016/j.scitotenv.2018.10.007

Wu, N., Zhang, Y., Li, W., Wang, J., Zhang, X., He, J., … Niu, Z. (2020). Co-effects of biofouling and inorganic matters increased the density of environmental microplastics in the sediments of Bohai Bay coast. *Science of the Total Environment*, *717*, 134431. https://doi.org/10.1016/j.scitotenv.2019.134431