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The Abundance of Microplastics in Sediment Siak River Pekanbaru City

Tasya Anaya Dzaki Khalis[1], Ternala Alexander Barus[2*], Hesti Wahyuningsih[2]

[1] Master Program of Biology, Faculty of Mathematics and Natural Science, Universitas Sumatera Utara, Medan, Indonesia.
[2] Department Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan, Indonesia.

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Corresponding Author:
Ternala Alexander Barus
ternala@usu.ac.id

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Abstract: Sediments are temporary and long-term reservoirs for waste including microplastic particles. Microplastics are large-sized plastics that are under 5mm in size. microplastic particles with a density greater than water can enter the sediment and accumulate. High water utilization activities can be a way for plastic waste from land to enter the waters, one of the rivers that has high utilization is the Siak River in Pekanbaru city. This study aims to analyze the abundance and distribution of microplastics based on 3 (three) stations in the Siak River. The research procedure consists of sampling, microplastic separation, and microplastic analysis. The results showed that the Siak River in Pekanbaru city contained microplastic types of fragments (32%), films (31%), fibers (25%), and granules (12%). The highest abundance of microplastics was at station 1 with an average abundance of 32.67/kg which was dominated by fragment-type microplastics. The Siak River in Pekanbaru city has been contaminated with microplastics which can be intentionally or unintentionally eaten by aquatic biota.

Keywords: Microplastic; Sediment; Siak river

Introduction

Plastic is a group of synthetic polymers invented in 1950 and has experienced massive production over time (Chen et al., 2020), which has been recorded to be found in all marine waters in the world Generally, more than 92% of all plastic objects found in marine waters are smaller than 5 mm (Van Sebille et al., 2015). Plastics with sizes below 5mm have become a global environmental issue called microplastics, this is because microplastics have high persistence in the environment, contain toxic chemicals, and are ubiquitous (Enyoh et al., 2020). Plastic production also increases with the increase in population because plastics have versatile properties and are currently applied to everyday life (Pilapitiya et al., 2024). In fact, global plastic production is recorded at >395 million tons per year, which means that plastic production has increased 180 times since 1950 (Haque et al., 2023). Plastics can enter the waters to become pollutants intentionally or unintentionally (Thushari et al., 2020), Plastics in aquatic environments such as rivers are sourced from land (Enders et al., 2019). Rivers are the way microplastics enter the sea so that the sea becomes the final disposal site for plastic particles, for example Indonesia is the largest contributor of plastic to the oceans in Asia with an average entry of plastic with a range of 9.80-63.70 tons per year sourced from fresh waters such as rivers (Lebreton et al., 2017).

Siak River is one of the deepest rivers in Indonesia and the largest river in Riau province (Onrizal et al., 2020). Administratively, this river is located in Riau province and passes through several regencies or cities, namely Rokan Hulu Regency, Kampar Regency, Siak Regency, Bengkalis Regency and especially Pekanbaru City. The rapid progress of Pekanbaru City followed by a population of 1.123.34 people, with a population growth rate from 2020-2023 of 2.99% will gradually increase the amount of plastic waste that can affect the

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aquatic ecosystem of Pekanbaru City. Plastic waste that enters river waters will undergo a degradation process into smaller sizes and become microplastics (Li et al., 2022). Then, Microplastics in rivers can enter to marine waters (Meng et al., 2015). But in this case, freshwater waters can store plastic in the temporary or long-term (Onoja et al., 2022; Sulaiman et al., 2023). The storage of plastic in freshwater waters is due to the deposition of plastic in sediments (Hurley et al., 2018). A number of variables, including water turbidity, coastline relief (sea), bathymetry, currents, tides, and distance to point sources, influence the entry of MP into bottom sediments (Uddin et al., 2021).

Sediment is a fragment of material carried by wind or water that is deposited at the bottom of the water due to the mechanical process of river currents. Sediment is considered a long-term shelter for microplastics (Van Cauwenberghe et al., 2015). Living organisms that are filter feeders have the ability to consume microplastics that sink to the bottom of the water in the sediment (Priyambada et al., 2023). In previous studies, microplastics stored in sediments caused ingestion of mp in shellfish organisms, fish and turtles (Akoueson et al., 2020). In this article we provide a report on the composition and abundance of microplastics in sediments in the Siak River Pekanbaru city, composition and abundance data can describe the distribution and source of plastic entry into water bodies. Differences in collection areas and sediment characteristics can cause variations in results along the river. The data in this article can be used for further management of the Siak River water environment and as a source for the lack of information about the presence of microplastics in the Siak River in Pekanbaru city.

Method

Location

The research was conducted in December 2023. The method used was purposive sampling method with three sampling stations (Figure 1). Station 1 is an observation point located under the Siak II Bridge on the Sumatra Cross Road, Rumbai Pekanbaru Subdistrict, this station is located in the upper reaches of the Siak River in Pekanbaru City which borders Kampar Regency, this location is at the coordinates 0°33'08.6 "N 101°24'00.4 "E.

Station 2 is an observation point that has coordinates 0°32'36.6 "N 101°25'56.6 "E, this point is located in the middle area of the Siak River that crosses the city of Pekanbaru so that this area has a fairly high utilization because at this location it is adjacent to residential areas, fish cages of fishermen, and the floodgates of the Siak River in Pekanbaru city. Station 3 is located in the active port area of Pekanbaru city which is located on Tanjung Datuk street Kec. Lima Puluh, Pekanbaru City, this location is located at coordinates 0°33'06.5 "N 101°27'42.0 "E.

Research Procedure

Sample Collection

Sediment samples are collected from the riverbed using an ekman grab, the ekman grab is lowered to the bottom of the water with a rope and then the dredged sample will be put into a container that has been prepared as much as ± 1 kilogram, then the sample container is tightly closed and put into a cool box.

Isolation of Microplastics

To analyze microplastics, it is necessary to carry out a separation stage, the separation of microplastics from sediments is carried out in stages: drying, volume reduction, density separation, screening, and visual sorting (Priyambada et al., 2023). Sediment samples were oven dried at 60˚C for 24 hours until the sediment grains did not stick together. The dried sediment was then pulverized using a mortar and pestle. Furthermore, the density separation stage by mixing a saturated NaCl solution as much as 3 times the weight of the sediment into the sediment, then stirring for 2 minutes (Rani et al., 2023; Schütze et al., 2022). After stirring the sediment sample bath is allowed to stand for 1 hour, the light plastic will separate and will be at the top. Furthermore, the supernatant (the floating part) is filtered with a mesh sieve and continued by filtering again using Whattman grade GF/A 47mm filter paper.

Observation and Identification of Microplastics

Filtered microplastics are visually analyzed, for smaller microplastics, visual analysis is carried out with the help of a binocular microscope with a magnification of 10x then microplastics are weighed, and visually analyzed (Vermeiren et al., 2020).

Analysis of Sediment Types

Sediment samples were collected as much as 50gr from each station in Siak River Pekanbaru City. Samples that have been obtained are then stored for further analysis. Determination of soil texture class was conducted using the hydrometer method. A total of 50g of soil was weighed and put into 600 mL beaker glass. Then added 25mL of 30% H_2O_2 and allowed to stand for 15 minutes. Then added 250 mL of distilled water and 100 mL Calgon reagent 5%. Determination of the type of sediment in the sample of each station is done using the USDA (United States Department of Agriculture) triangle.

Data Analysis

Data analysis is quantitative descriptive, with identification and classification of microplastics based on the shape, color, and distribution of microplastic abundance in sediment samples from the Siak River. Microplastics were categorized into four groups based on their morphologies using a technique from earlier research: fiber, fragment, pellet, and film (Jiang et al., 2018). For quantification, the calculation of microplastic abundance in sediments uses the equation by Masura et al. (2015), Microplastic abundance in sediment:

$$K = \frac{\text{n (Sample particle)}}{\text{v}} \tag{1}$$

Description:
K : Microplastic abundance (Particles/kg)
n : Number of Microplastics
v : Sample Volume

Result and Discussion

Type of Microplastics

The types of microplastics found in each sediment sample was found from the previously conducted analysis sediment samples of the Siak River in Pekanbaru city. The samples are fiber, film, fragments, and granules (Figure 1). Each type of microplastic was found at all sampling stations in the Siak River. The most dominant type of microplastics found was fragment-type microplastics with a percentage of 32% (Figure 1) and a total of 82 particles. This is the same as previous research on the sediments of the Sibam River, a tributary of the Siak River where the fragment type was found to be the most dominant in aquatic sediments.

Microplastics of the fragment type were found at every station location. Fragment-type microplastics are shaped like flakes or small pieces of larger plastics, fragment microplastics are asymmetrical in size and thickness (Dimassi et al., 2022; Hartmann et al., 2019). Fragments are hard flakes derived from the degradation of larger plastics that break down and fragment through photo, physical, or biological degradation into smaller particles (Lambert et al., 2016; Yuan et al., 2022). Sample fragments were found to dominate because in general, samples such as PVC, nylon, and PET that have a density exceeding the density of water will sink and are more easily found in sediments because they have a greater density (Alomar et al., 2016; Woodall et al., 2015) while polymers with lower densities will be lighter and on the surface of the water (Carr et al., 2016).

Film-type microplastics had a 31% presentation of presence with a total of 78 particles. Film microplastics are microplastics in the form of thin sheets and tend to be transparent Film microplastics come from food packaging, plastic bags, and other household activities that end up in the waters. The use of film-type plastics in large quantities and in everyday life causes film-type microplastics to spread in waters.

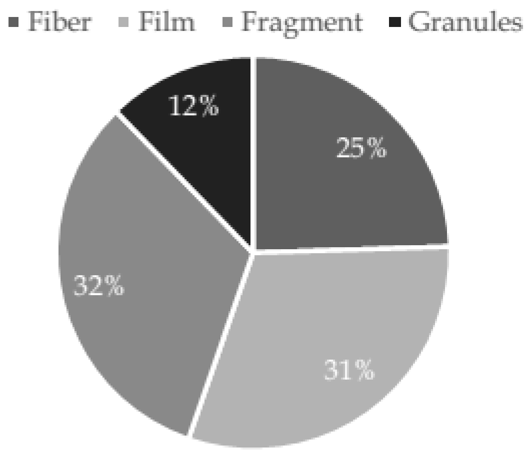

Figure 1. Percentage of total microplastics types

Microplastic fibers were present in every sediment sample with a presentation of 25%, totaling 61 particles. In previous studies, fiber is a microplastic present in sediments, subsurface water, and even sea ice (Martínez Silva et al., 2020).While granule-type microplastics are microplastics that are slightly found from each station. this type of microplastic is almost round in shape and comes from primary microplastics, in water samples a presentation of granule microplastics was found at 12%.

Color of Microplastics

Based on the color of microplastics in sediment samples there are 6 colors namely black, transparent, blue, white, purple, and pink. Figure 2 shows the comparison of colors found at each sampling station.

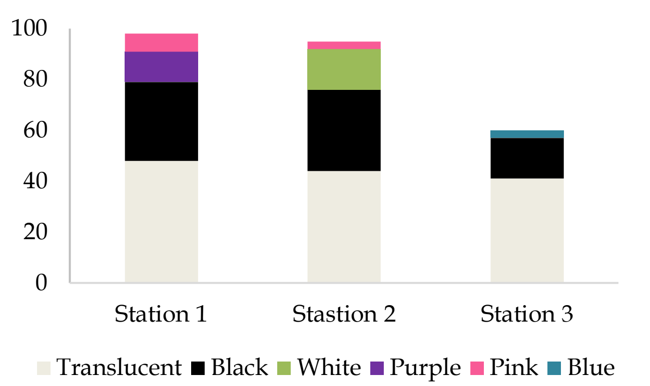

Figure 2. Comparison color of microplastic from each station

Syakti et al. (2018) claim that observing the color of microplastics can help identify the source of contaminants. Because these microplastics resemble their diet, the presence of color or transparency enables marine or freshwater biota to consume them (Borriello et al., 2023). The color of the microplastic also reveals the extent of weathering and the duration of residence time at the ocean's surface (Khuyen et al., 2022; Pan et al., 2019). A yellowish hue denotes an extended period of exposure to the water and oxidation (Ridlo et al., 2020).

The abundance of Microplastics

The abundance results and comparison of the abundance of microplastics found in the visual analysis are in the table 1.

Table 1. Total Abundance of Microplastics Between Every Station at the Siak River

Station Point		Abundance of Microplastics (particle/kg)	Average per station (particle/kg)
	1	26	
1	2	34	32.67
	3	38	
	1	32	
2	2	7	31.67
	3	56	
	1	31	
3	2	16	20
	3	13	

The results of this study's microplastic abundance in the Siak River of Pekanbaru city showed the level of microplastic contamination in the sediments of the Siak River of Pekanbaru city. The average abundance of microplastics in the Siak River was 32.67 particles/kg at station 1, 31.76 particles/kg at station 2 and 20 particles/kg at station 3 as seen in table 1.

Location with the highest abundance of microplastics is station 1, one of the factors that cause high particles at this station is the type of sediment owned by station 1 is a type of sandy clay loam with a clay fraction of 21%, small sediment grain size can precipitate particles more easily (Nugroho et al., 2018; Watters et al., 2010) than sediments such as rocks or gravel. Different sediment grain sizes can affect the integration of particles and sediments (Chakraborty et al., 2015).

The abundance of film-type microplastics dominates two sample points, namely sample points 1 and 3, while sample point 2 is dominated by the abundance of fragment-type microplastics with a larger amount when compared to the abundance of film at sample points 1 and 3 (Figure 3). Film-type microplastics originate from the degradation of plastic bags into smaller pieces (Sari et al., 2022; Tziourrou et al., 2021), this type of microplastics is thought to be sourced from household waste.

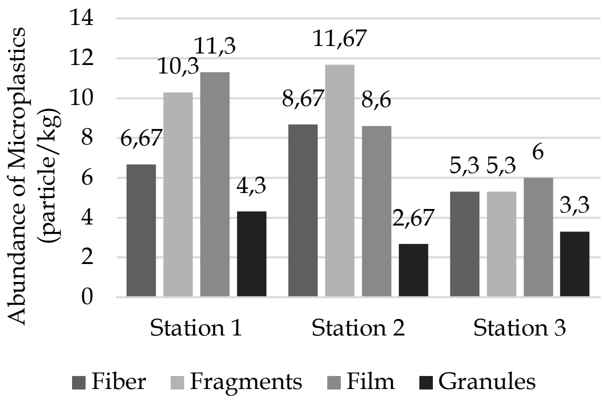

Figure 3. Comparison abundance of type microplastics

Conclusion

Microplastics were found in Siak River sediments from all sampling stations. Various types and colors of microplastics were found in these research areas. The samples found consisted of fragments (32%), films (31%), fibers (25%), and granules (12%). The highest abundance of microplastics was found at station 1 with an abundance of $32.67/m^3$. The color variations of microplastics found were transparent, black, white, pink, purple, and blue. Transparent color dominated all sediment sampling stations. Microplastics in sediments are thought to come from household waste, aquaculture and fishing activities, and industrial waste.

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Author Contributions

Conceptualization, T. A. D. K., T. A. B., H. W.; methodology, T. A. D. K.; validation, T. A. B. and H. W.; formal analysis, T. A. D. K.; investigation, T. A. B., and H. W.; resources, T. A. D. K. and T. A. B.; data curation, H. W.: writing—original draft preparation, T. A. D. K and T. A. B.; writing—review and editing, T. A. D. K.: visualization, and T. A. B.and T. A. D. K. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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