ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology, 2025, 26(2), 96–108
https://doi.org/10.12912/27197050/196801
ISSN 2719–7050, License CC-BY 4.0

Received: 2024.11.20
Accepted: 2024.12.20
Published: 2025.01.01

Presence of microplastics in surface waters and sediments of urban tropical river: A case study in the Karang Mumus River along Samarinda City, Indonesia

Hamdhani Hamdhani[1*], Abdunnur Abdunnur[1], Dea Saputri[1], Drew Elliot Eppehimer[2]

[1] Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Mulawarman University, Samarinda, Indonesia
[2] School of Natural Resources and the Environment, University of Arizona, Tucson, AZ, United States
* Corresponding author's e-mail: hamdhani@fpik.unmul.ac.id

ABSTRACT

The global prevalence of plastic use has raised concerns regarding microplastic pollution, which is widespread in water bodies around the world and poses significant risks to aquatic life. However, uncertainties still exist regarding the amount, types, and chemical composition of microplastics, particularly in tropical urban rivers. This study provides *scientific novelty* by offering the first comprehensive assessment of the abundance, distribution, types, and chemical makeup of microplastics in both the surface water and sediment of the urban tropical Karang Mumus River in Samarinda City, East Kalimantan, Indonesia – an area previously unexplored in this context. Microplastics were present in all surface water and sediment samples collected from six different sampling stations, with an average of 3.61 ± 1.26 particles/L in surface water and 1222.22 ± 308.80 particles/kg in sediment. The average microplastic concentrations observed in this study fall within the range reported in other urban river systems. No clear pattern was identified concerning the concentration of microplastics along the river from upstream to downstream. Microplastic fibers, fragments, and films were frequently detected, with films being the most common type found, followed by fibers and fragments in both surface water and sediment. In the surface waters, most particles were identified as polyethylene, followed by polystyrene, nylon, olefin fiber, and polypropylene. In the sediments, polyethylene was also the most common, followed by polypropylene, polystyrene, olefin fiber, and polyvinyl chloride. This research advances our understanding of microplastic pollution in under-studied tropical urban river systems and serves as a baseline for future studies and mitigation strategies.

Keywords: water quality monitoring, polymer, freshwater, non-point source pollution, lotic system.

INTRODUCTION

Microsplastics are often defined as plastic particles smaller than 5mm. Sources of microplastic particles can be classified into two types (An et al., 2020). First, primary sources, where microplastic particles originate from plastic pellets intentionally produced as raw materials for manufacturing various types of derivative plastic products. Additionally, there are plastic pellets (microbeads) produced and used as ingredients in personal care products (Kalčíková et al., 2017). The second source is secondary sources, where microplastic particles result from the fragmentation of various plastic materials. Although plastic materials are relatively durable, they undergo fragmentation into smaller sizes, including micro-sized particles, due to fragmentation processes caused by oxidation, weathering pressure, and biological activity (Andrady and Koongolla, 2022). Various poorly managed urban activities often become sources of plastic waste, including microplastics, in water bodies (Qiu et al., 2020).

Fish are among the aquatic organisms most vulnerable to consuming microplastic particles, either intentionally or unintentionally (Hamdhani et al., 2024). These particles often resemble microorganisms (natural prey), increasing the chances that aquatic species will consume them or could be incorporated into benthic matrices of algae, sediment, and biofilm and thus are susceptible to inadvertent consumption by benthivores or grazers (Lehtiniemi et al., 2018; Krause et al., 2021). Concerns arise because microplastic particles have the capacity to bind various hazardous and toxic substances (Rafa et al., 2023). Additionally, various additives used during the production of plastics can leach into the environment, potentially having negative impacts on aquatic organisms, such as disruptions to reproductive processes and feeding habits (Banaee et al., 2024). Given the importance of aquatic organisms, especially fish as a food source, the presence of microplastics in aquatic environments requires serious attention.

The presence of microplastic particles has been detected in various aquatic environments, both marine and freshwater, including rivers (Gola et al., 2021; Hamdhani et al., 2024). Rivers flowing through urban areas show a higher occurrence of microplastic particles compared to those flowing through non-urban areas (Xu et al., 2021). This is largely due to the contribution of urban runoff and drainage, which carry various types of anthropogenic materials, including microplastic particles, into urban rivers (Wang et al., 2022).

In tropical regions with high rainfall intensity, the elevated runoff in urban areas, where water infiltration areas are relatively limited, further exacerbates the accumulation of anthropogenic materials, including microplastics, in surrounding water bodies. The operation of urban wastewater treatment facilities also affects the amount of microplastics released into city rivers (Iyare et al., 2020). In fact, many cities worldwide still lack adequate wastewater treatment facilities, or in some cases, do not have them at all (Hamdhani et al., 2020).

The Karang Mumus River, located in the heart of Samarinda City, the capital of East Kalimantan Province, Indonesia, is directly impacted by the lack of a municipal wastewater treatment facility in the city. As a result, untreated urban wastewater is discharged into the drainage system, eventually entering the river. This raises concerns about potential contamination of the river's water and sediment with microplastic particles. Although there have been reports of fish species in the Karang Mumus River consuming microplastic particles (Hamdhani et al., 2024), there is currently no data on the concentration of microplastics in its water or sediment (Figure 1). This highlights the pressing need for research into the abundance, distribution, particle types, and polymer characteristics of microplastics in the river's water and sediment.

METHODOLOGY

Study location description

Pujowati et al. (2010) quantified that the catchment area of the Karang Mumus River is estimated to cover approximately 32.000 ha. The upstream section of the river consists of a reservoir fed by flows from several creeks. Calculations using ArcGIS revealed that the length of the Karang Mumus River from the reservoir to its

Figure 1. Karang Mumus River at an urban stretch

confluence with the Mahakam River is approximately 18 km. The Karang Mumus River flows through several densely populated areas, including passing by traditional markets, where illegal waste disposal into the river by the community still frequently occurs. The population density in Samarinda City reaches approximately 1.200 people km^{-2} (Central Agency of Statistics, 2021).

Sampling

Field sampling was conducted on October 29, 2023, at six selected sites along the Karang Mumus River. The last rainfall before sampling occured on October 25, 2023 as much as 15 mm. The sampling locations were selected based on their accessibility to the public and a minimum separation of 2.2 km between sites to minimize spatial autocorrelation. These sampling sites become progressively more urban as you move downstream (Figure 2). At each site, three measurements were taken: two from opposite sides near the riverbank and one from the middle of the river. The average distance between the sampling sites was approximately 3–4 kilometers. To assess microplastic concentrations in surface water, a filtration method was used. This involved filtering approximately 50 liters of river water, collected within 30 cm of the surface, using a plankton net with a mesh size of 50 µm. The cod end of the net was then rinsed with distilled water into 500 ml glass mason jars. To minimize contamination, the glass jars were rinsed with distilled water and sealed before sample collection. For assessing microplastic concentrations in sediment, a Van Veen grab sampler was used, capable of collecting up to 1 liter of wet sediment. The sediment from each sampling point was transferred into 500 ml mason jars and labeled. The sediment type at all stations was qualitatively evaluated and identified as silty mud.

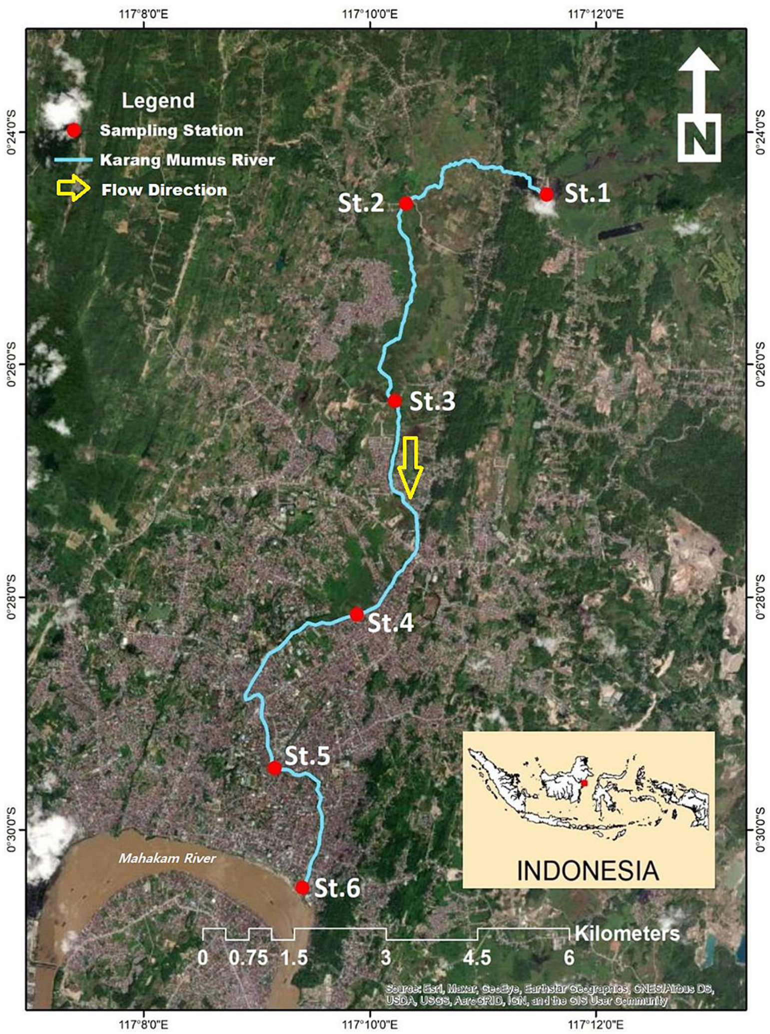

Figure 2. Map of sampling stations along Karang Mumus River

Sample processing

The water samples were filtered using a vacuum pump and a specialized filter to capture microplastics (47 mm diameter, 1.6 μm pore size). To prevent excessive buildup, several filters were used for samples with high silt content. The filters were then carefully removed, placed in aluminum cups, and dried in an oven at 60 °C for 3 hours.

For the sediment samples, microplastics were extracted using a density separation protocol based on the method outlined by Stock et al., (2019). The sediment was first oven-dried at 60 °C for approximately 48 hours until it reached a constant weight. The dried sediment was then homogenized using a ceramic mortar. Approximately 20 grams of this homogenized sediment were subjected to density separation using a saturated NaCl solution in a mason jar, following the procedure described by Löder and Gerdts (2015). The jar was vigorously shaken, allowing plastic particles, due to their lower density, to float and separate from the sediment. These floating particles were then carefully collected from the supernatant by filtration using a vacuum pump, similar to the water samples.

The digestion process of the samples was carried out if a significant amount of organic material was found. If not, the prepared water and sediment samples were directly observed using a dissecting microscope with a maximum magnification of 45×. Through microscopic observation, the types of microplastic particles, such as fibers, fragments, films, and beads, were identified following the guidelines developed by Hidalgo-Ruz et al. (2012). To minimize the risk of contamination by airborne synthetic microplastics during sample processing, the investigators used 100% cotton laboratory coats. All materials used in sample processing were thoroughly cleaned with distilled water before and after use. Beakers and aluminum cups were kept covered when not in use, and all processes were conducted in a laboratory with closed doors and windows to reduce external contamination.

Data analysis

Microplastic concentrations in surface water are measured in particles per liter of water, while in sediment, the concentration is reported as particles per kilogram of dried sediment. These units were chosen because they are standard in many microplastic studies (Dong et al., 2020; Eppehimer et al., 2021). The normality of data variation was first identified using the Skewness-Kurtosis test. Based on the normality test results, if the data meet the normality assumption, a one-way ANOVA was conducted. However, if the data do not meet the normality assumption, the Kruskal-Wallis test was used to determine the significance of differences between sample groups. A significance level of *alpha* < 0.05 is applied in these statistical tests. All statistical calculations are performed using Stata software (version 15.1) (Stata Statistical Software, 2017).

Attenuated total reflection Fourier-transform infrared spectroscopy (ATR-FTIR) was employed to identify the types of polymers. A proportional selection of microplastic particles, ranging in size from 1 to 5 mm, was made for this analysis. Fifty suspected microplastic particles were randomly chosen from both water and sediment samples to confirm their polymer types.

RESULTS AND DISCUSSION

Occurrence and spatial distribution of microplastics

Microplastics were detected in all surface water samples across the six sampling stations (St), with concentrations ranging from 2.73 to 4.79 particles per liter, and an average of 3.61 ±1.26 particles per liter (Table 1). The highest concentration was recorded at St.6, located at the confluence with the Mahakam River, with 4.79 particles per liter. Conversely, the lowest concentration was found at St.3, with 2.73 particles per liter (Figure 3). Similarly, microplastics were also detected in sediments at all six stations. The highest concentration in sediment was observed at St.5, with 1416.67 particles per kilogram, while the lowest was at St.1, with 983.33 particles per kilogram, and an across site average of 1222.22 ± 308.80 particles per kilogram.

Several factors, such as plastic properties, hydrological conditions, and weather patterns, can influence the distribution of microplastics in surface waters and sediments (Liedermann et al., 2018; He et al., 2021). Previous research has shown that microplastic concentrations in river systems tend to increase downstream, due to increasing inputs from urban runoff and atmospheric deposition along the river's length (McCormick

Table 1. Abundance of microplastics by types collected from surface waters and sediments

Station	Sub-station	Surface waters (particles/L)					Sediments (particles/kg dried sediment)				
		Fiber	Fragment	Film	Bead	Total	Fiber	Fragment	Film	Bead	Total
St.1	River right	0.76	0.36	0.56	0	1.68	200	400	800	0	1400
	Thalweg	1.16	1.32	1.84	0.12	4.44	300	150	300	0	750
	River left	1.04	0.92	1.36	0.04	3.36	0	350	450	0	800
Average						3.16					983.33
St.2	River right	2.28	1.88	2.04	0	6.2	1000	100	350	0	1450
	Thalweg	1.96	0.6	1.32	0.04	3.92	550	50	200	0	800
	River left	1.88	0.4	1.32	0	3.6	650	200	200	0	1050
Average						4.57					1100.00
St.3	River right	1.68	0.56	0.76	0	3	500	300	750	0	1550
	Thalweg	1.8	0.64	0.8	0	3.24	400	350	600	0	1350
	River left	1.32	0.4	0.24	0	1.96	450	250	200	0	900
Average						2.73					1266.67
St.4	River right	0.8	0.68	1.52	0	3	400	250	450	0	1100
	Thalweg	0.8	0.96	2.6	0.04	4.4	400	350	500	0	1250
	River left	0.28	0.44	1.2	0	1.92	550	400	550	0	1500
Average						3.1					1283.33
St.5	River right	0.68	1	2.32	0	4	200	500	1000	0	1700
	Thalweg	0.4	0.48	1.36	0	2.24	150	550	750	0	1450
	River left	0.88	0.6	2.16	0	3.64	200	200	700	0	1100
Average						3.29					1416.67
St.6	River right	0.84	1.32	2.72	0	4.88	100	350	1150	0	1600
	Thalweg	0.4	0.56	2.64	0	3.6	250	400	750	0	1400
	River left	0.92	1.28	3.68	0	5.88	50	300	500	0	850
Average						4.79					1283.33
		Total Average = 3.61 ±1.26					Total Average = 1222.22 ±308.80				

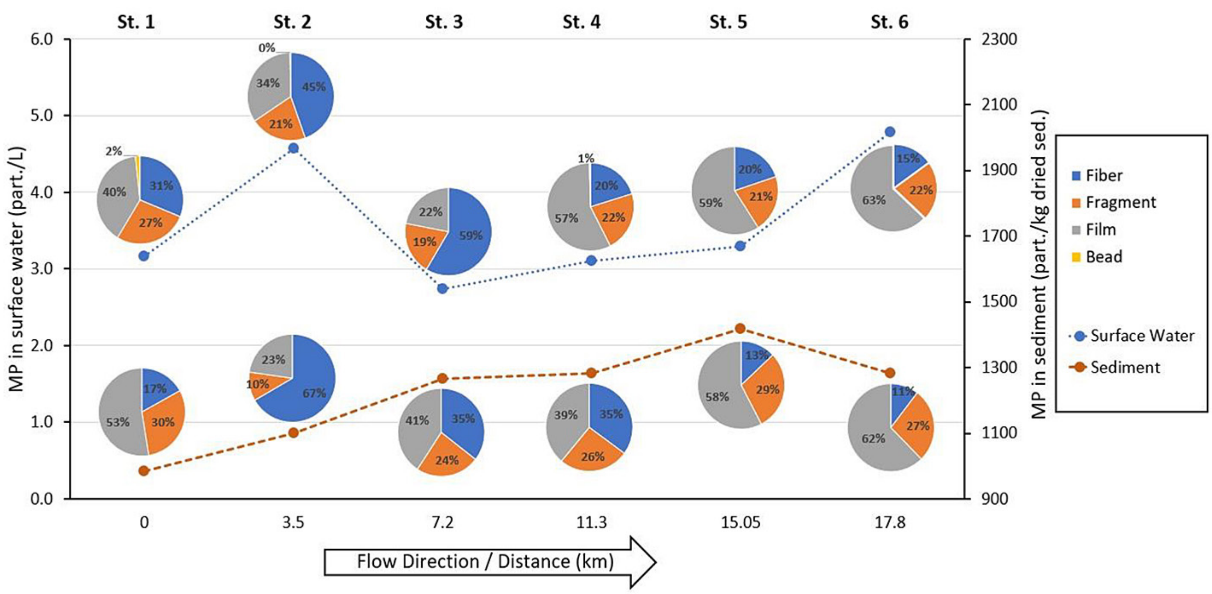

Figure 3. Abundance of microplastics in surface waters and sediments through flow distance of Karang Mumus River

et al., 2014; Kernchen et al., 2022). In this study, such a pattern was not obvious: variations in microplastic concentrations were observed in both surface waters and sediments, indicating that concentrations at certain sites were not always higher than those upstream. For instance, in the Karang Mumus River, the surface water at St.2 had a higher microplastic concentration than the downstream stations (St.3–5). In the sediments, microplastic concentrations generally increased along longitudinal downstream, except at St.6, where a slight decline was noted. St.6 is located at the confluence of the Karang Mumus River and the Mahakam River, which is a much larger river and significantly affects the tide patterns in the Karang Mumus River. Previous studies have indicated that tidal influences at river confluences can impact the concentration and distribution of microplastics in both surface waters and sediments (Lin et al., 2018; Fatema et al., 2023). Despite the variations in microplastic concentrations among stations in this study, no significant differences were found between the stations in either surface waters or sediments (Kruskal-Wallis test, $p > 0.05$).

The average concentration of microplastics in the surface water of the Karang Mumus River (3.61 ± 1.26 particles/L) falls within the range reported in some literature (Table 2). Our observed microplastic concentrations in water was relatively higher compared to those found in the more densely populated Tsurumi and Arakawa Rivers in Japan. Interestingly, the Tsurumi River's catchment area is slightly smaller, while the Arakawa River's catchment is nearly ten times larger than that of the Karang Mumus River (Kameda et al., 2021; Sankoda and Yamada, 2021). Japan is also a developed nation with waste collection and recycling services as well as wastewater treatment facilities (Takeuchi and Tanaka, 2020), which likely contributes to the lower concentrations relative to our samples. Microplastic concentrations in the Karang Mumus River are relatively similar to those observed in the urban Pearl and Fenghua Rivers in China, the Vistula River in Poland, and the Brantas and Ciwalengke Rivers in Indonesia, even though these rivers have much larger catchment areas compared to the Karang Mumus River (Alam et al., 2019; Buwono et al., 2021; Lin et al., 2018; Sekudewicz et al., 2021; Xu et al., 2021). Conversely, a study reported significantly higher microplastic concentrations in the surface waters of the Day River in Vietnam (Thi et al., 2021).

The average microplastic concentration (Table 1) observed in this study (1222.22 ± 308.80 particles/kg of dried sediment) falls within the range reported by Lin et al. (2018) for the Pearl River in China but is higher than those documented for

Table 2. Results of microplastic particle concentration in surface waters and sediments collected from several other studied urban river systems

River – catchment	Location	Residents	Concentration in surface waters (particles/L)	Concentration in sediments (particles/kg dried sediments)	Reference
Tsurumi River – 235 km^2	Japan	2 million (2021)	0.3–1.24	–	Kameda et al., 2021
Pearl River – 453,700 km^2	Guangzhou, China	15 million (2016)	0.38–7.92	80–9597	Lin et al., 2018
Arakawa River – 2940 km^2	Tokyo, Japan	37 million	0.0018	–	Sankoda and Yamada, 2021
Vistula River – 183,174 km^2	Warsaw, Poland	3.27 million	1.6–2.55	190–580	Sekudewicz et al., 2021
Day River – 7500 km^2	Vietnam	–	270 ± 61 - 863 ± 132	–	Thi et al., 2021
River Tame – 146 km^2	Birmingham, UK	1.1 million (2021)	–	165	Tibbetts et al., 2018
Multiple rivers	China	–	–	802	Peng et al., 2018
Yushan River	China	–	–	30–70	Niu et al., 2021
Fenghua River	Ningbo, China	9.6 million	0.3–4.0	–	Xu et al., 2021
Ciwalengke River	Majalaya, Indonesia	–	5.85 ± 3.28	30.3 ± 15.9	Alam et al., 2019
Brantas River – 11.900 km^2	East Java, Indonesia	–	0.13–5.47	–	Buwono et al., 2021
Karang Mumus River – 322 km^2	Samarinda-Indonesia	834,824 (2022)	3.61 ±1.26	1222.22 ±308.80	This study

the Vistula River in Poland, the River Tame in the UK, the Ciwalengke River in Indonesia, and several other rivers in China (Peng et al., 2018; Alam et al., 2019; Tibbetts et al., 2018; Niu et al., 2021; Sekudewicz et al., 2021).

Sediment samples can provide insights into the long-term interactions between water and land interfaces (Eppehimer et al., 2021; Lwanga et al., 2022) and provide valuable insights into the movement and fate of pollutants. The Karang Mumus River flows through the urban areas of Samarinda City and is affected by various anthropogenic activities. Microplastics in this area likely originate from land-based, residential sources and are transported via storm water runoff or sewage discharge into the river. Other sources include illegal residential settlements that still exist in some parts of the riparian buffer zone along the Karang Mumus River. The Samarinda City Government has been working to gradually relocate residents living along the riverbanks since 1998 (Shafira et al., 2019), but some areas still have residents living close to the river (Figure 1). Additionally, untreated sewage from the city that discharges into the Karang Mumus River may also introduce microplastics into the river system. Through the process of deposition, microplastics tend to accumulate in river sediments, making it challenging to assess the risk posed by microplastics in freshwater sediments due to the complex transport and accumulation processes involved.

Morphological characteristics of microplastics

Microplastic fibers, fragments, films, and beads were frequently found in surface water samples (Figure 4). All types of microplastics were detected at every substation, except for beads, which were only observed at two substations in St.1 and one substation each in St.2 and St.4. Films were the most prevalent type, making up 47% of the total and present in 100% of surface water samples. Fibers were the second most common, accounting for 31%, and were also found in all surface water samples. Fragments were the third most common type, constituting 22%, and were present in 100% of surface water samples. Beads, however, were much less common, making up only 0.37% of the total and detected in just 33.3% of the surface water samples (not shown in the graph).

In sediment samples, microplastic fibers, fragments, and films were commonly observed, but no beads were detected (Figure 4). Similarly, films were the most prevalent type in sediments, comprising 46% of the total microplastic concentration and found in 100% of the sediment samples. Fibers were the second most common type, accounting for 29%, and were present in 87.5% of the sediment samples. Fragments made up 25% of the total and were found in all sediment samples.

There was no significant difference in the distribution of microplastic types between surface waters and sediments (Kruskal-Wallis test, $p = 0.06$). In this statistical analysis, microplastic beads were excluded due to their very small proportion (< 1%) in surface water samples and their absence in sediment samples.

Our findings that film was the most common type of microplastic in both surface waters and sediments is intuitive due to the prevalence of plastic bag use in Samrinda City. Microplastic film are secondary microplastics typically created by the fragmentation of plastic packaging and plastic

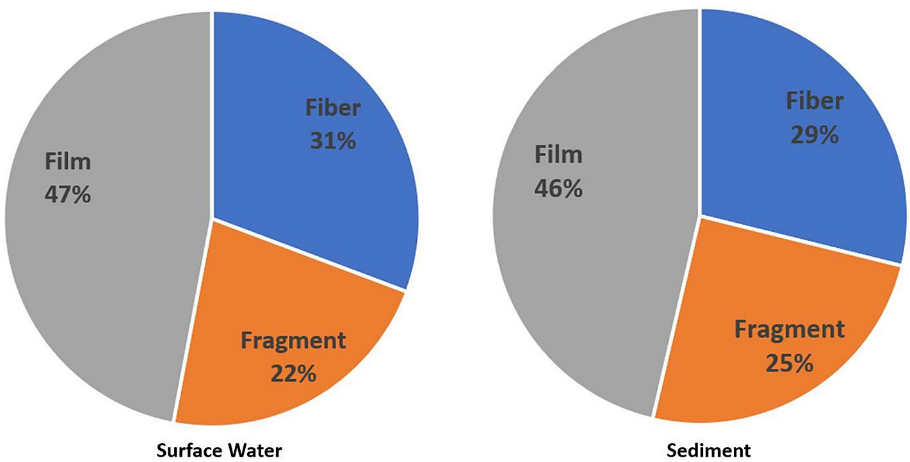

Figure 4. Percentage of microplastic particle types

bags (An et al., 2020). Like many other developing cities worldwide, Samarinda, with a population of over 800,000, relies heavily on plastic wrappings and bags for daily convenience. Unfortunately, most of these plastics are not properly recycled or disposed of, leading to their breakdown into microplastics through various processes (An et al., 2020). A lack of public awareness about proper plastic disposal contributes to this issue.

These findings also indicate that fiber microplastics are the second most commonly found type. Fiber microplastic particles are typically derived from textile products (Rebelein et al., 2021). The supply of fiber particles in aquatic environments generally originates from the degradation of textile materials. Clothing and various types of fabrics release numerous fiber particles during use and washing. It is estimated that nearly 2.000 particles are released from a single garment or piece of fabric during washing (Browne et al., 2011). While wastewater treatment facilities can separate some of these fiber particles from washing water, a significant portion still escapes into aquatic environments (Browne et al., 2011). To date, Samarinda City lacks a municipal wastewater treatment facility, resulting in untreated domestic wastewater, including that from laundry activities, being directly discharged through the municipal sewage system into nearby rivers and lakes, including the Karang Mumus River.

The findings of this study are surprising because many previous studies on freshwater environments have reported that microplastic fibers are the most common type of microplastics in surface waters and sediments (Alam et al., 2019; Lin et al., 2018; Wang et al., 2017). Fragments likely originate from the breakdown of hard plastics and outer packaging (An et al., 2020). Indeed, during sampling, large plastic debris was observed in the Karang Mumus River, and this debris gradually fragments over time due to natural physical and chemical processes, contributing to the presence of microplastic fragments in the water and sediment.

Microbeads, which are prevalent in numerous cleaning and cosmetic products are another type of microplastic (Miraj et al., 2021). Consumer products containing microbeads are just one of many visible and hidden sources of microplastics in the environment. The inadvertent release of plastic pellets during production and transport also exacerbates this issue (Rochman, 2013). Indonesia currently lacks regulations on the use of microbeads in personal care products, suggesting a potential rise in microplastic pollution in the future.

Table 3. Percentage of microplastic composition from 50 randomly selected particles from surface water and sediment samples

Compound name	Surface waters (%)	Sediments (%)
Anso IV Halofresh, nylon fiber	0	6
Berkley polyethylene	0	4
Berkley polypropylene	2	14
Fortrel, polyester fiber	12	10
Nylon 6/6	6	0
Olefin fiber	4	6
Polyester, terephthalate based	10	6
Polyethylene, eraclene 80	6	4
Polyethylene, liten MB 62	24	26
Polyethylene, scolefin PE AG 62 BA	12	8
Polystyrene, nope PS-netsark 336M	20	10
Polyvinyl chloride – soft	0	4
Non plastic	4	2
Total	100	100

Polymer identification of microplastics

In this study, fifty randomly selected microplastic samples were analyzed using FTIR (Table 3). Among the particles found in surface waters, 64% were identified as polyethylene/polyester, 20% as polystyrene, 6% as nylon, 4% as olefin fiber, and 2% as polypropylene. In sediment samples, 58% of the particles were identified as polyethylene/polyester, 14% as polypropylene, 10% as polystyrene, 6% as olefin fiber, 6% as nylon and 4% as polyvinyl chloride. The false positives accounted for 4% in surface water and 2% in sediment. Figure 5 shows the infrared spectrum of the two most commonly found microplastic particles in this study.

Plastics differ in their chemical makeup, leading to varying effects on the environment (Rodrigues et al., 2019). Polypropylene and polyethylene are the most widely used plastics, primarily in the production of elastic films, packaging materials, automotive parts, pipes, and household items (Worm et al., 2017). PVC, or polyvinyl chloride, is a versatile plastic used in a variety of applications such as plumbing, construction materials, and automotive parts (Turner and Filella, 2021). Polyethylene is another common plastic, found

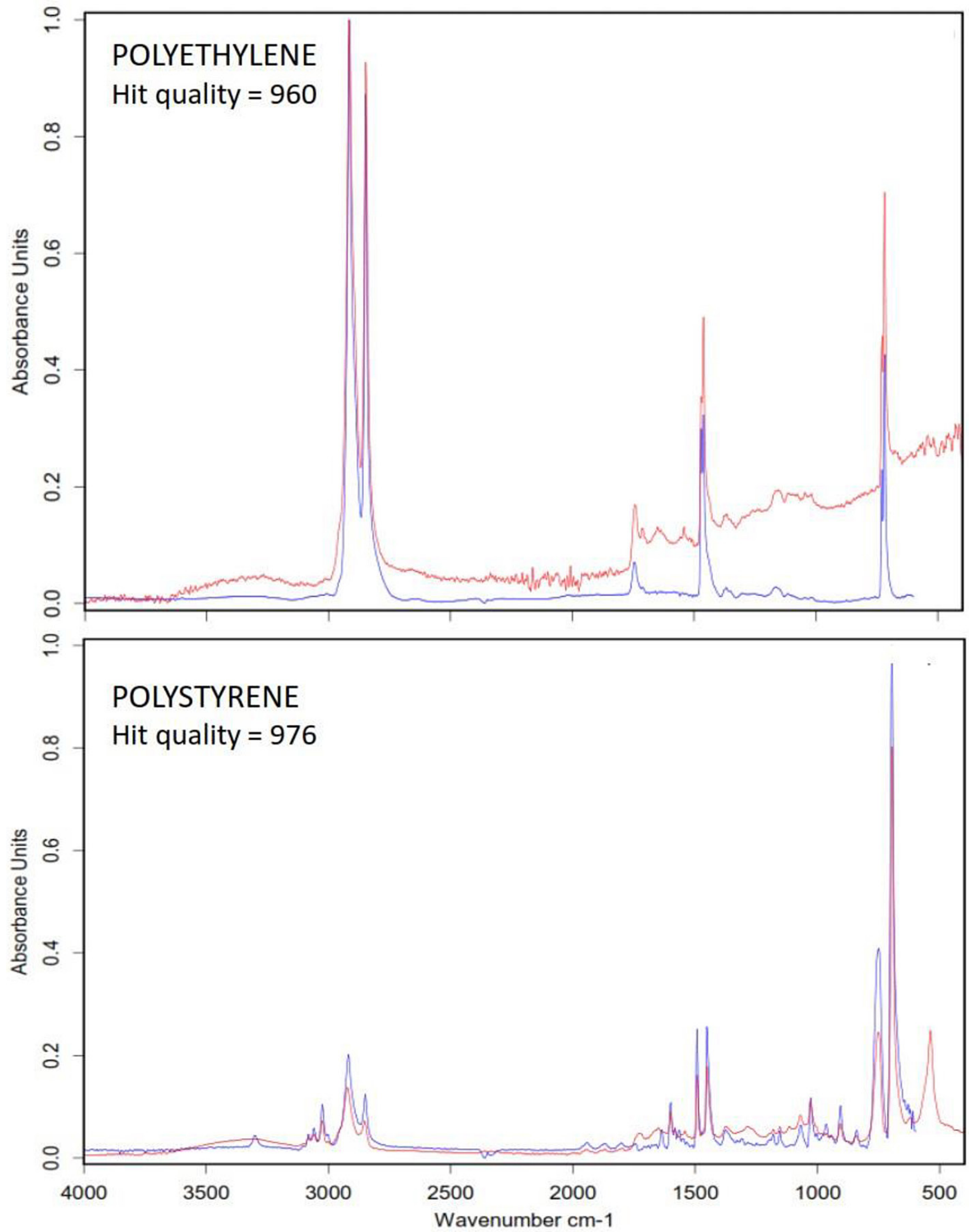

Figure 5. The infrared spectrum of the two microplastic particles found in current study, which were identified as polyethylene and polystyrene

in products like textile garments, food containers, and drink bottles. Polystyrene, often recognized by its brand name Styrofoam, is used in packaging and insulation materials (Ghatge et al., 2020).

Most plastic polymers are relatively low in toxicity because they are insoluble in water and biochemically inert due to their large molecular weight (Worm et al., 2017). However, plastics are made up of harmful monomers like styrene and vinyl chloride, which are linked together to create synthetic polymers. Traces of these toxic and cancer-causing substances can remain in plastic products, posing health risks (Wiesinger et al., 2021). For example, under laboratory conditions, Castro et al. (2022) found that polyethylene significantly reduced the larval length of *Chironomus sancticaroli* and the body length of *Daphnia magna*. Additionally, Kaloyianni et al. (2021) reported that exposure to polystyrene microplastics caused toxicity to the gills and liver of two freshwater fish species.

The findings of this study highlight the need for addressing microplastic contamination in the Karang Mumus River due to its potential to disrupt aquatic life, which could indirectly affect human health. There is an urgent need for further research to track changes in microplastic concentrations in surface water and sediments over time (across different seasons) and to monitor microplastic levels in various aquatic organisms, particularly fish that are commonly consumed by people. A prior study on the Karang Mumus River reported an average microplastic abundance of 22.40 (SE: 2.5) in Silver Barb fish (*Barbonymus gonionotus*) (Hamdhani et al., 2024).

CONCLUSIONS

The current study successfully examined the longitudinal abundance and dispersal of microplastics in the urban tropical Karang Mumus River, East Kalimantan, Indonesia. Microplastics were found in all water and sediment samples collected from six different sites. The average concentration of microplastics was 3.61 ±1.26 particles per liter of surface water and 1222.22 ± 308.80 particles per kilogram of sediment. These findings align with previous research on microplastic pollution in urban river systems. Interestingly, no clear pattern was observed in microplastic concentrations from upstream to downstream.

Microplastic fibers, fragments, and films were commonly observed, with films being the most prevalent type, followed by fibers and fragments in both surface water and sediment. In surface waters, the majority of particles were identified as polyethylene, followed by polystyrene, nylon, olefin fiber, and polypropylene. Similarly, in sediments, polyethylene was the dominant type, followed by polypropylene, polystyrene, olefin fiber, and polyvinyl chloride.

The occurrence of microplastic in urban Karang Mumus River requires attention due to the potential impact on aquatic biota, which then potentially have an indirect impact on humans. Further research is urgently needed to understand the dynamics of microplastic concentrations in surface water and sediment over time (seasonal change), including observing microplastic concentrations in various aquatic organisms, mainly fish that are frequently consumed by the public.

Acknowledgements

We thank Musyiir Sharaha and Alfian Khusmiadi for their help during field sampling.

REFERENCES

1. Alam, F. C., Sembiring, E., Muntalif, B. S., & Suendo, V. (2019). Microplastic distribution in surface water and sediment river around slum and industrial area (case study: Ciwalengke River, Majalaya district, Indonesia). *Chemosphere*, *224*, 637–645. https://doi.org/10.1016/j.chemosphere.2019.02.188
2. An, L., Liu, Q., Deng, Y., Wu, W., Gao, Y., & Ling, W. (2020). Sources of microplastic in the environment. *Microplastics in terrestrial environments: Emerging contaminants and major challenges*, 143–159. https://doi.org/10.1007/698_2020_449
3. An, L., Liu, Q., Deng, Y., Wu, W., Gao, Y., & Ling, W. (2020). Sources of microplastic in the environment. *Microplastics in terrestrial environments: Emerging contaminants and major challenges*, 143–159. https://doi.org/10.1007/978-3-030-56271-7
4. Andrady, A. L., & Koongolla, B. (2022). Degradation and fragmentation of microplastics. *Plastics and the Ocean: Origin, Characterization, Fate, and Impacts*, 227–268. https://doi.org/10.1002/9781119768432.ch8
5. Banaee, M., Multisanti, C. R., Impellitteri, F., Piccione, G., & Faggio, C. (2024). Environmental toxicology of microplastic particles on fish: A review. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, 110042. https://doi.org/10.1016/j.cbpc.2024.110042
6. Browne, M. A., Crump, P., Niven, S. J., Teuten, E., Tonkin, A., Galloway, T., & Thompson, R. (2011). Accumulation of microplastic on shorelines worldwide: sources and sinks. *Environmental science & technology*, *45*(21), 9175–9179. https://doi.org/10.1021/es201811s
7. Buwono, N. R., Risjani, Y., & Soegianto, A. (2021). Distribution of microplastic in relation to water quality parameters in the Brantas River, East Java, Indonesia. *Environmental Technology & Innovation*, *24*, 101915. https://doi.org/10.1016/j.eti.2021.101915
8. Castro, G. B., Bernegossi, A. C., Pinheiro, F. R., & Corbi, J. J. (2022). The silent harm of polyethylene microplastics: Invertebrates growth inhibition as a warning of the microplastic pollution in continental waters. *Limnologica*, *93*, 125964. https://doi.org/10.1016/j.limno.2022.125964
9. Central Agency of Statistics. (2021). *Population Statistic Report of East Kalimantan 2020*. https://kaltim.bps.go.id/indicator/12/572/1/-sp2020-jumlah-penduduk-hasil-sensus-penduduk-menurut-wilayah-dan-jenis-kelamin-di-provinsi-kalimantan-timur-2020.html (in Indonesian).
10. Dong, M., Luo, Z., Jiang, Q., Xing, X., Zhang, Q., & Sun, Y. (2020). The rapid increases in microplastics in urban lake sediments. *Scientific reports*, *10*(1), 848. https://doi.org/10.1038/s41598-020-57933-8

11. Eppehimer, D. E., Hamdhani, H., Hollien, K. D., Nemec, Z. C., Lee, L. N., Quanrud, D. M., & Bogan, M. T. (2021). Impacts of baseflow and flooding on microplastic pollution in an effluent-dependent arid land river in the USA. *Environmental Science and Pollution Research*, *28*, 45375–45389. https://doi.org/10.1007/s11356-021-13724-w
12. Fatema, K., Rahman, T., Islam, M. J., Sumon, K. A., Uddin, M. H., Hasan, S. J., Abe Kawsar, S. M., Arakawa, H., Haque, M. M., & Rashid, H. (2023). Microplastics pollution in the river Karnaphuli: a preliminary study on a tidal confluence river in the southeast coast of Bangladesh. *Environmental Science and Pollution Research*, *30*(13), 38853-38868. https://doi.org/10.1007/s11356-022-24998-z
13. Ghatge, S., Yang, Y., Ahn, J. H., & Hur, H. G. (2020). Biodegradation of polyethylene: a brief review. *Applied Biological Chemistry*, *63*, 1-14. https://doi.org/10.1186/s13765-020-00511-3
14. Gola, D., Tyagi, P. K., Arya, A., Chauhan, N., Agarwal, M., Singh, S. K., & Gola, S. (2021). The impact of microplastics on marine environment: A review. *Environmental Nanotechnology, Monitoring & Management*, *16*, 100552. https://doi.org/10.1016/j.enmm.2021.100552
15. Hamdhani, H., Eppehimer, D. E., & Bogan, M. T. (2020). Release of treated effluent into streams: A global review of ecological impacts with a consideration of its potential use for environmental flows. *Freshwater Biology*, 65(9), 1657–1670. https://doi.org/10.1111/fwb.13519
16. Hamdhani. H., Eppehimer, D. E., Khusmiadi, A., & Jailani, J. (2024). The abundance of microplastics in the digestive system of silver barb (*Barbonymus Gonionotus*) from the waters of the Karang Mumus River, Samarinda City, Indonesia. *Water Conservation & Management*, 8(2), 179–184. https://doi.org/10.26480/wcm.02.2024.179.184
17. 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
18. Hidalgo-Ruz, V., Gutow, L., Thompson, R. C., & Thiel, M. (2012). Microplastics in the marine environment: a review of the methods used for identification and quantification. *Environmental science & technology*, *46*(6), 3060–3075. https://doi.org/10.1021/es2031505
19. Horton, A. A., Jürgens, M. D., Lahive, E., van Bodegom, P. M., & Vijver, M. G. (2018). The influence of exposure and physiology on microplastic ingestion by the freshwater fish Rutilus rutilus (roach) in the River Thames, UK. *Environmental Pollution*, *236*, 188–194. https://doi.org/10.1016/j.envpol.2018.01.044
20. Iyare, P. U., Ouki, S. K., & Bond, T. (2020). Microplastics removal in wastewater treatment plants: a critical review. *Environmental Science: Water Research & Technology*, *6*(10), 2664–2675. https://doi.org/10.1039/D0EW00397B
21. Kalčíková, G., Alič, B., Skalar, T., Bundschuh, M., & Gotvajn, A. Ž. (2017). Wastewater treatment plant effluents as source of cosmetic polyethylene microbeads to freshwater. *Chemosphere*, *188*, 25–31. https://doi.org/10.1016/j.chemosphere.2017.08.131
22. Kaloyianni, M., Bobori, D. C., Xanthopoulou, D., Malioufa, G., Sampsonidis, I., Kalogiannis, S., Feidantsis, K., Kastrinaki, G., Dimitriadi, A., Koumoundouros, G., Lambropoulou, D. A., Kyzas, G. Z., & Bikiaris, D. N. (2021). Toxicity and functional tissue responses of two freshwater fish after exposure to polystyrene microplastics. *Toxics*, *9*(11), 289. https://doi.org/10.3390/toxics9110289
23. Kameda, Y., Yamada, N., & Fujita, E. (2021). Source-and polymer-specific size distributions of fine microplastics in surface water in an urban river. *Environmental Pollution*, *284*, 117516. https://doi.org/10.1016/j.envpol.2021.117516
24. Kernchen, S., Löder, M. G., Fischer, F., Fischer, D., Moses, S. R., Georgi, C., Nölscher A. C., Held A., & Laforsch, C. (2022). Airborne microplastic concentrations and deposition across the Weser River catchment. *Science of the Total Environment*, *818*, 151812. https://doi.org/10.1016/j.scitotenv.2021.151812
25. Krause, S., Baranov, V., Nel, H.A., Drummond, J.D., Kukkola, A., Hoellein, T., Smith, G.H.S., Lewandowski, J., Bonet, B., Packman, A.I. and Sadler, J. (2021). Gathering at the top? Environmental controls of microplastic uptake and biomagnification in freshwater food webs. *Environmental Pollution*, *268*, 115750. https://doi.org/10.1016/j.envpol.2020.115750
26. Lehtiniemi, M., Hartikainen, S., Näkki, P., Engström-Öst, J., Koistinen, A., & Setälä, O. (2018). Size matters more than shape: Ingestion of primary and secondary microplastics by small predators. *Food webs*, *17*, e00097. https://doi.org/10.1016/j.fooweb.2018.e00097
27. Liedermann, M., Gmeiner, P., Pessenlehner, S., Haimann, M., Hohenblum, P., & Habersack, H. (2018). A methodology for measuring microplastic transport in large or medium rivers. *Water*, *10*(4), 414. https://doi.org/10.3390/w10040414
28. Lin, L., Zuo, L. Z., Peng, J. P., Cai, L. Q., Fok, L., Yan, Y., Li, H. X., & Xu, X. R. (2018). Occurrence and distribution of microplastics in an urban river: a case study in the Pearl River along Guangzhou City, China. *Science of the total environment*, *644*, 375–381. https://doi.org/10.1016/j.scitotenv.2018.06.327

29. Löder, M.G.J., Gerdts, G. (2015). Methodology Used for the Detection and Identification of Microplastics—A Critical Appraisal. In: Bergmann, M., Gutow, L., Klages, M. (eds) Marine Anthropogenic Litter. Springer, Cham. 201–227. https://doi.org/10.1007/978-3-319-16510-3_8
30. Lwanga, E. H., Beriot, N., Corradini, F., Silva, V., Yang, X., Baartman, J., Rezaei M., Schaik, L. V., Riksen, M., & Geissen, V. (2022). Review of microplastic sources, transport pathways and correlations with other soil stressors: a journey from agricultural sites into the environment. *Chemical and Biological Technologies in Agriculture*, *9*(1), 20. https://doi.org/10.1186/s40538-021-00278-9
31. McCormick, A., Hoellein, T. J., Mason, S. A., Schluep, J., & Kelly, J. J. (2014). Microplastic is an abundant and distinct microbial habitat in an urban river. *Environmental science & technology*, *48*(20), 11863–11871. https://doi.org/10.1021/es503610r
32. Miraj, S. S., Parveen, N., & Zedan, H. S. (2021). Plastic microbeads: small yet mighty concerning. *International Journal of Environmental Health Research*, *31*(7), 788–804. https://doi.org/10.1080/09603123.2019.1689233
33. Niu, S., Wang, X., Rao, Z., & Zhan, N. (2021). Microplastics present in sediments of Yushan River: a case study for urban tributary of the Yangtze River. *Soil and Sediment Contamination: An International Journal*, *30*(3), 314–330. https://doi.org/10.1080/15320383.2020.1841731
34. Park, T. J., Lee, S. H., Lee, M. S., Lee, J. K., Lee, S. H., & Zoh, K. D. (2020). Occurrence of microplastics in the Han River and riverine fish in South Korea. *Science of the Total Environment*, *708*, 134535. https://doi.org/10.1016/j.scitotenv.2019.134535
35. Peng, G., Xu, P., Zhu, B., Bai, M., & Li, D. (2018). Microplastics in freshwater river sediments in Shanghai, China: a case study of risk assessment in mega-cities. *Environmental Pollution*, *234*, 448–456. https://doi.org/10.1016/j.envpol.2017.11.034
36. Pujowati, P., Arifin, A. S., & Mugnisjah, W. Q. (2010). Analisis sosial ekonomi masyarakat di Daerah Aliran Sungai Karang Mumus dalam rencana pengelolaan lanskap Agroforesty. *Jurnal Agro Ekonomi Kehutanan EPP*, *7*(1), 8–13 (in Indonesian).
37. Qiu, R., Song, Y., Zhang, X., Xie, B., & He, D. (2020). Microplastics in urban environments: sources, pathways, and distribution. *Microplastics in terrestrial environments: emerging contaminants and major challenges*, 41–61. https://doi.org/10.1007/698_2020_447
38. Rafa, N., Ahmed, B., Zohora, F., Bakya, J., Ahmed, S., Ahmed, S.F., Mofijur, M., Chowdhury, A.A. and Almomani, F. (2023). Microplastics as carriers of toxic pollutants: Source, transport, and toxicological effects. *Environmental Pollution*, 123190. https://doi.org/10.1016/j.envpol.2023.123190
39. Rebelein, A., Int-Veen, I., Kammann, U., & Scharsack, J. P. (2021). Microplastic fibers—underestimated threat to aquatic organisms?. *Science of the Total Environment*, *777*, 146045. https://doi.org/10.1016/j.scitotenv.2021.146045
40. Rochman, C. M. (2013). Plastics and priority pollutants: a multiple stressor in aquatic habitats. *Environ Sci Technol 47*, 2439–2440. https://doi.org/10.1021/es400748b
41. Rodrigues, M. O., Abrantes, N., Gonçalves, F. J. M., Nogueira, H., Marques, J. C., & Gonçalves, A. M. (2019). Impacts of plastic products used in daily life on the environment and human health: What is known?. *Environmental toxicology and pharmacology*, *72*, 103239. https://doi.org/10.1016/j.etap.2019.103239
42. Sankoda, K., & Yamada, Y. (2021). Occurrence, distribution, and possible sources of microplastics in the surface river water in the Arakawa River watershed. *Environmental Science and Pollution Research*, *28*, 27474–27480. https://doi.org/10.1007/s11356-021-12459-y
43. Sekudewicz, I., Dąbrowska, A. M., & Syczewski, M. D. (2021). Microplastic pollution in surface water and sediments in the urban section of the Vistula River (Poland). *Science of The Total Environment*, *762*, 143111. https://doi.org/10.1016/j.scitotenv.2020.143111
44. Shafira, J., Prakoso, C. T., & Zulfiani, D. (2019). Program Relokasi Warga Permukiman Bantaran Sungai Karang Mumus ke Rusunawa Wanyi di Bengkuring Raya Kecamatan Samarinda Utara. *Journal Administrasi Negara, 7*(3), 9148–9162 (in Indonesian).
45. Stata Statistical Software. (2017). Release 15, StataCorp LLC, College Station, TX, USA.
46. Stock, F., Kochleus, C., Bänsch-Baltruschat, B., Brennholt, N., & Reifferscheid, G. (2019). Sampling techniques and preparation methods for microplastic analyses in the aquatic environment–A review. *TrAC Trends in Analytical Chemistry*, *113*, 84-92. https://doi.org/10.1016/j.trac.2019.01.014
47. Takeuchi, H., & Tanaka, H. (2020). Water reuse and recycling in Japan—History, current situation, and future perspectives. *Water Cycle*, *1*, 1-12. https://doi.org/10.1016/j.watcyc.2020.05.001
48. Thi, O. D., Thi, T. D., Nhu, H. N. T., Thi, Q. H., Phuong, Q. L. T., Hong, P. D., Phuong, T. L., & Huyen, T. B. (2021). Preliminary results on microplastics in surface water from the downstream of the Day River. *Vietnam Journal of Earth Sciences*, *43*(4), 485–495. https://doi.org/10.15625/2615-9783/16504
49. Tibbetts, J., Krause, S., Lynch, I., & Sambrook Smith, G. H. (2018). Abundance, distribution, and drivers of microplastic contamination in urban river environments. *Water*, *10*(11), 1597. https://doi.

org/10.3390/w10111597

50. Turner, A., & Filella, M. (2021). Polyvinyl chloride in consumer and environmental plastics, with a particular focus on metal-based additives. *Environmental Science: Processes & Impacts*, *23*(9), 1376–1384. https://doi.org/10.1039/D1EM00213A
51. Wang, C., O'Connor, D., Wang, L., Wu, W. M., Luo, J., & Hou, D. (2022). Microplastics in urban runoff: Global occurrence and fate. *Water research*, *225*, 119129. https://doi.org/10.1016/j.watres.2022.119129
52. Wang, W., Ndungu, A. W., Li, Z., & Wang, J. (2017). Microplastics pollution in inland freshwaters of China: A case study in urban surface waters of Wuhan, China. *Science of the Total Environment*, *575*, 1369–1374. https://doi.org/10.1016/j.scitotenv.2016.09.213
53. Wiesinger, H., Wang, Z., & Hellweg, S. (2021). Deep dive into plastic monomers, additives, and processing aids. *Environmental science & technology*, *55*(13), 9339–9351. https://doi.org/10.1021/acs.est.1c00976
54. Worm, B., Lotze, H. K., Jubinville, I., Wilcox, C., & Jambeck, J. (2017). Plastic as a persistent marine pollutant. *Annual Review of Environment and Resources*, *42*, 1–26. https://doi.org/10.1146/annurev-environ-102016-060700
55. Xu, Y., Chan, F.K.S., Johnson, M., Stanton, T., He, J., Jia, T., Wang, J., Wang, Z., Yao, Y., Yang, J. and Liu, D. (2021). Microplastic pollution in Chinese urban rivers: The influence of urban factors. *Resources, Conservation and Recycling*, *173*, 105686. https://doi.org/10.1016/j.resconrec.2021.105686