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Identification of Microplastics in River Sediments: Type, Abundance, and Characteristics of Asam River Sediment, Jambi City

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Abstract

Introduction: *Microplastics have become a critical environmental pollutant in aquatic ecosystems, particularly in river sediments. The Asam River, a tributary of the Batanghari River in Jambi City, Indonesia, experiences substantial anthropogenic pressure from surrounding settlements, markets, and recreational areas.* ***Objective:*** *This study aimed to identify the types, abundance, colour variation, size distribution, and sediment characteristics of microplastics in the Asam River, Jambi City.* ***Method:*** *Sediment samples were collected from 9 sampling points using the grab sampling method (depth 0.8 – 1.2 m). Microplastic identification was performed by visual inspection under a stereo microscope. Sediment characterisation included analyses of water content, sand fraction, and silt content.* ***Result and Discussion:*** *A total of 152 microplastic particles were identified. Filaments dominated at 54.60%, followed by fibres (32.23%), fragments (10.52%), and granules (2.63%). Particle sizes ranged from 0.085 to 4.907 mm with a mean of 0.699 mm. Blue and transparent colours were predominant across all sampling points. Sampling point 1 recorded the highest abundance (30 particles; 20%), attributed to its proximity to dense urban activities and the Batanghari River confluence. Sampling point 6 had the lowest abundance (7 particles; 5%) and was located adjacent to plantation areas.* ***Conclusion:*** *Asam River sediment is contaminated by microplastics dominated by filament-type particles, with abundance strongly associated with proximity to human settlements and commercial activities.*

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Introduction

Microplastics are plastic particles with a size of ≤ 5 mm and are classified into two categories: primary microplastics (intentionally manufactured at small sizes, e.g., microbeads in cosmetics and personal care products) and secondary microplastics (derived from the fragmentation of larger plastic items through photodegradation, mechanical abrasion, and biodegradation) (Kalsum et al, 2023). Due to their persistence, hydrophobic nature, and high surface-area-to-volume ratio, microplastics act as carriers of toxic pollutants, including polychlorinated biphenyls (PCBs), heavy metals, and endocrine-disrupting compounds, posing significant risks to aquatic organisms and human health through the food chain (Kalsum et al., 2023).

Microplastic contamination has become an important public health concern because these particles can enter the human body through several environmental exposure pathways (Ramadhani, Gathfan, Al Hakim, Sabittah, & Fikri, 2026). Drinking water represents one of the most relevant pathways, particularly in urban areas where raw water is obtained from rivers receiving domestic wastewater, plastic waste, industrial discharge, and surface runoff. Conventional water treatment processes may reduce the number of suspended particles; however, very small microplastics may remain in treated water when filtration and monitoring systems are not specifically designed to remove them. Therefore, contamination in river systems should not be viewed solely as an ecological problem, but also as a potential threat to the safety and quality of drinking-water sources (Faujiah & Wahyuni, 2022); (Cahyaningtyas & Chandra, 2024); (Ratnaningsih, Prayogo, Saputra, & Shabrina, 2025).

Aquatic food may also contribute to human exposure. Microplastics present in water and sediment can be ingested by fish, shellfish, and other aquatic organisms during feeding or through contact with contaminated habitats. Sediment-dwelling and bottom-feeding organisms are particularly relevant because they interact directly with areas where microplastics tend to accumulate. When contaminated aquatic organisms are consumed, microplastic particles and associated pollutants may be transferred through the food chain. This pathway is especially important in Indonesia, where freshwater and marine products constitute a major component of household food consumption and local livelihoods

In riverine environments, microplastics accumulate preferentially in sediments, where concentrations can exceed those in the water column by orders of magnitude (Balestra et al, 2024). The accumulation pattern is governed by particle density, size, and hydrodynamic conditions. Research in Indonesian rivers has documented considerable microplastic contamination: Lau et al (2020) found 1,175 particles/kg in Code River sediment, and (Fajri, 2024) identified microplastics in Kendal River estuary sediments, with fibre types predominating. Batanghari River, the longest river in Sumatra (870 km) and the primary drinking water source for Jambi City's PDAM, receives pollutant loads from multiple land-based sources, including markets, industries, and domestic wastewater (Kalsum, 2023).

The Asam River is a first- and second-order tributary of the Batanghari River, flowing through the densely populated urban areas of Jambi City. Its catchment encompasses traditional markets (Pasar Angso Duo), tourism zones, shopping centres, and agricultural plots, all of which generate plastic waste that potentially enters the river system. Despite its ecological sensitivity and hydrological connection to the main water supply, microplastic contamination in the sediments of the Asam River remains inadequately characterised. This study, therefore, aimed to comprehensively identify the types, abundance, colour distribution, size range, and sediment characteristics of microplastics across 9 sampling points in the Asam River, Jambi City, to provide a scientific basis for environmental management decisions.

Method

Study Area and Sampling Design

This study was conducted on the Asam River in Jambi City, Indonesia (a tributary of the Batanghari River). Nine sampling points were established systematically at the confluence zones of Asam Primary River (1st order) and Asam Secondary River (2nd order), encompassing areas from the Batanghari River confluence (Point 1) to upstream plantation areas (Points 6 and 9). Sediment samples were collected at a depth of 0.8–1.2 m using grab sampling in accordance with SNI 19-3964-1994, during August 2023.

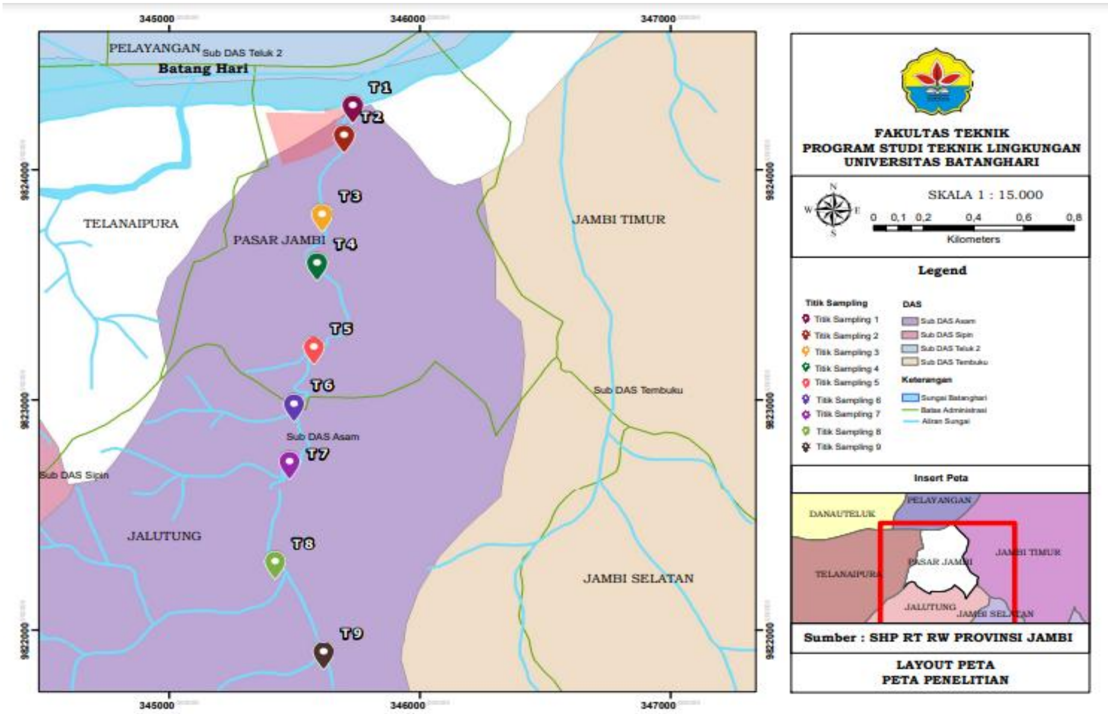

Figure 1. Sampling Point Map along the Asam River, Jambi City

Microplastic Identification

Each sediment sample (100 g dry weight) was subjected to density separation using saturated NaCl solution (density ≈1.2 g/cm³), followed by vacuum filtration through a 0.45 µm glass fibre filter. Retained particles were examined under a stereo microscope (10×40× magnification) and classified morphologically into four types: filament, fibre, fragment, and granule. Each particle was recorded by colour and measured for length (mm) using a calibrated eyepiece micrometre. Microplastic abundance and distribution were calculated using the following equations:

Abundance (particles/g) = n particles ÷ 100 g dry sediment…………………………… (1)
Abundance (particles/kg) = (n particles ÷ 100 g) × 10 ………………………………. (2)
Percentage (%) = (n particles per point ÷ total particles) × 100 ……………………. (3)

Sediment Characterization

Sediment mechanical properties were determined through sieve analysis using mesh sizes 20, 40, 80, 100, and 200 to classify coarse, medium, and fine sand fractions. Water content (%) and silt content (%) were measured gravimetrically. A cone penetration test (CPT/Sondir) was additionally conducted at one representative location (Simpang III Sipin, Jambi; coordinates 1°38’01.6"S, 103°35’18.6"E) to a depth of 10 m. Sediment characterization was limited to particle-size distribution, water content, and silt content because these parameters were directly used to describe sediment conditions and interpret the distribution and accumulation of microplastics at each sampling point. The CPT/Sondir examination was excluded from the methodological analysis because its results were not integrated into the assessment of microplastic abundance or sediment characteristics

Result and Discussion

Microplastic Type Distribution per Sampling Point

A total of 152 microplastic particles were identified across 9 sampling points in the Asam River sediment, comprising four morphological types: filament, fibre, fragment, and granule. The detailed distribution of each type per sampling point is presented in Table 1.

Table 1
Microplastic Type Distribution per Sampling Point

Sample Point	Location Description	Filament	Fiber	Fragment	Granule	Total	% of Total
1	Sungai Batang Hari	19	7	3	1	30	20
2	Sebelum Pintu Air Sungai Asam	9	10	7	2	28	18
3	Jl. MH Tamrin, Beringin	5	3	0	0	8	5
4	Jl.Sultan Agung – Lrg. Karang Anyar	14	8	0	0	22	14
5	Jl.Sultan Agung – Lorong Penjahit	20	7	1	0	28	18
6	Jl.Dr.Moh.Yamin – Lebak bandung	1	5	1	0	7	5
7	Kac.Jelutung – Kelurahan Handil Jaya	6	2	1	0	9	6
8	Jl. Widuri – Pal V – Kota Baru	6	4	2	0	12	8
9	Jl.Perdana (Perumnas) – Kota Baru	3	3	1	1	8	5
	Total	**83**	**49**	**16**	**4**	**152**	**100**

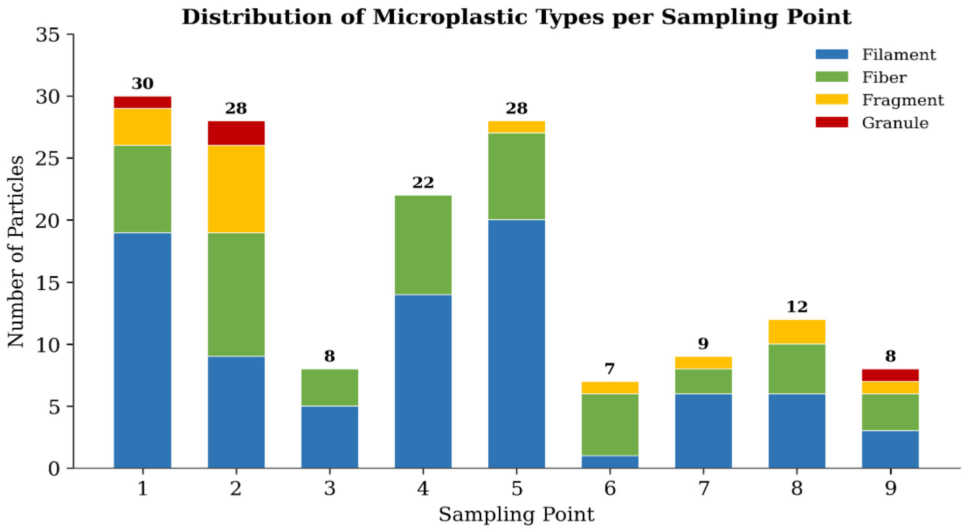

Figure 2. Distribution of Microplastic Types per Sampling Point

As shown in Table 1, filament was the dominant microplastic type overall (83 particles; 54.60%), followed by fibre (49 particles; 32.23%), fragment (16 particles; 10.52%), and granule (4 particles; 2.63%). However, the type composition varied considerably among sampling points. At Sample 2, fragments were notably higher (7 of 28 particles; 25%), which may be associated with particle retention and mechanical fragmentation near the water gate, although this interpretation requires further verification. Sample 6 was unique in having fibre as the dominant type (5 of 7 particles; 71.4%), with only one filament particle, indicating a possible local input of fibre-shaped particles whose specific source could not be confirmed in this study

Filament dominance at most sampling points is consistent with findings from riverine studies in Indonesia and globally. He et al (2021) attributed the prevalence of filament-type fibres to synthetic textile fibres released through domestic laundry wastewater and fishing net degradation. The high filament counts at Points 1, 4, and 5 may therefore indicate inputs from surrounding anthropogenic activities. However, the particles cannot be specifically attributed to laundry wastewater or fishing equipment because polymer identification and direct source surveys were not conducted. Granule-type particles were found only at Points 1 and 2 (from Samples 1 and 2) and Point 9, and their possible association with cosmetic microbeads or pre-production resin pellets remains tentative (Tatsii et al., 2024).

Microplastic Abundance and Spatial Distribution

The abundance of microplastics varied substantially across the 9 sampling points, as summarised in Table 2. Sampling point 1, located at the confluence of the Asam River and Batanghari River, recorded the highest abundance (30 particles; 0.30 particles/g; 3.0 particles/kg; 20% of total). This location receives combined inputs from the entire Asam River catchment, as well as direct deposition from the Batanghari River. The surrounding environment includes Pasar Angso Duo (a major traditional market), shopping centres, tourism zones, and dense residential areas, all of which are significant generators of plastic waste (Wijayanti et al, 2021).

Table 2
Microplastic Abundance, Color, and Size Range per Sampling Point

Sample	Total	Abund. (part./g)	Abund. (part./kg)	% of Total	Dominant Color	Size Range (mm)
1	30	0.30	3.0	20	Blue & Transparent	0.098 – 4.907
2	28	0.28	2.8	18	Blue & Red	0.085 – 2.869
3	8	0.08	0.8	5	Blue & Black	0.609 – 1.748
4	22	0.22	2.2	14	Transparent & Blue	0.134 – 3.188
5	28	0.28	2.8	18	Transparent & Blue	0.095 – 2.663
6	7	0.07	0.7	5	Blue & Transparent	0.203 – 1.602
7	9	0.09	0.9	6	Transparent & Red	0.125 – 1.386
8	12	0.12	1.2	8	Transparent	0.131 – 2.549
9	8	0.08	0.8	5	Blue & Red	0.140 – 0.670
Total/Mean	**152**	**1.52**	**15.2**	**100**	**Blue & Transparent**	**0.085 – 4.907**

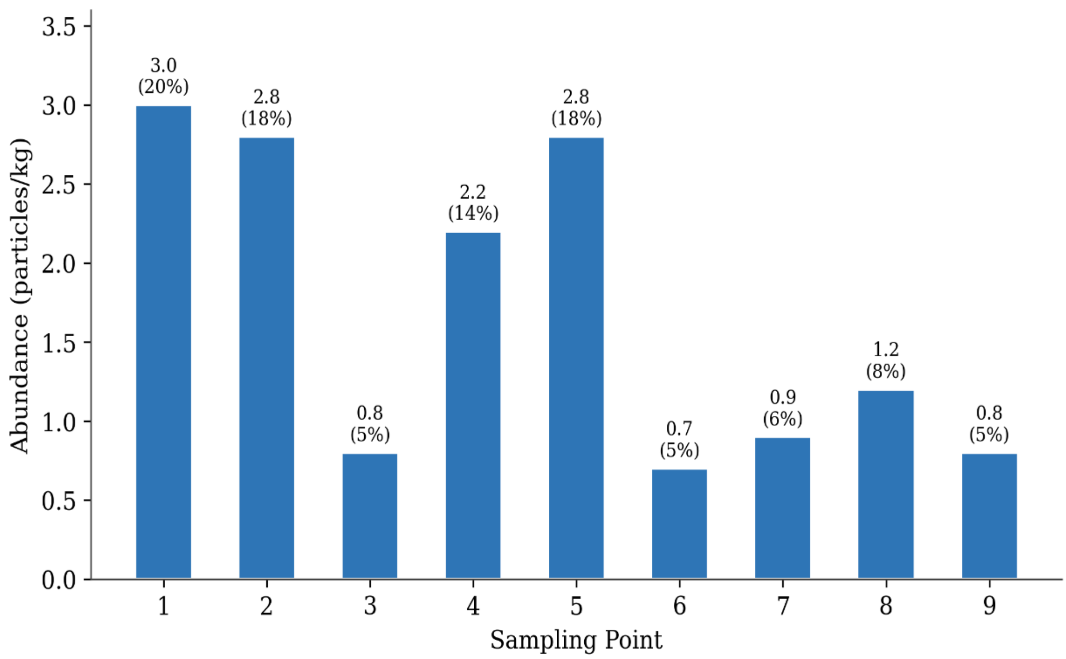

Figure 3. Microplastic Abundance per Sampling Point

Sampling point 5 (near settlement, n=28; 18%) and sampling point 2 (upstream gate, n=28; 18%) recorded the second-highest abundance, jointly. Point 5's high count is associated with adjacent residential areas and the hydrodynamic effect of reduced flow velocity, allowing microplastic deposition. Point 2, located immediately upstream of the water gate, likely experiences accumulation due to hydraulic trapping, in which reduced current velocity promotes sedimentation of suspended microplastics. This phenomenon has been reported by (Syarif, Daud, & Natsir, 2021), who found higher microplastic concentrations at hydrodynamically quiescent zones.

Sampling point 6 recorded the lowest abundance (7 particles; 0.07 particles/g; 0.7 particles/kg; 5%), followed by points 3 and 9 (8 particles each; 5%). Point 6 is situated in a plantation-dominated area with limited direct residential or commercial activity, resulting in reduced plastic waste inputs. Similarly, points 3 and 9 are located in areas with lower human activity density, consistent with the general principle that microplastic abundance correlates positively with proximity to anthropogenic pollution sources (Hafitri et al2022).

Color Distribution of Microplastic Particles

Colour analysis of microplastic particles revealed a predominance of blue and transparent colours across all sampling points, consistent with the most common plastic product colours in consumer goods and packaging materials in Indonesia. Table 3 presents the colour distribution per sampling point.

Table 3

Color Distribution of Microplastic Particles per Sampling Point

Sample	Blue	Transparent	Red	Black	Pink	Green	Mixed/Other	Total
1	8	8	4	1	1	1	7	30
2	9	4	6	1	0	2	6	28
3	4	0	0	3	0	0	1	8
4	5	7	0	3	2	1	4	22
5	11	12	4	0	0	1	0	28
6	3	3	0	0	0	0	1	7
7	1	5	3	0	0	0	0	9
8	2	6	1	0	1	0	2	12
9	4	1	2	0	0	1	0	8
Total	**47**	**46**	**20**	**8**	**4**	**6**	**21**	**152**
%	**30.9**	**30.3**	**13.2**	**5.3**	**2.6**	**3.9**	**13.8**	**100**

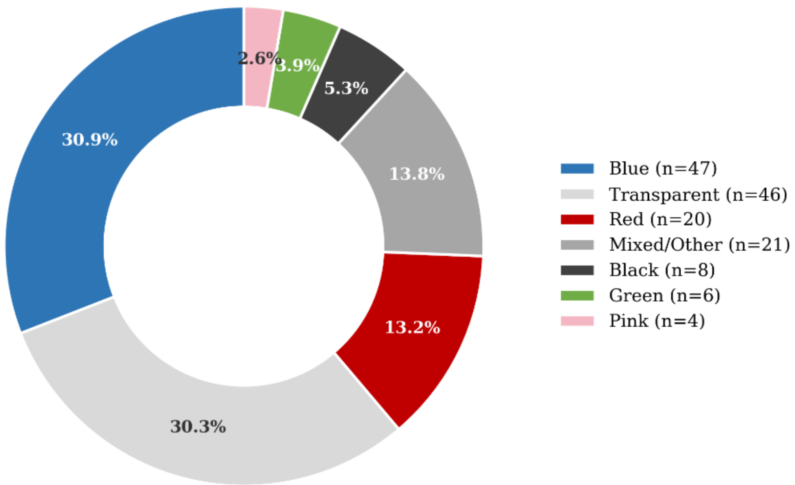

Figure 4. Overall Color Distribution of Microplastic Particles (n = 152)

Blue particles accounted for approximately 30.9% and transparent particles 30.3% of the total, followed by red (13.2%), mixed/other colours (13.8%), black (5.3%), green (3.9%), and pink (2.6%). Blue and transparent colours in microplastics are commonly associated with polyethene (PE) and polypropylene (PP) consumer packaging, plastic bags, and textile fibres used in everyday household goods (Amir, 2023). The prevalence of these colours suggests that domestic waste and laundry effluent are primary contributors to microplastic contamination in the Asam River. Red particles (20 particles; 13.2%) were concentrated at Points 1, 2, 5, and 7, suggesting the presence of degraded red plastic packaging or fishing equipment. Black particles (8 particles; 5.3%) were prominent at Points 3 and 4, potentially originating from black polyethene mulch films used in nearby agricultural areas.

Size Distribution of Microplastic Particles

The size of identified microplastic particles ranged from 0.085 mm (Sampel 2, blue fragment) to 4.907 mm (Sampel 1, pink fibre), with an overall mean size of 0.699 mm. All particles were within the standard definition of microplastics (≤5 mm). The size distribution data per sampling point are presented in Table 4.

Table 4

Microplastic Particle Size Statistics per Sampling Point

Sample	n Particles	Min Size (mm)	Max Size (mm)	Largest Particle	Smallest Particle
1	30	0.098	4.907	Pink fiber (4.907 mm)	Blue fragment (0.098 mm)
2	28	0.085	2.869	Transparent filament (2.869 mm)	Blue fragment (0.085 mm)
3	8	0.609	1.748	Black fiber (1.748 mm)	Blue filament (0.609 mm)
4	22	0.134	3.188	Green fiber (3.188 mm)	Transparent filament (0.134 mm)

5	28	0.095	2.663	Transparent fiber (2.663 mm)	Transparent filament (0.095 mm)
6	7	0.203	1.602	Transparent fiber (1.602 mm)	Blue fiber (0.203 mm)
7	9	0.125	1.386	Transparent filament (1.386 mm)	Red fragment (0.125 mm)
8	12	0.131	2.549	Transparent fiber (2.549 mm)	White filament (0.131 mm)
9	8	0.140	0.670	Blue filament (0.670 mm)	Red granule (0.140 mm)
Overall	**152**	**0.085**	**4.907**	**Pink fiber – Sample 1**	**Blue fragment – Sample 2**

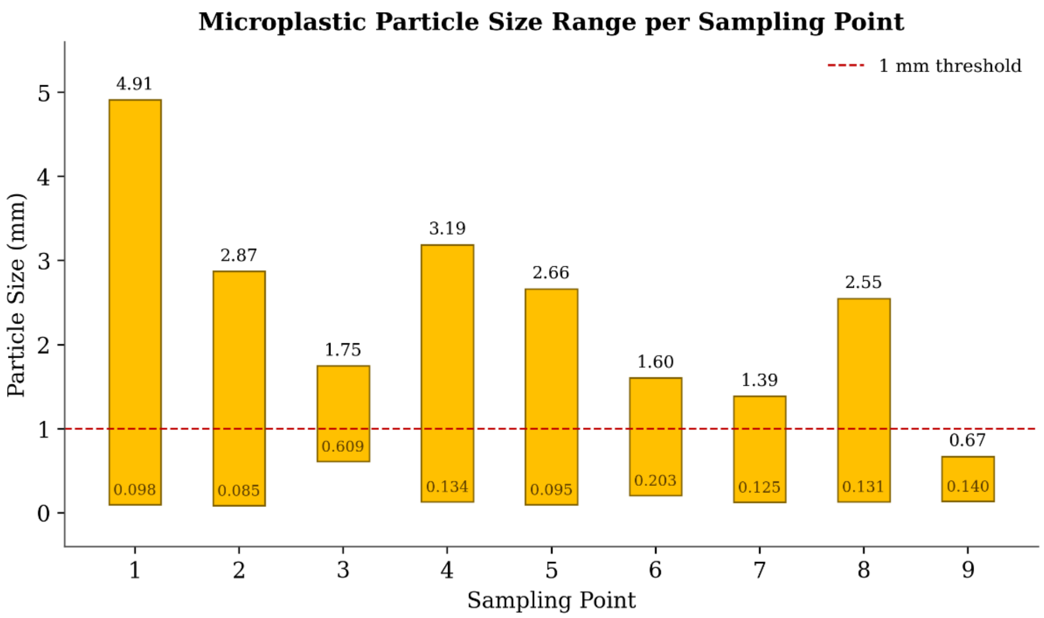

Figure 5. Microplastic Particle Size Range per Sampling Point

The largest particle recorded was a pink fibre at Sampling Point 1 (4.907 mm), indicating that plastic fragmentation is still ongoing and not yet complete at this site, consistent with its position as the final collection point before entering Batanghari River. Sampling Point 9 showed the smallest size range (0.140–0.670 mm), which may reflect advanced weathering and particle fragmentation in the clay dominated sediment environment, where longer particle residence times promote progressive size reduction (Syarif et al, 2021). The relatively small mean size (0.699 mm) across all samples indicates that most particles have undergone considerable fragmentation, consistent with secondary microplastic formation through photodegradation and mechanical weathering processes (Amir, 2023).

Particles smaller than 1 mm (approximately 67% of all identified particles based on size distribution pattern) present a particular ecological concern, as they are more readily ingested by benthic invertebrates and small fish than larger particles (Kalsum et al., 2023). The presence of particles approaching the nanoscale lower boundary (0.085 mm) also raises concerns about potential translocation across biological membranes in aquatic organisms, a phenomenon documented for particles smaller than 500 μm (Syarif et al, 2021).

Sediment Characteristics and Relationship to Microplastic Distribution

Sediment characterisation revealed distinct textural differences among the 9 sampling points, reflecting the heterogeneous geomorphological and hydrological conditions along the Asam River. These differences are relevant to understanding microplastic accumulation and retention patterns.

Table 5

Sediment Characteristics at Each Sampling Point

Sample	Water Content (%)	Coarse Sand (20M) (%)	Med. Sand (40M) (%)	Fine Sand (80M) (%)	Silt Content (%)	Microplastic (n)	Soil Texture
1	7.64	0.28	0.08	54.98	3.79	30	Sandy
2	7.92	1.90	0.16	52.94	0.49	28	Sandy
3	9.43	0.40	0.12	20.18	0.98	8	Sandy-Loam
4	5.44	1.89	0.38	11.26	0.34	22	Loamy-Sand
5	9.13	0.48	0.14	29.42	0.37	28	Sandy-Loam
6	10.08	1.88	0.03	11.30	1.98	7	Sandy-Loam
7	8.42	4.56	0.14	63.48	0.10	9	Sandy
8	11.07	1.36	0.62	5.16	3.25	12	Clay-Sandy
9	11.51	1.50	0.03	8.58	4.41	8	Clay
Max	**11.51**	**4.56**	**0.62**	**63.48**	**4.41**	**-**	
Min	**5.44**	**0.28**	**0.03**	**5.16**	**0.10**	**-**	

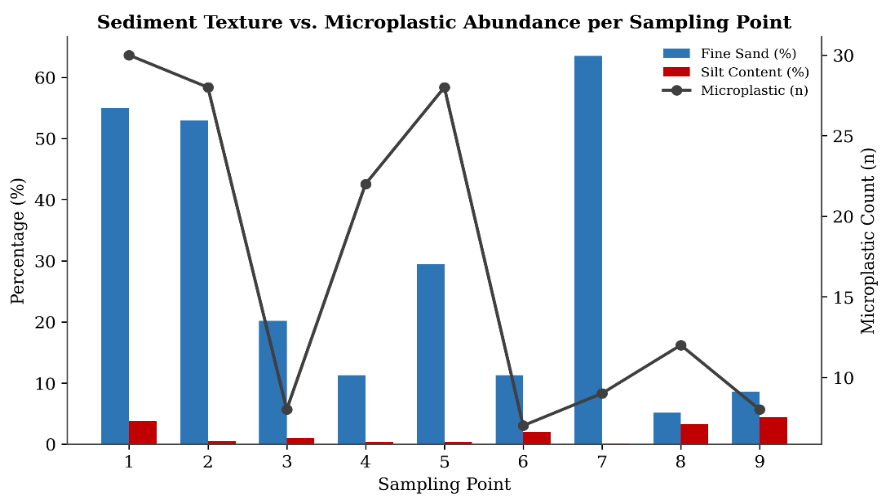

Figure 6. Sediment Texture vs. Microplastic Abundance per Sampling Point

Water content ranged from 5.44% (Sample 4) to 11.51% (Sample 9). The higher water content in Sample 9 is associated with clay-textured sediment, which has a finer particle size and greater capillary water retention capacity than sandy substrates (Xue et al, 2021). Samples 8 and 9, classified as clay-sandy and clay, respectively, exhibited relatively high silt contents (3.25% and 4.41%), consistent with their positions in low-velocity flow zones where fine particles preferentially deposit.

A noteworthy relationship is observed between sediment texture and microplastic accumulation when anthropogenic influence is controlled. Among sites with comparable human activity levels (Samples 3, 6, 7), the sandy-textured Sample 7 (fine sand 63.48%; silt 0.10%) retained fewer microplastics (9 particles) compared to sandy-loam Sample 6 (11.30% fine sand; 1.98% silt; 7 particles). Although the particle counts at these low-activity sites are too small for statistical inference, the trend is consistent with the established principle that fine-grained, high-organic sediments adsorb microplastics more effectively due to greater specific surface area and hydrophobic interactions (Pradipta. et al, 2022). At high activity sites (Samples 1, 2, 4, 5), anthropogenic input overwhelms the effects of sediment texture, resulting in uniformly elevated microplastic counts regardless of grain size.

Implications for Microplastic Management

The findings of this study underscore the urgency of integrated microplastic management in the Asam River. Given the hydrological connection between the Asam River and the Batanghari River, which serves as the primary raw water source for Jambi City's drinking water supply, microplastic contamination at the study sites represents a direct risk to water treatment systems and public health. Bioremediative approaches using indigenous microbes such as Bacillus megaterium, Pseudomonas sp., and Ralstonia eutropha have demonstrated potential for plastic degradation under controlled laboratory conditions (Pal et al., 2025). For drinking water treatment, coagulation/flocculation combined with sand and activated carbon filtration has achieved 70–83% microplastic removal efficiency at full-scale plants in the Czech Republic, suggesting viable technical solutions for Jambi's water treatment infrastructure.

Community based waste management interventions, particularly targeting plastic waste disposal behaviours in market areas and riverbank settlements, are equally critical. The strong spatial association between microplastic abundance and proximity to Pasar Angso Duo and residential zones (Samples 1, 2, 5) highlights the need to enforce existing waste management regulations and expand plastic waste collection infrastructure in these areas. However, the potential sources discussed in this study were inferred from particle morphology, colour, surrounding land use, and spatial proximity. Therefore, these interpretations should be considered preliminary and require confirmation through polymer identification and direct surveys of pollution sources

Conclusion

This study identified 152 microplastic particles across 9 sampling points in the Asam River sediment, Jambi City. Four morphological types were documented: filament (83 particles; 54.60%), fibre (49 particles; 32.23%), fragment (16 particles; 10.52%), and granule (4 particles; 2.63%). Particle sizes ranged from 0.085 to 4.907 mm with a mean of 0.699 mm. Blue and transparent colours dominated (30.9% and 30.3%, respectively), reflecting the prevalence of common consumer plastic types in the catchment. Microplastic abundance was highest at Sampling Point 1 (30 particles; 20%), located at

the Batanghari River confluence and near dense commercial and residential areas, and lowest at Sampling Point 6 (7 particles; 5%), adjacent to plantation areas with minimal human activity. Sediment texture varied from sandy (Sample 7; fine sand 63.48%) to clay (Sample 9; silt 4.41%; water content 11.51%), with fine-grained sites showing greater microplastic retention potential under equivalent pollution pressure. These findings confirm that Asam River sediment is contaminated with microplastics at ecologically significant concentrations, driven primarily by proximity to anthropogenic activities. Integrated waste management, enhanced pollution enforcement at market areas, and further monitoring of microplastic dynamics in the Batanghari River catchment are recommended.

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