Environmental Science

AIMS Environmental Science, 13(2): 348–361.
DOI: 10.3934/environsci.2026014
Received: 30 January 2026
Revised: 30 March 2026
Accepted: 14 April 2026
Published: 24 April 2026

https://www.aimspress.com/journal/environmental

Research article

Seasonal variations and spatial distribution of microplastics in tributary rivers and the Mekong mainstream in Ubon Ratchathani, Thailand

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Abstract: Microplastic (MP) pollution has emerged as a growing environmental concern in freshwater ecosystems, yet data from northeastern Thailand, a key hydrological region within the Mekong River Basin, remain limited. In this study, we investigated the abundance, characteristics, and seasonal variations of microplastics in six tributary rivers and four Mekong mainstream sites in Ubon Ratchathani Province. Surface-water samples were collected during the dry (April 2021) and wet (October 2021) seasons using a surface-trawl microplastic sampler, and particles were isolated through density separation and oxidative digestion before identification by FTIR spectroscopy. Nine polymer types were detected across all sites and seasons, with polypropylene (PP) and polyethylene (PE) as the predominant polymers. Seasonal differences were evident, with fragment-shaped MPs more abundant in the wet season, reflecting intensified hydrodynamic fragmentation, while fibers and sheets were more prevalent during the dry season. Tributary sites exhibited consistently higher MP abundances than Mekong mainstream sites, highlighting the importance of localized land-based inputs such as municipal wastewater, stormwater runoff, and urban activities. Overall, the findings demonstrate that hydrological conditions and land-use characteristics influence microplastic distribution within the region. This study provides baseline data for northeastern Thailand and contributes to understanding microplastic distribution in the Mekong River Basin.

Keywords: microplastics; Mekong River; seasonal variation; terrigenous input; polymer composition

1. Introduction

Plastic waste has become a major global environmental concern due to rapid population growth and increasing consumption, which result in the widespread release of persistent plastic debris into natural environments [1]. Among these pollutants, microplastics (MPs) are recognized as emerging contaminants with long-term ecological and human health implications [2]. Larger plastic items gradually fragment into small particles, usually defined as less than 5 mm in size, that can remain in aquatic ecosystems for extended periods and interact with biota at multiple trophic levels [2,3]. Their resistance to degradation enables them to accumulate in water, sediments, and organisms, where they can adsorb and transport chemical contaminants such as organic pollutants and plastic additives [3,4]. These properties raise concerns not only for aquatic ecosystem health but also for potential exposure through drinking water and food chains. Despite extensive research on marine microplastics, freshwater systems, particularly rivers, remain comparatively understudied, even though they function as major pathways transporting land-based plastics to the oceans [5]. Rivers are dynamic environments influenced by hydrological conditions, land-based activities, and pollutant pathways, all of which shape the environmental fate, transport, and distribution of MPs [6]. Studies have further highlighted the importance of hydrodynamic processes such as flow velocity, turbulence, and sediment interactions in controlling the transport, retention, and resuspension of microplastics in river systems [7–9]. In addition, runoff-driven inputs during rainfall events and seasonal discharge variations play a critical role in mobilizing plastic debris from terrestrial environments into river channels, reinforcing the significance of terrigenous inputs in freshwater microplastic pollution [10,11].

Southeast Asia is among the regions with the highest levels of riverine microplastic pollution, with significant concentrations reported in major rivers such as the Chao Phraya in Thailand, the Citarum in Indonesia, and the Saigon in Vietnam [12]. Rapid urbanization, dense populations along river corridors, and inadequate waste management systems contribute to high plastic leakage into waterways in this region [12,13]. Within this context, the Mekong River is recognized as a critical transboundary system that supports fisheries, agriculture, transportation, and livelihoods for millions of people, yet is increasingly affected by plastic pollution [13]. Assessments in the Lower Mekong Basin indicate substantial plastic inputs into river channels and growing pressures on water quality [13]. Modeling studies further show that plastic debris transported through the Mekong can originate from multiple upstream countries, underscoring the basin-wide complexity of pollution pathways and emphasizing the need for coordinated regional management efforts [14]. Investigations in the Mekong River Basin have also reported spatial variability in microplastic abundance linked to urban centers, tributary inflows, and seasonal hydrological changes, highlighting the influence of local sources and large-scale transport processes [15,16]. These findings emphasize the need for site-specific monitoring in tributary systems, which can act as important pathways for microplastic inputs into the main river.

Thailand is identified as one of the principal contributors of ocean-bound plastic waste in Southeast Asia, discharging an estimated 0.15–1.29 million tons annually [17]. Microplastic contamination in Thai rivers originates diverse land-based activities, including urban runoff, insufficient wastewater treatment, aquaculture operations, and tourism-related pressures [17]. Researchers have documented MPs in rivers across several regions of the country, such as the Nan River in the north and multiple rivers in the southern provinces [18,19], indicating that riverine microplastic pollution is a nationwide issue. However, northeastern Thailand, despite being one of the country's largest agricultural production zones and home to rapidly expanding peri-urban communities, remains notably understudied. These land-use and demographic characteristics may lead to contamination patterns that differ from those observed in northern and southern regions, highlighting the importance of establishing baseline data for this part of the Mekong Basin.

Seasonal variability strongly influences the transport and distribution of MPs in river systems, yet these dynamics remain insufficiently characterized in tropical monsoon regions [20,21]. Establishing baseline information on MP abundance, composition, and spatiotemporal patterns is important for improving understanding of microplastic dynamics in such environments [22,23]. Therefore, we aimed to investigate the abundance, characteristics, and seasonal variations of microplastics in selected rivers of Ubon Ratchathani Province, northeastern Thailand.

2. Materials and methods

2.1. Study area

This study was conducted in Ubon Ratchathani Province in northeastern Thailand, where several major tributaries flow into the Mekong River. Ten sampling sites were selected based on population density, land-use characteristics, and the presence of potential plastic leakage hotspots. Six sites were located along tributary rivers, whereas four sites were situated on the Mekong River mainstream. This spatial design was adopted to enable a comparison between local tributaries, which reflect predominantly local land-based inputs, and the Mekong River, which integrates broader basin-scale and transboundary influences. In addition, sampling locations were categorized into two types: accumulation sampling and regional sampling. Accumulation sampling refers to areas where microplastics are likely to concentrate due to hydrodynamic conditions such as reduced flow velocity or localized retention zones. Regional sampling represents broader river sections used to assess spatial variation in microplastic distribution across the study area. A map of all sampling locations is presented in Figure 1. Sampling was performed during two hydrologically contrasting periods: the dry season (April 2021) and the wet season (October 2021). These periods represent low-discharge and high-discharge conditions, respectively, and have been shown to influence microplastic (MP) transport, mobilization, and fragmentation processes in tropical monsoon river systems [20].

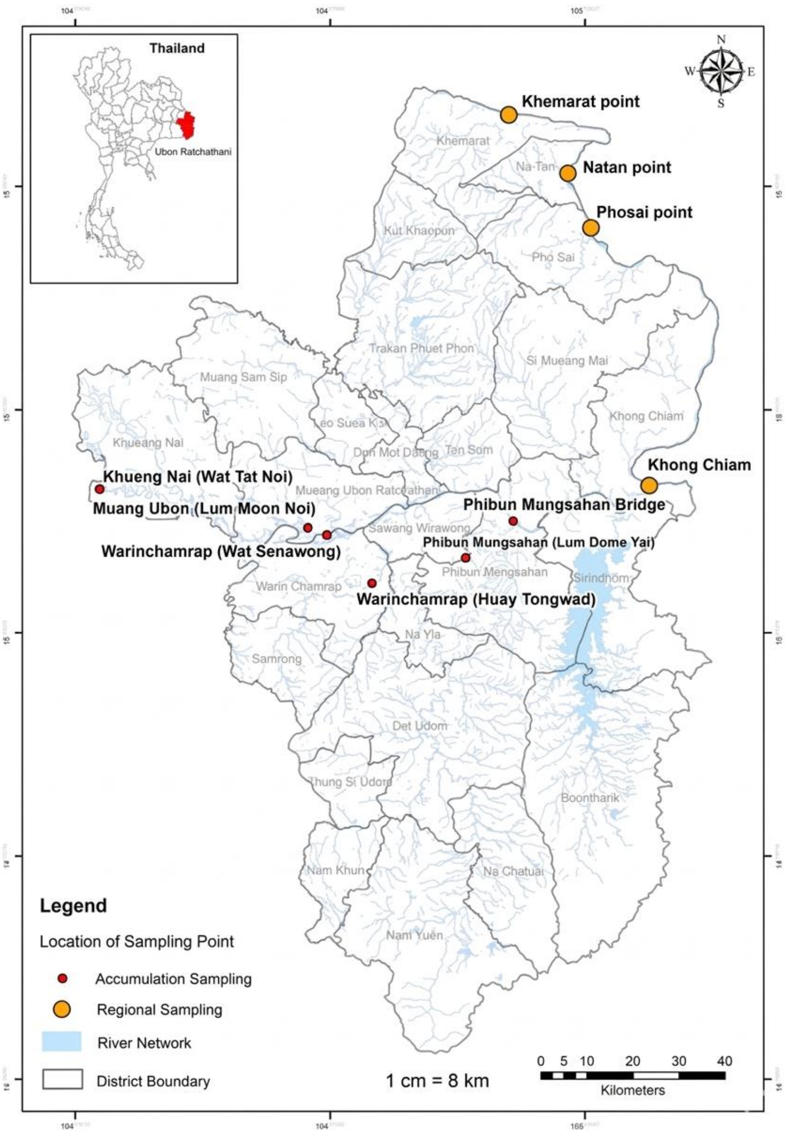

Figure 1. Map of the ten sampling locations in Ubon Ratchathani Province, including six tributary sites and four Mekong River sites.

2.2. Microplastic sampling procedure

Surface-water samples were collected using an Albatross surface-water trawling system (Pirika Inc., Japan), which comprises a motorized intake mechanism and a fine-mesh plankton net (mesh size 0.3 mm). The device is designed for microplastic surveying in freshwater, estuarine, and coastal environments, enabling sampling under a range of flow conditions via towed, naturally drained, or power-driven modes [24]. In this study, sampling was conducted under stationary conditions, with the device deployed at a fixed point rather than towed. The intake was positioned at the water surface, with a submergence depth of less than 30 cm, targeting the upper surface layer under natural flow conditions. At each sampling site, the device was operated for a fixed duration of 3 minutes to standardize sampling effort across locations and ensure comparability. Prior to and immediately after each sampling event, flow meter readings were recorded to determine the total volume of filtered water. Upon retrieval, the plankton net was thoroughly rinsed to ensure complete recovery of retained particles. The collected material was subsequently passed through a secondary collection net with a 100 µm mesh to capture smaller particles that may have passed through the primary net. The secondary nets were then sealed, labeled, air-dried, and transported under contamination-controlled conditions to Pirika Inc. (Japan) for laboratory analysis. At each sampling site and season, a single sampling event was conducted ($n = 1$). Therefore, variability among replicates could not be assessed, and the results should be interpreted as exploratory.

2.3. Laboratory processing and microplastic isolation

All collected samples were transferred to pre-cleaned glass beakers and processed under contamination-controlled conditions to minimize the introduction of airborne fibers or laboratory-derived particles. Microplastics were isolated using a two-step procedure commonly applied in freshwater MP research. First, density separation was performed using a NaCl solution (1.2 g/cm^3), enabling low-density polymers such as polyethylene (PE) and polypropylene (PP) to float while heavier mineral particles settled. Although this approach may have limited efficiency for high-density polymers (e.g., polyethylene terephthalate (PET) and polystyrene (PS)), it was selected due to its cost-effectiveness, low environmental impact, and widespread application in freshwater studies [3]. To minimize potential omission of high-density particles, additional visual inspection and polymer identification steps were applied to ensure that particles retained in the residual fraction were not overlooked. The supernatant fraction was carefully collected for subsequent purification.

Second, organic residues were removed through oxidative digestion using 30% hydrogen peroxide (H_2O_2) combined with 0.05 M Fe (II), following the Fenton reaction at 50 °C for one hour. The digestion was conducted under controlled conditions with continuous stirring to ensure homogeneous reaction. This method efficiently degrades organic matter without altering the physical integrity of plastic polymers, enabling reliable downstream identification [3].

2.4. Microplastic identification and characterization

Following purification, isolated particles were filtered, air-dried, and examined under a stereomicroscope. Each particle was classified according to shape (fragment, fiber, or sheet), color, and size. Size measurements were obtained using calibrated digital imaging software. Polymer identification was performed using Fourier Transform Infrared Spectroscopy (FTIR), an established technique for characterizing microplastics based on their molecular vibration spectra. A spectral match threshold of $\geq 70\%$ was applied to confirm polymer identity, which was consistent with criteria used in other freshwater microplastic studies in Thailand [3,19]. This threshold ensures reliable identification while accounting for spectral variability in environmental samples. Due to analytical constraints, FTIR analysis was conducted on a representative subset of particles rather than the entire sample set. The selected particles were chosen to reflect the diversity of shapes, sizes, and visual characteristics observed in each sample. This approach enables representative identification of dominant polymer types, including polyethylene (PE), polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET), polyurethane (PU), and other less common polymers.

2.5. Quality assurance and quality control (QA/QC)

To minimize contamination, strict QA/QC measures were applied during field sampling and laboratory processing. All sampling equipment and glassware were pre-cleaned and rinsed with filtered distilled water prior to use. During sampling, the plankton net was thoroughly rinsed after each deployment to ensure complete particle recovery, and collected samples were immediately sealed, labeled, and transported under contamination-controlled conditions. The absence of field blanks is acknowledged as a limitation; however, precautions were taken to minimize sample exposure to ambient conditions during collection and handling.

In the laboratory, all procedures were conducted under controlled conditions to reduce airborne contamination. Laboratory personnel wore cotton lab coats to minimize the introduction of synthetic fibers. All solutions used were filtered where applicable, and equipment was thoroughly rinsed with filtered distilled water prior to use. Procedural blanks consisting of filtered distilled water were included and processed alongside samples to monitor potential contamination from handling, equipment, and the surrounding environment. In addition, procedural blanks were used as indicators of potential airborne contamination during laboratory processing.

2.6. Data analysis

Microplastic abundance was quantified as the total number of particles per sampling event. Descriptive statistics were used to summarize MP characteristics for each site and season, and all data processing was conducted using Microsoft Excel. Due to the limited number of samples collected at each site and during each season, formal inferential statistical analyses were not performed. Therefore, the observed differences between groups should be interpreted as exploratory patterns rather than statistically significant differences. Comparisons were made between dry and wet seasons, tributary and Mekong mainstream locations, and among particle shapes, sizes, colors, and polymer types. Spatial patterns were interpreted in relation to land use, population density, wastewater discharge, and surrounding human activities, which have been identified as key contributors to microplastic contamination in Thai freshwater systems [3,18].

3. Results

3.1. Microplastic abundance

Microplastic abundance exhibited seasonal and spatial contrasts across the study area are shown in Table 1. During the dry season, concentrations ranged from 0.29 to 8.17 particles/m^3, with the highest value recorded at Warinchamrap (Wat Senawong) (8.17 particles/m^3), a tributary site influenced by municipal wastewater discharge and dense residential activities. Tributary sites generally exhibited higher dry-season abundances than Mekong mainstream locations, reflecting more localized inputs under low-flow conditions. In contrast, wet-season concentrations ranged from 0.16 to 14.60 particles/m^3, with the highest value observed at Khemmarat (14.60 particles/m^3). Other Mekong sites, including Phosai (10.71 particles/m^3) and Khong Chiam (7.14 particles/m^3), also showed substantial increases, indicating strong monsoon-driven hydrological flushing and transport of upstream microplastics into the main river channel. These patterns suggest that tributaries act as concentrated microplastic sources during the dry season, whereas the Mekong River becomes the dominant receptor and long-distance transport pathway during the wet season.

Table 1. Microplastic abundance (particles/m³) at all sampling sites during the dry and wet seasons.

Location name	Dry season (particles/m³)	Wet season (particles/m³)	Sampling
Khueng Nai (Wat Tat Noi)	0.61	0.85	Accumulation Sampling
Muang Ubon (Lum Moon Noi)	5.05	1.23	Accumulation Sampling
Warinchamrap (Wat Senawong)	8.17	2.60	Accumulation Sampling
Warinchamrap (Huay Tongwad)	1.24	2.07	Accumulation Sampling
Phibun Mungsahan (Lum Dome Yai)	0.32	0.16	Accumulation Sampling
Phibun Mungsahan Bridge	1.05	2.62	Accumulation Sampling
Khemmarat	0.29	14.60	Regional Sampling
Natan	0.64	2.62	Regional Sampling
Phosai	0.49	10.71	Regional Sampling
Khong Chiam	0.33	7.14	Regional Sampling

3.2. Polymer types of microplastics

A total of nine polymer types were identified across all sites and seasons, including polypropylene (PP), polyethylene (PE), polystyrene (PS), polyethylene terephthalate (PET), polydimethylsiloxane (PDMS), polyurethane (PU), nylon, and polychloroprene. Polymer distribution differed seasonally. PP was the predominant polymer during the dry season (68.6%) and remained the most abundant during the wet season (47.5%). PP and PE together accounted for the majority of particles, reflecting the prevalence of packaging and household plastic waste in the study area. These patterns are illustrated in Figure 2.

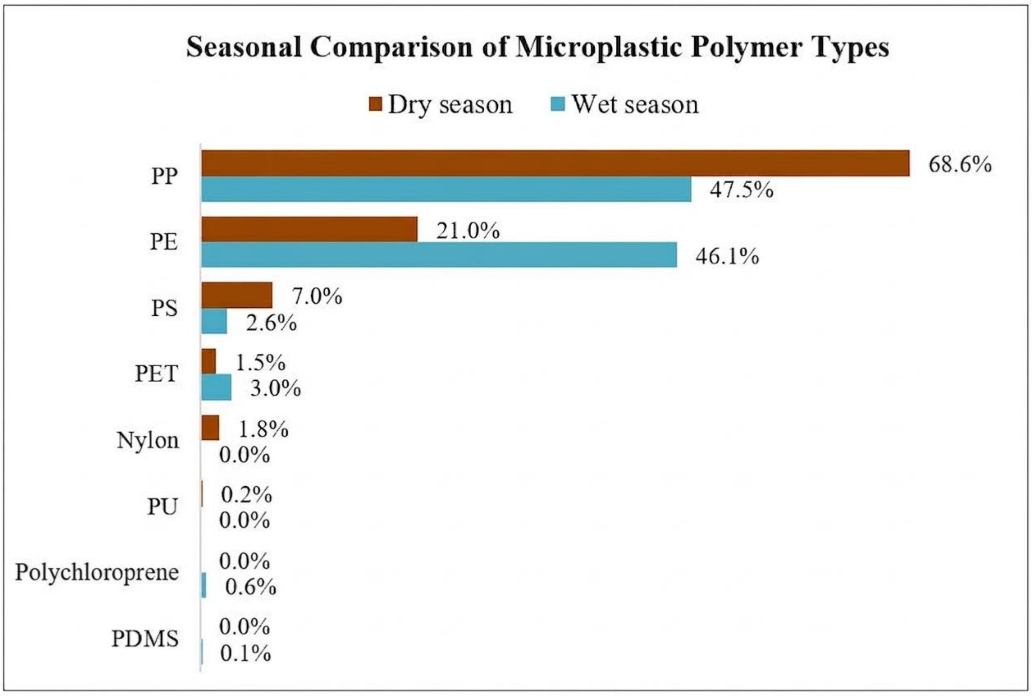

Figure 2. Polymer composition of microplastics identified in (a) dry season and (b) wet season.

3.3. *Size, colors, and shapes of microplastics*

3.3.1. Size distribution

Microplastic sizes ranged from 0.44–17.61 mm in the dry season and 0.09–16.79 mm in the wet season. Smaller particles (<1 mm) were more common in the wet season, consistent with enhanced fragmentation under high-flow conditions. It should be noted that the reported size range included particles larger than 5 mm, which exceed the conventional definition of microplastics. In this study, these larger particles were classified as mesoplastics and were intentionally included to provide a more comprehensive assessment of plastic debris. For clarity, the term microplastics was used here to broadly describe plastic particles, encompassing microplastics (<5 mm) and mesoplastics (>5 mm), as they share similar sources and environmental behavior.

3.3.2. Color distribution

Seven colors were recorded during the dry season, with white being the most common (48.5%), followed by transparent (27.0%), blue (6.9%), and green (6.9%). In the wet season, nine colors were observed, with white again being dominant (44.7%), followed by transparent (39.3%) and blue (5.7%). As shown in Figure 3, color compositions differed between seasons, with a broader color range observed during the wet season.

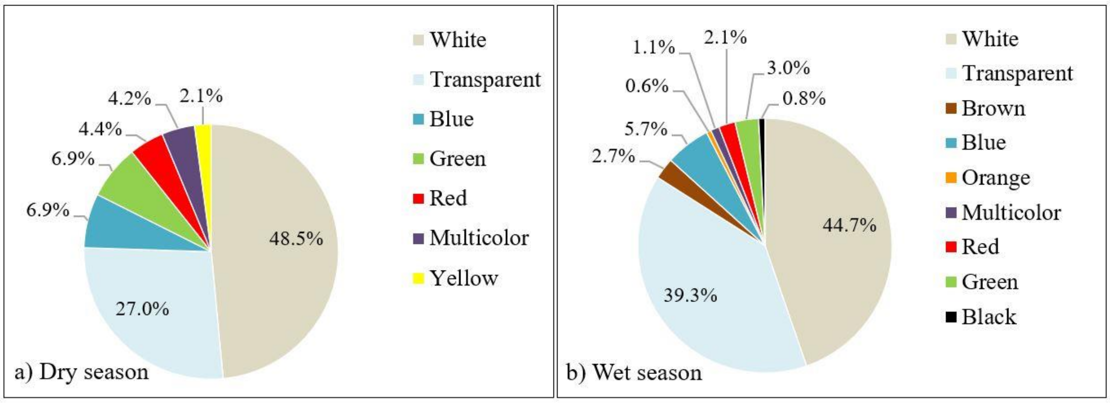

Figure 3. Color distribution of microplastics identified in (a) dry season and (b) wet season.

3.3.3. Shapes of microplastics

Fragments, fibers, and sheets were observed across all sites, with seasonal differences. The dry season was characterized by higher proportions of sheets and fibers, whereas fragments dominated the wet season (62.1%). These seasonal changes are shown in Table 2.

Table 2. Distribution of microplastic shapes identified in the dry and wet seasons.

Shape type	Dry season (%)	Wet season (%)
Fragments	23.3%	62.1%
Fibers	31.7%	9.9%
Sheets	45.0%	28.0%

3.4. Spatial distribution of microplastics

Microplastics were detected at all ten sampling sites, but their spatial distribution differed markedly between tributary rivers and the Mekong mainstream, with clear seasonal shifts. During the dry season, tributary locations showed much higher microplastic abundances than Mekong sites. The most contaminated location was Warinchamrap (Wat Senawong), where very large numbers of particles were recorded, dominated by polypropylene and polyethylene. This pattern reflects strong influences from nearby residential areas and effluent from municipal wastewater sources. Muang Ubon (Lum Moon Noi) also exhibited elevated concentrations and a wide variety of polymers, including polyethylene, polypropylene, polyethylene terephthalate, and polystyrene, consistent with inputs from urban runoff and household waste leakage. Other tributary sites such as Phibun Mungsahan Bridge, Phibun Mungsahan (Lum Dome Yai), and Warinchamrap (Huay Tongwad) showed moderate levels of contamination. In contrast, the Mekong mainstream sites at Khemmarat, Natan, Phosai, and Khong Chiam contained relatively few microplastics during the dry season, likely due to a greater dilution capacity under low-flow conditions.

During the wet season, microplastic abundances increased markedly at Mekong mainstream sites, with Khong Chiam showing the highest concentration, followed by Phosai and Khemmarat. These peaks likely reflect monsoon-driven hydrodynamic transport and inflow of microplastics from upstream regions of the Mekong River. Tributary sites generally exhibited lower abundances during the wet season, consistent with dilution under high-flow conditions. Only a few tributary locations, such as Phibun Mungsahan (Lum Dome Yai) and Muang Ubon (Lum Moon Noi), showed moderate increases. In contrast, Warinchamrap (Huay Tongwad) recorded one of the lowest wet-season values, indicating minimal local wash-off or strong dilution effects during peak runoff.

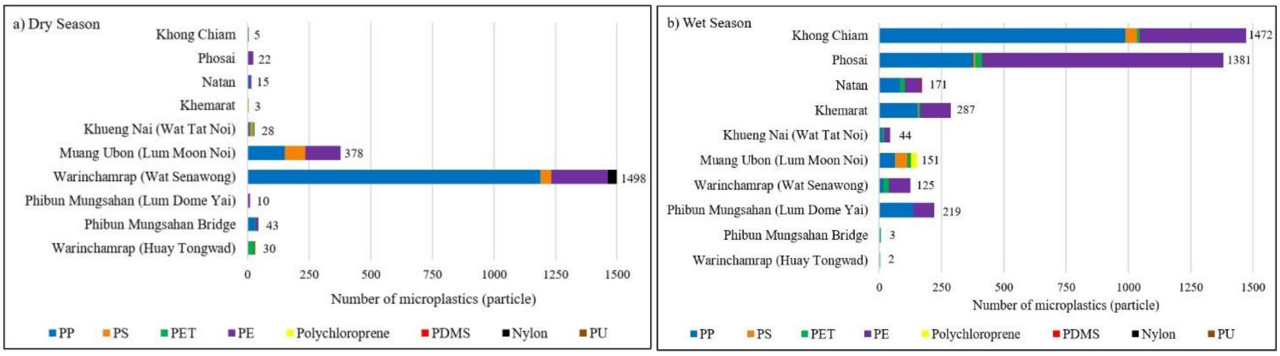

Figure 4. Composition of microplastic polymers at each sampling site during (a) dry and (b) wet seasons. Values represent particle counts per sampling event (n = 1) and are not averaged. A consistent set of polymer types is shown across both seasons; absence of a polymer indicates non-detection.

Figure 4 shows the polymer distributions across sites and seasons, revealing the persistent dominance of polypropylene and polyethylene but also a broader range of polymer types in the Mekong River during the wet season. Overall, the spatial patterns indicate that tributary rivers function as the main entry points of microplastics during the dry season, when contamination reflects localized waste leakage, while the Mekong River becomes the key transport route during the wet season, receiving plastics mobilized from nearby tributaries and upstream transboundary sources. These findings demonstrate the combined influence of hydrological variability, land-use characteristics, and wastewater discharge on microplastic distribution across the river network.

4. Discussion

In this study, we provide a seasonal assessment of microplastics (MPs) in tributary rivers and the Mekong mainstream within Ubon Ratchathani Province, revealing spatial and temporal variations in polymer types, shapes, sizes, and colors. Across both seasons, PP and PE were consistently the dominant polymers, aligning with other studies in Thailand and Southeast Asia that identified household packaging, plastic bags, and consumer products as major contributors to riverine MP pollution [3,12,17]. The prevalence of these low-density polymers corresponds to their buoyant behavior, which enables long-distance transport within river systems [14]. This pattern is consistent with findings from other rivers within the Mekong Basin, where researchers have reported a dominance of common consumer-related polymers such as PP, PE, and PET, although some locations showed higher proportions of PET or polyester fibers associated with textile sources and wastewater inputs. For example, investigations in the lower Mekong have identified PET or polyester as major components, particularly in downstream and urban-influenced areas [15].

Similarly, studies from tropical river systems across Southeast Asia, including rivers in Thailand, Indonesia, and Vietnam, have consistently reported PE and PP as the predominant polymers in surface waters, often accompanied by smaller contributions from PET, PS, and PVC [25–28]. This regional consistency reflects the widespread use of single-use plastics and packaging materials, as well as similar waste management challenges across rapidly urbanizing catchments. Comparable patterns have also been reported in parts of the Mekong River Basin, where variations in polymer composition are influenced by local land use, wastewater inputs, and transboundary transport processes. The slight variation in dominant polymer types between studies may be attributed to differences in local sources, such as domestic wastewater, textile-derived fibers, and land-based plastic leakage, as well as methodological differences, including sampling depth, mesh size, and analytical techniques [29,30]. In this context, the predominance of PP and PE observed in this study is consistent with regional trends, while also reflecting local consumption patterns and hydrological conditions in the study area.

Distinct seasonal patterns were observed in polymer profiles, with PP dominating in the dry season and PE in the wet season. The increase in PE during the wet season may reflect wash-off from residential areas, increased stormwater inputs, and intensified catchment runoff, all of which mobilize large quantities of lightweight plastics during periods of high rainfall [21]. Seasonal hydrodynamics also influenced microplastic morphology. However, no quantitative analysis linking hydrological parameters (e.g., flow rate, velocity, or runoff) with microplastic characteristics was performed in this study, and these relationships should therefore be interpreted qualitatively. The marked increase in fragment-shaped MPs during the wet season is consistent with hydrological processes that accelerate abrasion, turbulence-induced breakdown, and UV-mediated fragmentation of larger plastics, as documented in other monsoon-driven river systems [1,6,21]. Corresponding increases in smaller particles (<1 mm) further support the role of wet-season flows in enhancing mechanical degradation and long-distance transport. However, detailed size classification and correlation analyses between particle size and polymer type or morphology were not performed in this study. Therefore, these patterns should be interpreted as indicative rather than quantitatively resolved.

Color distributions provide additional insights into sources. The dominance of white and transparent MPs mirrors patterns reported in Thai freshwater systems, where degraded PP/PE films, shopping bags, and packaging materials are considered likely contributors to riverine inputs [18]. The broader range of colors observed during the wet season may indicate increased mobilization of plastic debris from residential and commercial areas during stormwater runoff events.

Spatial variability was substantial. Tributary rivers consistently exhibited higher MP abundance than Mekong mainstream sites, underscoring their role as major conduits for land-based plastic leakage. Sites with the highest MP concentrations, Warinchamrap (Wat Senawong) in the dry season and Warinchamrap (Huay Tongwad) in the wet season, are adjacent to dense residential zones, local markets, and wastewater discharge points. These observations suggest that wastewater effluent and urban activities may act as important pathways for MP inputs at these locations. However, no quantitative analysis linking microplastic abundance with land use, population density, or wastewater discharge was performed in this study, and these interpretations should therefore be considered indicative rather than definitive. Wastewater effluent, in particular, has been reported as a major pathway for MP release in Thailand [18,19,23], which is consistent with the patterns observed in this study. This spatial structure reflects broader findings across Southeast Asia, where urban tributaries act as critical hotspots for plastic leakage into major river basins [6].

Evidence from the Mun River further highlights the ecological implications of this contamination. Researchers reported substantial MP ingestion in freshwater fish, dominated by polyethylene and fiber-shaped particles, particularly in urbanized areas of Ubon Ratchathani [4]. This supports the likelihood that MPs transported from tributaries not only enter the Mekong system but also interact with aquatic food chains within the province.

At the basin scale, these findings have important implications for the Mekong River Basin (MRB). The MRB is recognized as a major pathway for plastic leakage from inland communities to downstream ecosystems, contributing to transboundary plastic pollution across countries [13,14]. Ubon Ratchathani serves as a significant upstream gateway in Thailand, and plastic leakage from its tributaries may contribute to downstream accumulation and transboundary impacts. The dominance of PP and PE in this study reinforces the urgency of implementing community-level interventions targeting single-use plastics, which represent the bulk of the region's mismanaged waste [17].

Overall, the results indicate that microplastic occurrence in Ubon Ratchathani's rivers is likely influenced by hydrological conditions, land-use patterns, wastewater discharge, and local waste management practices. Across all sampling sites and both seasons, microplastic composition was consistently dominated by PP and PE, reflecting their widespread use in packaging materials and consumer products. White and transparent particles were the most common, supporting the contribution of degraded PP/PE bags and films, while fragments and sheets represented the predominant morphologies, with proportions varying seasonally in response to hydrodynamic conditions. Moreover, integrating polymer, color, and shape characteristics with spatial patterns suggests that microplastic contamination in the study area is driven by a combination of land-based household waste leakage, wastewater inputs, and seasonal river dynamics. Tributary rivers appear to function as important entry points for microplastics into the Mekong River system, highlighting the combined influence of local anthropogenic activities and environmental processes. However, these source attributions are based on observed patterns and comparisons with the literature, and should therefore be considered indicative rather than definitive due to the absence of direct source-tracking analyses. Reducing microplastic pollution in the region will require targeted strategies, including improved upstream waste segregation, enhanced wastewater treatment, and community-based plastic reduction measures. The dataset generated in this study provides critical baseline information for long-term monitoring, regional management planning, and transboundary assessments of plastic movement within the Mekong Basin.

This study has several limitations that should be acknowledged. First, the number of samples collected at each site and during each season was limited, restricting the application of inferential statistical analyses; therefore, observed differences are interpreted as exploratory rather than statistically significant. Second, the use of a NaCl solution for density separation may have led to an underestimation of high-density polymers such as PET and PVC. Third, source attribution is based on observed spatial patterns and comparisons with other studies, as direct source-tracking approaches (e.g., land-use quantification or wastewater discharge measurements) were not performed. Despite these limitations, the study provides valuable baseline data and insights into the spatial and seasonal behavior of microplastics in a previously understudied region of the Mekong River Basin.

5. Conclusions

This study provides a seasonal assessment of microplastics in tributary rivers and the Mekong mainstream of Ubon Ratchathani Province, revealing spatial and temporal patterns influenced by hydrological conditions and local anthropogenic activities. PP and PE were the predominant polymers, while fragment-shaped particles increased during the wet season, suggesting enhanced mobilization and mechanical fragmentation under high-flow conditions. Tributary rivers exhibited higher microplastic abundance than Mekong mainstream sites, indicating their potential role as important pathways for land-based plastic inputs into the Mekong River system. These findings highlight the need for improved upstream waste management, wastewater treatment, and community-level interventions targeting single-use plastics. The dataset generated in this study provides baseline information for future monitoring and may support the development of strategies to mitigate riverine plastic pollution in the region.

Use of AI tools declaration

The authors declare that Artificial Intelligence (AI) tools were used only to assist with language editing, text refinement, and figure preparation. No AI tools were used to generate, analyze, or interpret the research data. All scientific content, data analysis, and final conclusions were developed and verified solely by the authors.

Acknowledgments

The authors gratefully acknowledge financial support from the UNEP CounterMEASURE II Project: Promotion of Action Against Marine Plastic Litter in Asia and the Pacific. The authors also extend their appreciation to Pirika Inc. (Japan) for providing laboratory analysis and technical support.

Pawena Limpiteeprakan: Conceptualization, methodology, investigation, data curation, formal analysis, writing–original draft, writing–review & editing, supervision, project administration; Sanga Tubtimhin: Investigation, data curation, validation, writing–review & editing. All authors have read and approved the final version of the manuscript for publication.

Conflict of interest

The authors declare no conflict of interest.

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