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RESEARCH ARTICLE
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Urbanization Drives Microplastic Pollution in Thailand's Mun River: A Multi-Index Risk Assessment and Spatial Distribution Analysis

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ABSTRACT

A comprehensive investigation assessed microplastic contamination in Thailand's lower Mun River system, a critical freshwater resource in Southeast Asia. Sampling was conducted during the dry season using the Albatross Mark 6 (AM-6) device across four distinct land-use zones: pristine natural areas, agricultural landscapes, urban developments, and the Mun-Chi River confluence. Mean microplastic concentration was quantified at 168.41±66.64particles/m^3, with urban zones exhibiting significantly elevated concentrations compared to natural areas (mean difference: 168.33particles/m^3; 95% CI: 151.11-185.55, P<0.001). Morphological and spectroscopic analyses revealed a predominance of blue-pigmented fibrous particles, with polypropylene (PP) constituting 40.57% of identified polymers. Ecological risk assessment using Plastic Hazard Index (PHI), Pollution Load Index (PLI), and Potential Ecological Risk Index (PERI) demonstrated substantial environmental and human health implications across all sampling sites, with urban zones manifesting the highest risk profiles. These findings provide crucial evidence for the spatial heterogeneity of microplastic pollution in this riverine ecosystem, emphasizing the necessity for targeted mitigation strategies, particularly in urban corridors, to preserve the Mun River's ecological integrity and safeguard public health in this developing region.

Keywords: Microplastic contamination, Microplastics pollution, Polymer hazard index (PHI), Pollution load index (PLI), Potential ecological risk index (PERI).

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INTRODUCTION

Microplastics, defined by the National Oceanic and Atmospheric Administration (NOAA) as plastic particles less than 5mm in diameter, represent an emerging global environmental contaminant of significant concern (NOAA, 2020). These pollutants are categorized into two distinct classifications: primary microplastics, intentionally manufactured at microscopic sizes for use in cleansers, cosmetics, and industrial applications, which predominantly enter aquatic systems through municipal and industrial wastewater discharge (Bayo et al., 2023), and secondary microplastics, generated through the environmental degradation of larger plastic debris (Cole et al., 2011; Hayat et al., 2025). A significant additional source is synthetic fiber release during textile laundering, which contributes substantially to contamination by mismanaged plastic waste (MPW) (Priya et al., 2023). Upon entering aquatic ecosystems, microplastics exhibit significant potential to adsorb contaminants through surface porosity developed by biodegradation and physical weathering. These particles effectively accumulate various environmental pollutants, including pesticides (Wang et al., 2020), heavy metals, and polycyclic aromatic hydrocarbons (Khan et al., 2024). While global research efforts intensify to quantify microplastic contamination in sediments and surface waters (Tien et al., 2020), developing Asian nations face disproportionate impacts from aquatic pollution (Yuan et al., 2019). Environmental risk assessment (ERA) methodologies have evolved to incorporate sophisticated

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hazard scoring systems that evaluate critical parameters, including polymer composition, quantity and concentration (Tomlinson et al., 1980; Lithner et al., 2011; Peng et al., 2017). Of particular concern is the potential for trophic transfer through aquatic food webs (Nara, 2019), with documented accumulation in organisms ranging from zooplankton to fish (Parvin et al., 2021) and shellfish (Ding et al., 2020). This biomagnification pathway poses escalating risks to human health, as corroborated by the detection of microplastic particles in human biological samples, including colonic tissue, feces and blood (Schwabl et al., 2019; Ibrahim et al., 2021; Leslie et al., 2022).

In Thailand, extensive documentation of microplastic pollution exists across marine ecosystems, encompassing coastal beaches (Tharamon et al., 2016; Ekchit & Ruamkaew, 2019) and marine biota (Srisiri et al., 2024). While comparatively less studied, freshwater systems have also demonstrated significant contamination in both surface waters and sediments (Ta & Babel, 2019), with documented bioaccumulation in freshwater organisms (Kasamesiri & Thaimuangphol, 2020). The Mun River, extending 630km through northeast Thailand before its confluence with the Kong River, represents a complex socio-ecological system supporting diverse anthropogenic activities, including aquaculture operations, floating restaurants, residential structures and riverine communities. Environmental monitoring data from 2020-2022 indicate a marked deterioration in water quality, attributed to multiple stressors including industrial effluents, agricultural drainage, urban runoff, and domestic wastewater discharge. A particularly concerning finding from the Environment and Pollution Control Office 12 revealed that 92.74% of waste disposal facilities in the lower Mun River basin operate without proper scientific management protocols (Environment and Pollution Control Office 12, 2022). The system's vulnerability to microplastic contamination is further amplified by recurring flood events, driven by overflow from both the Chi River and upper Mun River watersheds. These hydrological events facilitate the transport and redistribution of microplastics within freshwater environments, introducing terrestrially-derived particles of diverse morphologies (Song et al., 2020; Lahon & Handique, 2023). Flood-induced erosion processes mobilize previously sequestered microplastics from riverbed sediments (Eppehimer et al., 2021), while simultaneously transporting associated contaminants, including heavy metals and agrochemicals. Previous studies have documented post-flood microplastic concentrations reaching up to 14-fold higher than baseline levels (Gündoğdu et al., 2018), highlighting the significant impact of these hydrological events on pollutant dynamics.

This study presents the first comprehensive assessment of microplastic pollution in the Mun River system, focusing on surface waters across four distinct land-use zones in Ubon Ratchatani and Warinchamrap City: the Mun-Chi River confluence, agricultural areas, urban developments, and natural landscapes. The research objectives were twofold: (i) to characterize microplastic abundance, morphology, color distribution and polymer composition; and (ii) to evaluate environmental risks through the application of multiple indices, including the Polymer Hazard Index (PHI), Pollution Load Index (PLI), and Potential Ecological Risk Index (PERI). These findings establish crucial baseline data for informed environmental management strategies and policy development in this rapidly evolving region.

MATERIALS & METHODS

Study Areas

Surface water samples were collected from four sampling stations along the Mun River in the Ubon Ratchathani Province, Northeast Thailand. The four sampling sites (S1-S4) encompass a variety of land uses along the river. S1, located at 15°16'54.41"N 105° 0'32.82"E, is a natural area with surrounding empty space, a national forest, and fishing activity. S2, at 15°13'18.2"N 104°45'50.4"E, is agricultural land with surrounding areas dedicated to farming, fishing, and aquatic farming. S3, the most urbanized site at 15°13'23.0" N 104°51'24.5" E, features a dense residential zone, commercial areas, aquatic farming, fishing, and a wastewater plant in its vicinity. Finally, S4, positioned at the confluence of the Mun and Chi Rivers (15°10'54.6"N 104°42'55.9"E), has surrounding areas dedicated to aquatic farming and fishing, reflecting the riverine confluence (Fig. 1).

Sampling Method

Water Sample Collection

Water sampling was conducted during the dry season in Ubon Ratchathani, with a total of twelve samples collected across three sampling events. Sample collection was performed using the Albatross Mark 6 (AM-6) microplastic sampling device (Fig. 2). The AM-6 system comprises three primary components: (1) a plankton net (24 cm mouth diameter, 750 cm length), (2) a submersible waterproof power supply unit equipped with a propeller (RDS200, Yamaha, Japan) for water propulsion and (3) a flow counter (GO-2030 R6, General Oceanics, Miami, FL, USA).

The sampling protocol consisted of positioning the Albatross device in the water column, completely submerged near the river surface, for a standardized three-minute sampling period. Flow counter rotations were carefully documented to facilitate filtered volume calculations according to the established methodology of Abeynayaka et al. (2020). After sampling, the collected materials were thoroughly rinsed from the net and sieved into 1-L glass containers with deionized water.

Sample Preparation and Processing

Initial sample processing involved filtration through a 5.0mm stainless-steel sieve with deionized water rinses. Organic matter exceeding 5.0mm (including leaves, insects, algae, and woody debris) was meticulously removed using tweezers following established protocols (Masura et al., 2015). The samples underwent organic matter digestion using 30% hydrogen peroxide (H_2O_2) for 12hours to eliminate naturally occurring organic substances adhering to microplastic surfaces. Subsequently, the digested samples were filtered through 0.45µm filter paper and dried at 65°C prior to microplastic analysis (Yasaka et al., 2022).

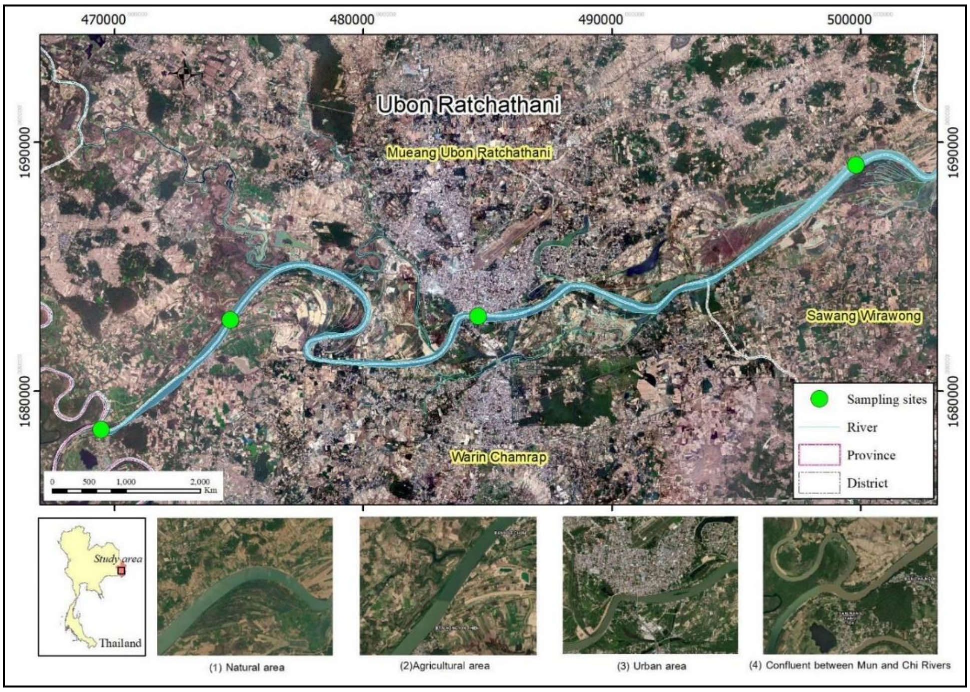

Fig. 1: Sampling site study areas.

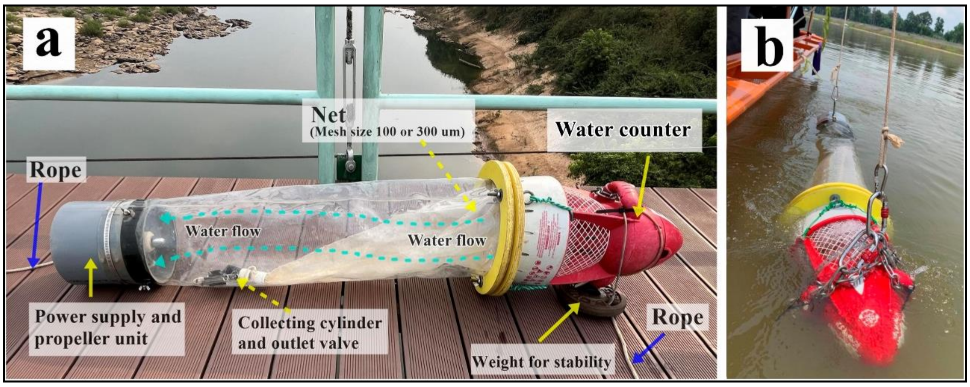

Fig. 2: Albatross Mark 6 (AM-6): a) components, b) water sampling.

Inspection and Identification of Microplastics

The number of microbeads retained on the filter were viewed under a stereomicroscope (Motic: SMZ-171). The physical characteristics, numbers of microplastic particles, size, shape, and colours were recorded. The microplastic polymer type was then examined by Fourier transform infrared spectroscopy (FT-IR) (Thermo Scientific: nicolet 6700).

Polymer Hazard Index (PHI)

The Pollution Load Index (PLI), developed by Tomlinson et al. (1980), is used for a comprehensive assessment of MPs contamination levels in the study's area. The PLI was employed to comprehensively assess microplastic pollution in the study area (Tomlinson et al., 1980). The PLI was calculated using the following equations (2)-(4) (Lithner et al., 2011):

$$PHI = \sum P_n \text{ x } S_n \qquad (1)$$

Where PHI is the polymer hazard index resulting from MP, P_n is the percentage of specific polymer types (Table 1) gathered at each sampling location, and S_n denotes the hazard scores of polymer types of MPs as obtained from previous studies (Lithner et al., 2011). The PHI values were categorized into four levels: I (<10), II (10–100), III (100–1000) and IV (>1000).

A hazard classifying methodology was created to categorize hazardous components and assess multiple polymers based on their potential impact on the environment and human health. Each polymer type is associated with hazard data that reflects the intrinsic hazardous qualities of the compounds employed in its synthesis. The method for determining the total hazard score of the polymer relies on the categorizations of the monomer from which the polymer is produced (Ranjani et al., 2021).

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$$PLI = \sqrt{CF_i} \qquad (2)$$

$$CF_i = \frac{C_i}{C_{oi}} \qquad (3)$$

$$PLI_{zone} = \sqrt[n]{PLI_1 \times PLI_2 \times \ldots \times PLI_n} \qquad (4)$$

Table 1: Detailed information for the primary hazard statements and scores of MP polymers found in surface water from the Mun River (Lithner et al., 2011)

Polymer	Monomer	Density (g cm^{-3})	Primary hazard statements	Hazard highest level	Score
Styrene acrylonitrile (SAN)	Styrene and Acrylonitrile	1.06-1.08	May release toxic fumes if burned or heated	V	2,788
Polyethylene terephthalate (PET)	Ethanediol	1.37-1.38	Harmful if swallowed	II	4
Nylon	Adipic acid and Hexamethylenediamine	1.12-1.15	May release hazardous fumes if burned	NC	NC
Polyethylene (PE)	Ethylene	0.91-0.97	May release toxic fumes if heated	I	11
Polystyrene (PS)	Styrene	0.28-1.04	Harmful if inhaled. May release hazardous fumes if heated	II	30
Polycarbonate (PC)	Carbonate	1.20-1.22	May release toxic fumes if burned	IV	610
Polypropylene (PP)	Propylene	0.89-0.92	May release hazardous fumes if heated	I	1
Polyvinyl Chloride (PVC)	Vinyl chloride	1.30-1.40	Harmful if inhaled. May release toxic fumes if burned	V	5001

Where CF_i is the MPs contamination factor, C_i is the MPs concentration at the sampling site, and C_{oi} is the background MPs concentration (Lithner et al., 2011). In the present study, C_{oi} represents the average MPs concentration found in the surface water of the natural zone at station 1.

The level of risk associated with MPs was categorized into four tiers: I (minor), II (high), III (danger) and IV (extreme danger), based on PLI values of <10, 10–20, 20–30, and >30, respectively (Arredondo-Navarro et al., 2021).

Potential Ecological Risk Index (PERI)

The potential ecological risk index (PERI) is used to evaluate the level of contamination of MPs (Peng et al., 2017). The formula for calculating the PERI is as follows (5)- (7):

$$T_r^i = \sum_{N=i}^{n} \frac{P_n}{C_i} \times S_n \quad (5)$$

$$E_r^i = T_r^i \times C_f^i \quad (6)$$

$$\mathrm{PERI} = \sum E_r^i \quad (7)$$

Where C_i represents the concentration of pollutant 'i' (microplastic) and C_n represents the concentration in unpolluted samples. The toxicity coefficient (T_r^i) quantifies the amount of toxicity and biological sensitivity. The hazard score of plastic polymers (S_n) multiplied by the proportion of specific polymers in the whole sample (P_n/C_i) provides the toxicity coefficient [9]. The ecological risk potential, as determined by the PERI values, is categorized into five levels: minor (<150), medium (150–300), high (300–600), danger (600–1200), and extreme danger (>1200) (Arredondo-Navarro et al., 2021; Doan et al., 2023).

Statistical Analysis

Statistical analyses were performed using Stata software (version 14). Both descriptive statistics (means, standard deviations, and percentages) and inferential statistics were computed. Multiple linear regression analysis was employed to assess spatial and temporal variations in microplastic concentrations across sampling sites, with results expressed as 95% confidence intervals (95% CI) and corresponding P-values. Microplastic abundance in water samples was standardized and reported as particles per cubic meter (items/m³).

RESULTS AND DISCUSSION

Amount of Microplastic Contamination

Microplastic particles were detected across four sampling sites along the Mun River system. Quantitative analysis revealed a mean concentration of 168.41±66.64particles/m³ throughout the study area. The highest concentration was observed in the urban zone (269.33±16.50particles/m³), while the natural area exhibited significantly lower levels (101.00±5.00particles/m³). Statistical analysis demonstrated that microplastic concentrations in urban areas exceeded those in natural areas by 168.33particles/m³ (95% CI: 151.11-185.55, P<0.001), as illustrated in Table 2. This spatial heterogeneity can be attributed to the intense anthropogenic activities characterizing the urban sector, including dense residential developments, floating commercial establishments, markets, and municipal infrastructure along the riverfront. Notably, the presence of a wastewater treatment facility likely contributes to elevated microplastic concentrations, consistent with previous findings regarding the influence of wastewater treatment systems on microplastic distribution in aquatic environments (Bayo et al., 2020). These observations align with existing literature documenting peak microplastic concentrations in urbanized watersheds (de Carvalho et al., 2021). The spatial distribution pattern suggests that anthropogenic activities significantly influence microplastic abundance. The water quality of the Mun River Basin is predominantly affected by non-point source pollution (Sikam et al., 2019), with potential contributions from stormwater discharge and urban runoff (Mak et al., 2020), highlighting the complex interplay between urban development and microplastic contamination in aquatic systems.

The spatial analysis of microplastic concentrations across global urban river systems, as illustrated in Table 3. Revealed significant variations, with the highest concentration documented in the Ravi River, Pakistan (1650.00±80.00particles/m³) (Irfan et al., 2020), substantially exceeding other studied waterways. The Mun-Chi River, Thailand (269.33±16.50 particles/m³) and Hunnicutt Creek, USA (269.00±30.00particles/m³) (Bowman et al., 2024) demonstrated notably similar contamination levels despite their geographical differences. Asian river systems exhibited the most pronounced range in microplastic concentrations, from 1.01±0.65particles/m³ in the Yangtze River estuary (Wu et al., 2024) to the maximum levels observed in the Ravi River, with intermediate levels in the Houjin River (183.33±128.95particles/m³) (Huang et al., 2023). European urban rivers, represented by the River Oker in Germany, showed moderate contamination (63.00±31.00particles/m³) (Büngener et al., 2024).

Table 2: Comparison average of microplastic contamination in water separated by sampling site

Variable	Microplastic (particles)	$\bar{X}$±S.D.*	Mean Difference	95% CI	P-value
Sampling sites					
Natural area (S1)	396	101.00±5.00	Ref.	Ref.	
Agricultural area (S2)	514	171.33±3.06	70.33	53.11-87.55	<0.001
Confluence of Mun and Chi River area (S3)	303	132.00±5.29	31.00	13.77-48.22	0.003
Urban area (S4)	808	269.33±16.50	168.33	151.11-185.55	<0.001

*Average number of microplastics (particles / m^3)

Table 3: Global Comparison of Microplastic Concentrations in Urban River Systems (2020-2025)

Study Area	Land Use Type	Microplastic Concentration (particles/m^3)	Comparison to Current Study
Mun-Chi River (Current Study)	Urban (S3)	269.33±16.50	Reference
	Agricultural (S2)	171.33±3.06	
	Confluence (S4)	132.00±5.29	
	Natural (S1)	101.00±5.00	
Ravi River, Pakistan	Urban	1650±80[40]	512.6% higher
Hunnicutt Creek, USA	Urban	269±30[41]	Similar (-0.1%)
Yangtze River, China	Urban	1.01±0.65[42]	99.6% lower
Houjin River, Taiwan	Urban	183.33±128.95[43]	31.9% lower
River Oker, Germany	Urban	63±31[44]	76.6% lower
Ikopa River, Madagascar	Urban	79.3±8.4[45]	70.6% lower
Vitor & Quilca rivers, Peru	Urban	35.3433±49[46]	86.9% lower
Xinghu Lake, China	Urban	10.1±7.6[49]	96.2% lower
Aras River, Iran	Natural	12.8±10.5[47]	87.3% lower
Mekong River, Cambodia -Vietnam	Natural	24[48]	76.2% lower

The relationship between urbanization intensity and microplastic pollution was evident across studied systems, with the Ikopa River in Madagascar (79.30±8.40particles/m^3) (Rabezanahary et al., 2024) and Vitor-Quilca rivers in Peru (35.34±49.00particles/m^3) (Larrea Valdivia et al., 2025) demonstrating how varying degrees of urbanization impact contamination levels. Seasonal and hydrological factors significantly influenced distribution patterns, as demonstrated in studies of the Yangtze River estuary (Wu et al., 2024) and Aras River (Vayghan et al., 2022), aligning with observations in the Mekong River system where temporal variations correlate with seasonal changes (Mendrik et al., 2025). While methodological differences may partially explain the range of reported concentrations, the consistency between some geographically distant systems suggests that standardized methods can produce comparable results, as emphasized in recent urban lake studies (Huang et al., 2023; Li et al., 2023), highlighting the complex interplay between urbanization, waste management infrastructure, and microplastic pollution in river systems.

Shape and Colour of Microplastics

Fibrous microplastics dominated the morphological distribution across all sampling stations (Fig. 3). This observation aligns with findings from similar studies conducted in the Wei River, northwestern China (Ding et al., 2019). The prevalence of fibrous microplastics is primarily attributed to domestic wastewater discharge and fishing activities in aquatic environments (Lithner et al., 2011).

Spectral analysis revealed ten distinct color categories among the recovered microplastics (Fig. 4), with blue predominating across all sampling stations. This chromatic distribution pattern aligns with recent findings (Haque et al., 2023; Napper et al., 2023). The prevalence of blue microplastics can be attributed to the widespread use of blue synthetic fibers in textile manufacturing globally (Gago et al., 2018).

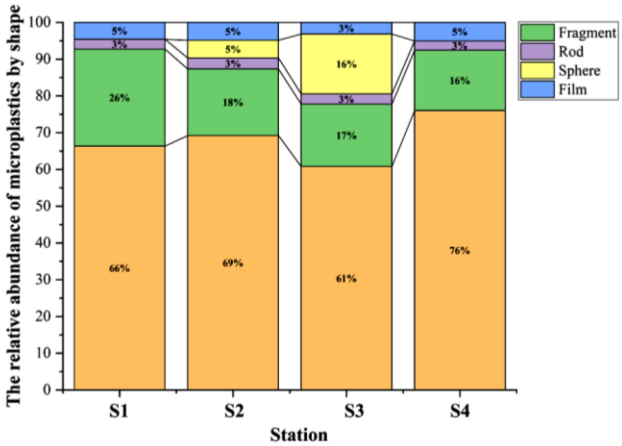

Fig. 3: The relative abundance of microplastics by shape.

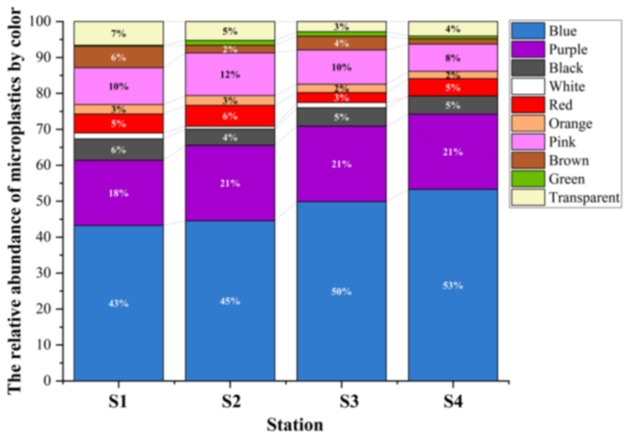

Fig. 4: The relative abundance of microplastics by colour.

Polymer Composition of Microplastics

Microplastic contamination was ubiquitous across all four sampling zones (natural, agricultural, urban, and river confluence) in the Ubon Ratchathani region. Polymer characterization revealed polypropylene (PP) and polyethylene (PE) as the predominant polymer types, constituting 38-42% and 27-32% of the total microplastic particles, respectively (Fig. 5). The urban zone exhibited the highest concentrations, followed by agricultural areas, natural areas, and the river confluence. This polymer distribution pattern is consistent with findings from other major Southeast Asian river systems, including the Chao Phraya, Saigon, and Citarum Rivers, reflecting regional consumption patterns in Thailand, Vietnam, and Indonesia (Wichai-utcha & Chavalparit, 2019; Trị, 2021; Babel et al., 2022). The prevalence of PP and PE can be attributed to their extensive use in consumer products, including packaging materials, containers, single-use plastics (Cole et al., 2011) and personal care products (Leslie & Van Den, 2014). As the most abundantly produced polymer types globally (Plastics Europe, 2018) and frequently detected in aquatic environments (Wu et al., 2024), their widespread presence raises significant concerns regarding potential ecological and human health implications.

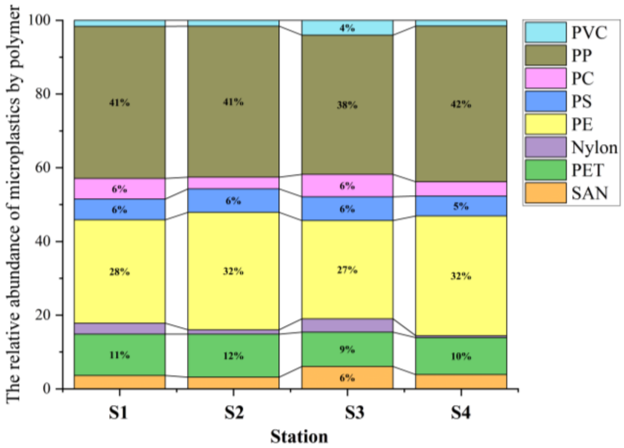

Fig. 5: The relative abundance of microplastics by polymer.

Risk Assessment Analysis

Microplastics present complex environmental hazards due to their polymer composition and associated chemicals. These polymers are synthesized through polymerization reactions that can leave residual unreacted monomers and hazardous additives. Environmental factors such as solar radiation and thermal exposure accelerate the weathering of microplastics in both terrestrial and marine environments, potentially facilitating the release of harmful chemical constituents. Notably, hazard-ranking models based on the United Nations' Globally Harmonized System have classified the chemical components of more than 50% of plastic materials as hazardous (Lithner et al., 2011; Rochman et al., 2013). The ecological risk assessment was conducted using three complementary indices: Potential Hazard Index (PHI), Pollution Load Index (PLI), and Potential Ecological Risk Index (PERI). These metrics provide a comprehensive evaluation of microplastic contamination in both terrestrial and marine sediments. Analysis of PHI values indicated that the overall microplastic pollution risk in India fell within Hazard Levels IV to V (Table 4). The distribution of pollution types and their associated ecological risks is presented (Fig. 6).

Risk Indices Analysis and Ecological Implications

The Polymer Hazard Index (PHI) analysis revealed substantial human health risks across all sampling sites. Urban areas exhibited the highest PHI value (41,277.99), followed by agricultural (19,317.21), river confluence (21,472.72), and natural zones (22,359.41). This distribution pattern correlates with microplastic concentrations, suggesting a potential dose-response relationship between microplastic abundance and human health risks. Similar correlations have been documented in Asian water systems, including the Changjiang Estuary, China (Wu et al., 2024) and the Code and Gajahwong Streams, Indonesia (Sabilillah et al., 2023).

Table 4: Pollution categories of potential ecological risk posed by microplastics

PHI	Hazard category	PLI	Hazard category	PERI	Risk category
<10	I	<10	I	<150	Minor
10-100	II	10-20	II	150-300	Medium
100-1000	III	20-30	III	300-600	High
>1000	IV	>30	IV	600-1200	Danger
				≥1200	Extreme danger

The Pollution Load Index (PLI) exhibited significant spatial variation, ranging from 8.00 in natural zones to 26.17 in urban areas. According to the established risk classification parameters, natural zones (PLI=8.00) and agricultural areas (PLI=8.84) fall within hazard category I (PLI <10), indicating minor ecological risk. River confluence areas (PLI=11.83) demonstrated moderate contamination levels, classified as hazard category II (PLI 10-20). Urban sites, with the highest recorded PLI value (26.17), reached hazard category III (PLI 20-30), signifying high ecological risk. Urban sites exceeded the critical threshold value of 10, surpassing pollution levels reported in previous studies (Xu et al., 2018). Notably, these values were lower than those recorded in the Ubonrat Reservoir, where PLI values exhibited significant seasonal variations: 9-110 during dry seasons and 2-30 in wet seasons (Kasamesiri et al., 2023). The elevated pollution levels in urban areas, dominated by PP and PE polymers, align with observations from other Southeast Asian River systems, including the Chao Phraya and Citarum Rivers (Babel et al., 2022).

The Potential Ecological Risk Index (PERI) assessment revealed concerning ecological risks across all sampling locations. Notably, urban environments exhibited the most significant ecological vulnerability with the highest PERI value (17,359.69), substantially exceeding values recorded in other zones. The remaining sampling areas demonstrated lower but still concerning risk levels: natural habitats (8,361.38), river confluences (8,041.84), and agricultural regions (7,554.73). This spatial distribution pattern indicates a direct relationship between microplastic pollution intensity and ecological risk severity. According to established risk classification criteria, all sampling locations exceed the threshold for extreme danger (≥1200), suggesting that areas with elevated microplastic concentrations face compounded ecological risks due to the cumulative effects of diverse polymer types.

The integration of multiple risk indices (PHI, PLI and PERI) provided a comprehensive assessment of environmental and health risks associated with microplastic contamination. However, the interpretation of PERI values would benefit from standardized thresholds

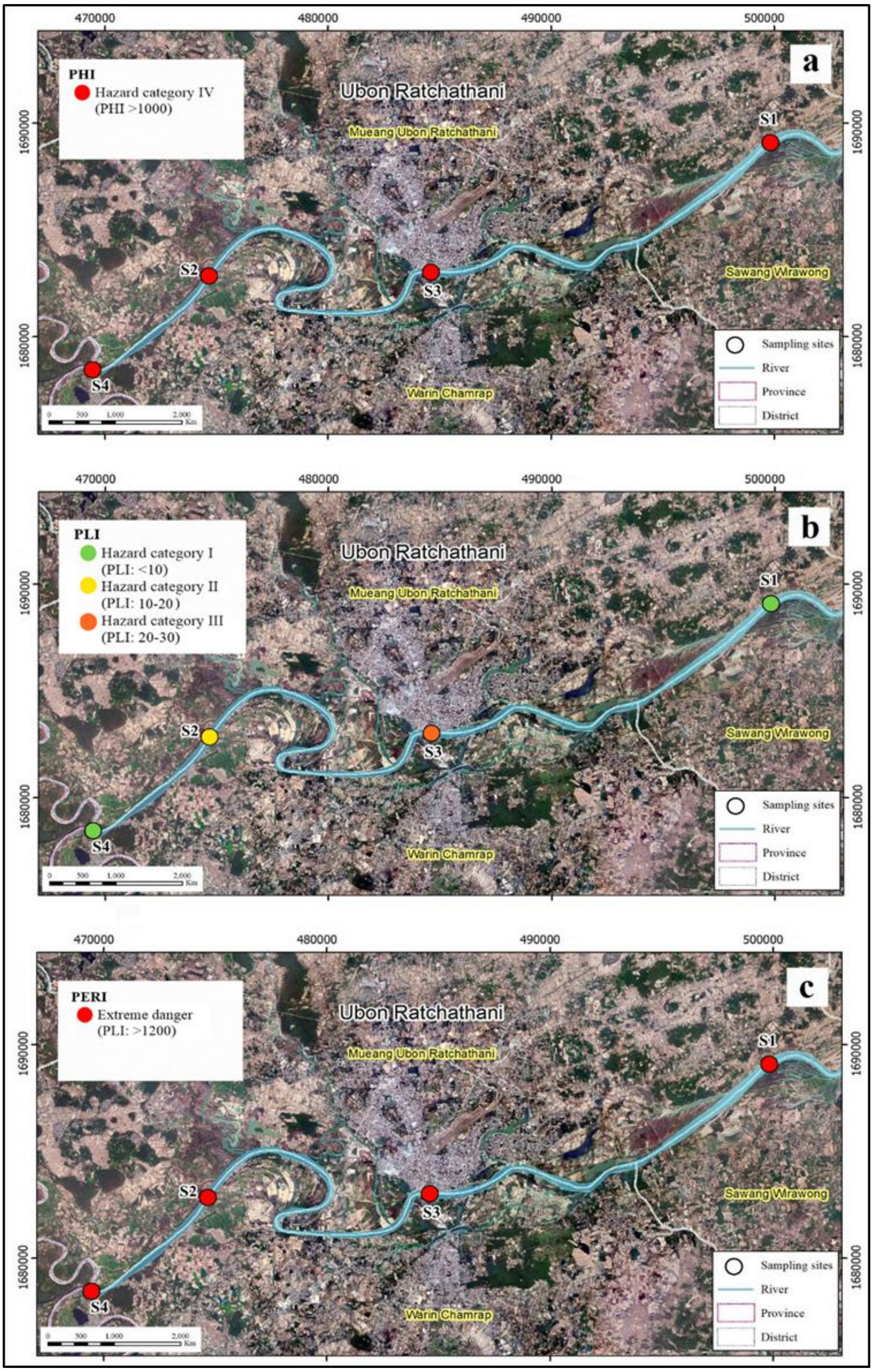

Fig. 6: Potential ecological risk posed by microplastics: a) Polymer hazard index (PHI), b) Pollution load index (PLI), c) Potential ecological risk index (PERI).

specific to microplastic contamination. While Sabilillah et al. (2023) employed similar indices (PLI and PERI) to identify moderate risk levels in heavily contaminated areas, the established risk categorization frameworks primarily derive from heavy metal contamination studies (Kuang et al., 2016; Liu et al., 2021). The development of standardized risk assessment criteria specific to microplastic contamination would enhance our ability to quantify potential ecological impacts and facilitate more meaningful comparisons across different aquatic systems. This standardization would contribute to a more nuanced understanding of microplastic-associated environmental risks and support evidence-based management strategies.

Conclusion

This investigation revealed ubiquitous microplastic contamination in the Mun River system, with mean concentrations of 168.41particles/m^3. Urban zones exhibited significantly elevated concentrations compared to natural areas, with fibrous, blue-colored microplastics predominating across all sampling sites. Polymer characterization identified polypropylene (PP) as the dominant polymer type, raising significant environmental and health concerns. Risk assessment utilizing multiple indices demonstrated concerning patterns. The Polymer Hazard Index (PHI) indicated elevated risk levels across all sampling sites, with urban areas showing particularly high values. This pattern aligns with observations from other Asian surface waters, suggesting a potential correlation between microplastic presence and human health risks. The Pollution Load Index (PLI) revealed variable contamination levels, with urban areas exceeding critical thresholds and demonstrating significantly higher pollution loads than previously reported. The Potential Ecological Risk Index (PERI) indicated substantial ecological hazards across all sampling sites, with maximum risk levels in urban zones, correlating with observed microplastic concentration patterns. These findings underscore the urgent need for further research into microplastic-mediated health and ecological impacts, particularly regarding mechanistic pathways. Integration of water quality parameters with microplastic monitoring would provide a more comprehensive understanding of these environmental concerns. Implementation of targeted mitigation strategies, including enhanced wastewater treatment protocols and plastic use reduction initiatives, particularly in urban areas, is crucial for protecting the ecological integrity of the Mun River system and safeguarding public health. Such interventions are essential for ensuring the sustainable management of water resources and protecting community well-being.

DECLARATIONS

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Conflict of Interest: The authors declare that they have no conflicts of interest related to this study.

Data Availability: Data will be available at request.

Ethics Statement: This research was approved by Khon Kaen University Ethics Committee for Human Research based on the Declaration of Helsinki and the ICH Good Clinical Practice Guidelines (HE652162).

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