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Assessment of microplastic contamination in the urban lower Chao Phraya River of Bangkok city, Thailand

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ABSTRACT

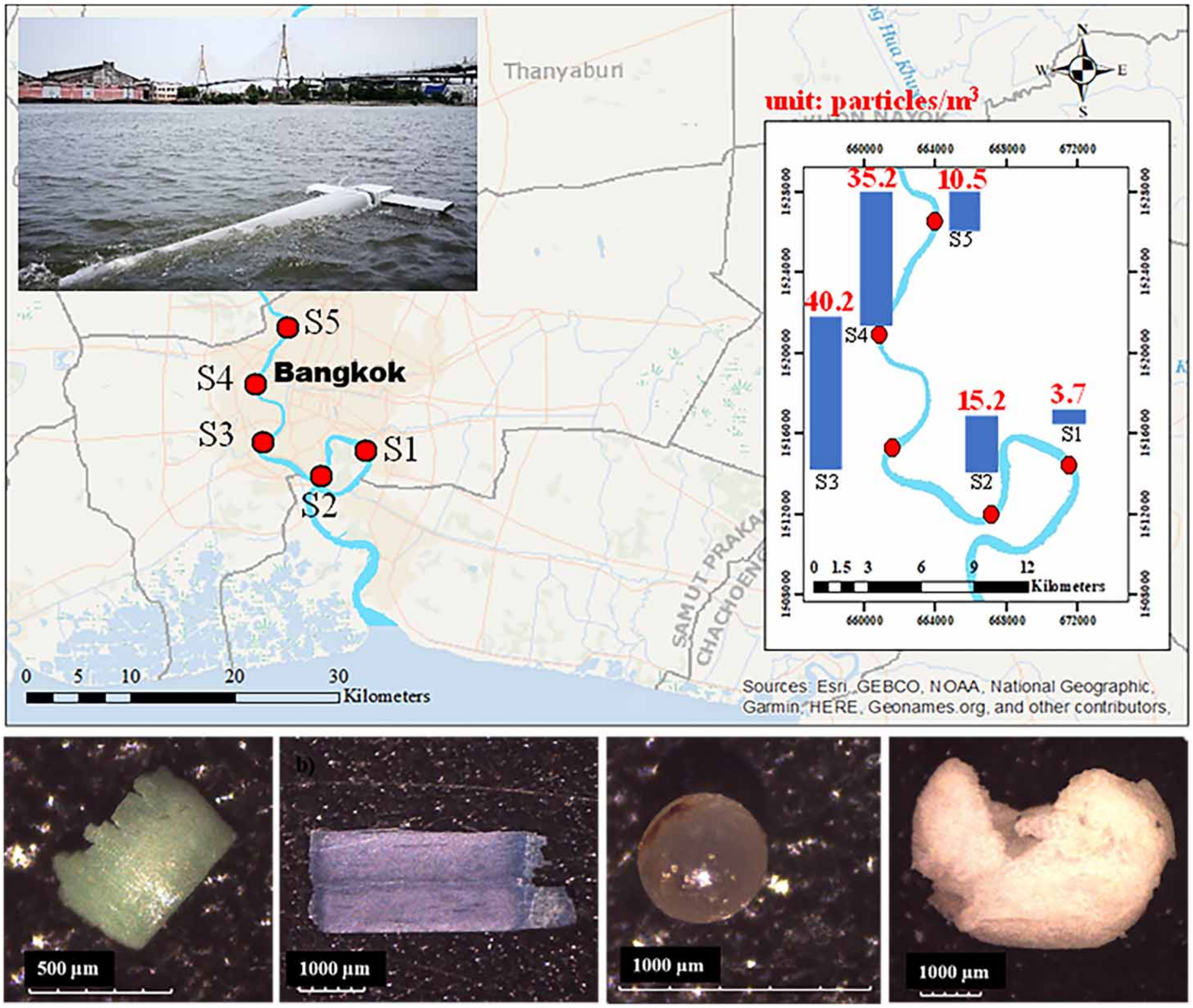
Rivers are one of the major pathways for the transportation of microplastics (MPs) from land-based sources to the ocean. However, there are only a few studies on MPs in freshwater environments, particularly in Asian countries. In this study, MP contamination in the Chao Phraya River in selected locations distributed throughout Bangkok, Thailand was investigated. MPs were collected using a Manta net with a mesh size of 335 μm. After digestion and distinction based on density, MPs were observed using a stereomicroscope, and polymer types were identified using Fourier Transform Infrared Spectroscopy. MP concentrations detected in the five sampling locations of the river water from upstream to downstream were 11, 35, 40, 15, and 4 particles/m^3, with an average concentration of 21 ± 16 particles/m^3. Most MPs were identified as either fragments or sheets/films. Polypropylene was the dominant polymer type. The number of MPs increases as their size decreases. Potential sources of MPs may include the degradation of single-use plastic products, especially containers and plastic packaging. MP concentrations and characteristics varied for different locations, indicating different sources and pathways of MPs in urban contexts. Further investigation on the different pathways of the transportation of MPs to river water from land-based sources is required.

Key words: freshwater microplastics, lower Chao Phraya River, Thailand, urban area, urban river

HIGHLIGHTS

- Microplastic (MP) contamination in an urban river in Bangkok, Thailand, was investigated.
- Most MPs were identified as either fragments or films.
- Polypropylene was the dominant polymer type.
- There are different sources and pathways of MP contamination in urban rivers.
- The number of MPs increases as their size decreases.

GRAPHICAL ABSTRACT



1. INTRODUCTION

Owing to its high durability and long half-life, plastic waste is a global threat to the environment. Previous studies have estimated that since the production of plastics in the 1950s, 4900 million metric tons of plastics out of 8300 primary products or roughly 60% of plastics produced over the past 65 years have been disposed in the environment (Geyer *et al.* 2017). Consequently, plastics are ubiquitous, especially in marine environments, and are present in every ocean and shoreline from the Arctic through the tropics to the Antarctic (UNEP 2016). Plastic waste is highly durable and is thus present in the environment for long periods of time. Recently, a newly identified type of micropollutant called microplastics (MPs) has raised global concern.

MPs are plastic particles with sizes of <5 mm in their longest dimensions (Thompson *et al.* 2004). MPs originate from the breakdown of larger plastics by UV degradation coupled with impact from the wind and waves as well as other weathering processes (Leslie 2014). In addition, certain MPs were intentionally produced for certain purposes, such as plastic pellets for plastic production or MPs used in personal care and cosmetic products (PCCPs). Other MPs are directly released from certain anthropogenic activities, such as microfibers released from synthetic textiles of domestic washing and tire dust released from the abrasion of car tires (UNEP 2016).

The massive global consumption of plastic has resulted in the abundance of MPs in various marine and freshwater environments (Rios Mendoza & Balcer 2018). Aquatic organisms directly ingest and accumulate MPs in their digestive tracts after consuming MP-contaminated prey. The impact of MPs on organisms is mechanical damage, such as blockage of the digestive tract and intestinal damage, which is sometimes fatal (Peng *et al.* 2020). Previous studies conducted in various zones around the world found that MPs affected aquatic organisms, such as zooplankton, in the South China Sea, sea anemones along the coast of Brazil, corals and sponges in southeast United States, and fish in the southwestern Atlantic and south India (Bauer *et al.* 2008; Amin *et al.* 2020; Devi *et al.* 2020; Morais *et al.* 2020; Macieira *et al.* 2021). MPs polluted the water environment and entered the food web, primarily the aquatic ecosystem (Guo & Wang 2019). Owing to the organic pollutants and heavy metals they adsorb, MPs in the food web are potentially highly hazardous to human health (Cao *et al.* 2021).

According to a report on Thailand's plastic waste situation by the pollution control department (PCD), nine million metric tons of plastic pellets were generated in 2019, and the total consumption of plastic in the country was 6.07 million metric tons across all industries, including packaging, electrical appliances and electronics, construction, automotive parts, and household appliances (PCD 2019). Thailand was recently ranked sixth among the countries with the highest levels of mismanaged plastic waste, with 1.03 million metric tons of mismanaged plastic waste per year (Jambeck *et al.* 2015). In Thailand, solid waste management is primarily based on landfill treatment, which may result in MP generation and contamination of the water environment through runoff. In addition, solid waste collection continues to be inefficient, resulting in the dumping of solid waste in impervious areas, such as canals and rivers (Johnson & Trang 2019; PCD 2019). Sun *et al.* (2019) revealed that the overall efficiency of wastewater treatment plants (WWTPs) with and without tertiary treatment was approximately 97 and 88%, respectively, indicating that WWTPs cannot completely remove MPs from wastewater. Therefore, MPs from runoff water and wastewater can be discharged from the land to freshwater environments, transported from freshwater to marine environments, thus finally accumulating in marine environments (Oo *et al.* 2021).

The Chao Phraya River, the major river in Thailand, which forms the Chao Phraya River basin, covers 30% of the land area in the country and supplies water resources for irrigation, electricity generation, industrial use, domestic water use, navigation, and river integrity. The river encompasses most of the irrigated area, and the lower basin of the river flows through the metropolitan area of Bangkok, the capital city of Thailand (Molle 2007). With a population of approximately 12 million, Bangkok is one of the most heavily populated cities in Southeast Asia. As the Chao Phraya River runs through the heart of Bangkok, the river acts as the receiving water body of complicated waterway systems, feeding into hundreds of canals in and around the city (Tewari *et al.* 2013). Ta *et al.* (2020) studied the effects of high population density on MP contamination in the Chao Phraya River; however, only one sampling point was observed and analyzed in their study. No study has comprehensively assessed MP contamination in the urban lower Chao Phraya River of Bangkok city, Thailand.

The present study aimed to investigate the occurrence of MPs in the surface water of the lower Chao Phraya River, primarily focusing on contamination from the Bangkok area. This study is expected to provide background information on MP pollution in the Chao Phraya River as well as the potential sources of MP pollution in the river.

2. MATERIALS AND METHODS

2.1. Sample collection

MPs were collected from five sampling points distributed across the surface water of the lower Chao Phraya River. The detailed locations (latitude and longitude) of the sampling points are presented in Table 1. Sampling points (S1–S5) were selected considering the water quality sampling points of the PCD, Thailand, and with consistent distances between

Table 1 | MP sampling locations and area description in the lower Chao Phraya River, Bangkok city

Sampling point	Area description	GPS (Latitude, Longitude)
S1	Bangkok port	13.693815, 100.585860
S2	Bhumibol bridge	13.671648, 100.545654
S3	Krung Thep bridge	13.702033, 100.494272
S4	Phra Puttha Yodfa bridge	13.752938, 100.487851
S5	Rama VI bridge	13.803633, 100.517004

points. The five selected sampling points were distributed throughout Bangkok, representing the urbanization areas. The surrounding areas of all sampling points were also observed to determine the potential MP sources, such as the sampling points near the waterfront community, the points affected by wastewater from canals, where the risk of waste dumping is high, the point where the wastewater treatment plant discharges its effluent into the river, and the area where the water is contaminated by water traffic transportation. Samples were collected on the same day during the low tide period to avoid interference from tidal effects and intrusion of MPs from seawater. Samples were collected in July 2019 using a Microplastic Manta net (Hydrobios Company, Germany; opening, 30 cm high × 15 cm wide, and length of net, 200 cm, with a mesh size of 335 μm). Sample collection was performed against the direction of the river flow (downstream toward upstream), from stations S1 to S5. Manta nets were trawled on the surface of the river outside of the wake zone beside the rented long-tail boat for 15 min at an average trawling speed of 5.5 km/h, depending on the wave and weather conditions. To minimize the effect of the boat's turbulence, the manta net was attached to a steel rail on the boat and extended into the water 1 m away from the hull (Figure 1). The filter water volume was calculated using the Mechanical Flow Meter Model 438 110, with a pitch of 0.3 m/revolution (Hydrobios, Germany) that was installed in the lower frame of the mouth opening of the manta net. The average filter water volume was 47 m^3 at all sampling points. The collected samples were rinsed with deionized (DI) water from a manta net bag and stored in a 1 L glass jar before being transferred to the laboratory for further analysis.

2.2. MP purification

The collected samples were washed with DI water through a stack of stainless-steel sieves (mesh size: 5.15, 0.99, 0.515, and 0.108 mm), and the particles retained on the 5.150-mm sieve were discarded. All remaining particles were separated into three size ranges: 5.15–0.99, 0.990–0.515, and 0.515–0.335 mm, based on the mesh and manta net sizes of the seives. The separated particles were purified and treated with 200 mL of 30% hydrogen peroxide to allow for the digestion of inherent organic matter, and then incubated at 55 °C for 3 days. After incubation, MPs were separated from other inorganic substances using 5.3 M NaI (density 1.52 g/cm^3) via the density separation method. The separated particles from the three size ranges were transferred to glass petri dishes and dried at 55 °C in an oven.

2.3. Size measurement and identification of MPs

The particles remaining in each size range after purification were weighed with a precision balance (five decimal places, 0.00001 g). For visual observation and identification, 25% of the weight of each size range was randomly set as the representative, and then observed under a Trinocular Zoom Stereomicroscope (Iris, model SZM45-B8 L-T, Thailand). Images of each particle were captured using a Moticam 5+ camera. The Motic Image Plus program (version 3.0) was used for particle size

Figure 1 | MP sampling with a Manta net on the surface water of the Chao Phraya River, Bangkok area.

measurements. After visual observation, the chemical components of the representative particles were identified using a Nicolet 6700 Fourier Transform Infrared (FT-IR) spectrometer in diamond ATR mode. FT-IR analysis was performed on 32 scans per particle to obtain a resolution of 4 cm^{-1} in the infrared (IR) range of 600–4000 cm^{-1}. The collected spectra were compared with the reference spectra of the OMNIC polymer database provided by Thermo Fisher. Particles with a similarity index exceeding 70% were regarded as MPs, and those with one below 70% were assumed to be non-plastics (Kroon *et al.* 2018).

2.4. MP contamination control

To prevent MP pollution, non-plastic equipment or containers, such as glass or aluminum, were used instead. Before being dried in the oven, all containers were thoroughly rinsed with DI water to remove the remaining contaminants. Researchers wore cotton clothing or lab coats during all processes to guard against self-contamination. To prevent contamination from the surrounding air, all samples and equipment were covered with glass or aluminum foil. DI water was used as the control to check for airborne contamination. Pre-treatment and extraction in the process of MP recovery were determined using standard plastic pellets. To evaluate the method recovery, polypropylene (PP) and polyethylene (PE) pellets were added to river water as a spike group (five replicates) and DI water as a control group (triplicates). All samples were examined under a stereomicroscope and FT-IR spectrometer to ensure MP recovery.

3. RESULTS AND DISCUSSION

3.1. MP abundance

Recovery was performed to assess the efficacy of the methods for the pre-treatment and extraction of MPs. The recovery rate of PP pellets was 100% in both the spike (river water) and control groups (DI water), whereas PE pellets were recovered within a range of 83–93% with an average of 87% in the control group and 77–100% with an average of 91% in the spikes group. Experimental bias may occur during the digestion process with 30% H_2O_2, resulting in the loss and change of PE particles. As a result, MP abundance may be underestimated. While MP contamination was not detected in the DI water (triplicate) with no spikes MPs pellets, the MP extraction process had been performed to check for airborne MP contamination inside the laboratory. MP abundance at each sampling location is shown in Figure 2 (upstream to downstream), MP abundance values in the surface water of the Chao Phraya River were 10.5, 35.2, 40.2, 15.2, and 3.7 particles/m^3, at S5, S4, S3, S2, and S1, respectively. MP abundance at S5 was not high, as this area was connected to the Nonthaburi province, which has a lower population than Bangkok. In contrast, MP concentration was drastically increased at S4 and S3, as these two points were located next to high-density population and high traffic areas, such as tourist attractions and one tertiary

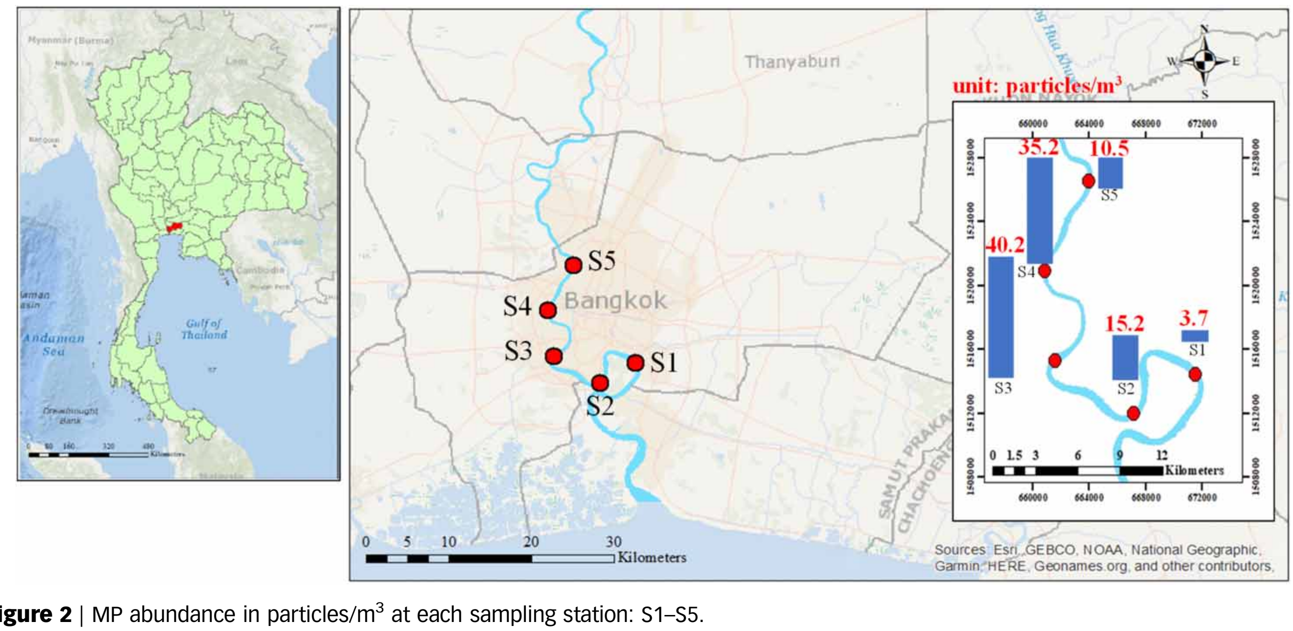


Figure 2 | MP abundance in particles/m^3 at each sampling station: S1–S5.

hospital. MP abundance dropped sharply to 15.2 particles/m^3 at S2 and significantly decreased to 3.7 particles/m^3 at S1. The relatively low MP abundance values at S1 and S2 were probably caused by the sedimentation of MPs, as the curvy meandering pathway of the Chao Phraya River might increase river sediment around the riverbank. Ta & Babel (2020) previously reported the MP concentrations in the Chao Phraya River sediments as 86 ± 17 and 96 ± 12 particles/g sediment on two sides of the river bank in the Tha Pra Chan area of Bangkok (between S5 and S4 of this study). Additionally, anthropogenic activities alongside the river at S2 and S1 also decreased, as certain parts of the area were converted to environmental conservation areas. Furthermore, the Chao Phraya River carries a boat and ferry system that operates along S5, S4, and S3 but terminates before S2.

In Table 2, MP abundance at all sampling stations (S1–S5) was categorized into three different size ranges, from largest to smallest: 5.15–0.99, 0.990–0.515, and 0.515–0.335 mm. Aside from the MP concentration changes discussed in the previous section, categorization of MP abundance into three different sizes revealed an increase in MP abundance as MP sizes decreased, which corresponds to reports on MP abundance in other urban rivers, such as the Yangtze and Hanjiang rivers, Wuhan, China (Wang *et al.* 2017), Pearl River, Guangzhou, China (Yan *et al.* 2019), Ciwalengke River, Majalaya, Indosenia (Alam *et al.* 2019), and Saigon River, Ho Chi Minh City, Vietnam (Lahens *et al.* 2018). In contrast, MPs at S1 contained a greater number of large MPs ranging from 5.15 to 0.99 mm, with an abundance of 2.4 particles/m^3 or six times higher than those ranging from 0.515 to 0.335 mm. According to Wang *et al.* (2018), small MPs, especially those below 300 μm, accounted for 85% of the sediments of the Wen-Rui Tang River watershed, a low-gradient urban river located on the coastal plain in Wenzhou Zhejiang Province, southeast China. In addition, the size of MPs in the sediments of the lower Chao Phraya River in a previous study was reported to be within the size range of 0.05–0.3 mm (Ta & Babel 2020). Therefore, the decrease in small MPs in the downstream area (S2 and S1) of the Chao Phraya River was speculated to result from small MPs sinking to the bottom of the river owing to cake filtration or agglomeration (Ta & Babel 2020). Furthermore, the higher sedimentation of MPs in the downstream area was attributed to the curvy meandering pathways of the Chao Phraya River, which increases sedimentation on the riverbank.

3.2. Shape and composition of MPs

3.2.1. Shape of MPs

MPs were classified into five groups by visual observation under a stereomicroscope based on the standardized sorting system proposed by Crawford & Quinn (2017) into fragments, sheets/films, foams, fibers, and beads. Figure 3 shows an example of MPs of different shapes based on sorting.

The morphological classification of MPs can reveal important information on MP sources. As shown in Figure 4(a), fragments and sheets/films accounted for more than 90% of MPs in all locations, with the majority of contaminants identified as secondary MPs originating from the degradation of larger plastic waste, especially single-use plastic containers and plastic packaging such as plastic bottles, bags, cups, straw, and wrappers (Chen *et al.* 2021). These findings were consistent with the PCD's report stating that in Thailand, approximately 0.03 million tons of plastic waste were discharged into the environment, and the most prevalent type of plastic is packaging, that is single-use plastic (PCD 2019). The proportion of the foam

Table 2 | MP abundance in three different size ranges in each sampling station: S1–S5

Sampling point (Latitude, Longitude)	Abundance (particles/m^3) 5.15–0.99 mm	0.990–0.515 mm	0.515–0.335 mm	Total
S5 (13.803633, 100.517004)	2.6	3.9	4.0	10.5
S4 (13.752938, 100.487851)	8.2	10.9	16.2	35.2
S3 (13.702033, 100.494272)	10.2	13.7	16.3	40.2
S2 (13.671648, 100.545654)	3.8	6.4	5.0	15.2
S1 (13.693815, 100.585860)	2.4	0.9	0.4	3.7
Mean	5.4	7.2	8.4	21.0
SD	3.5	5.2	7.4	15.9

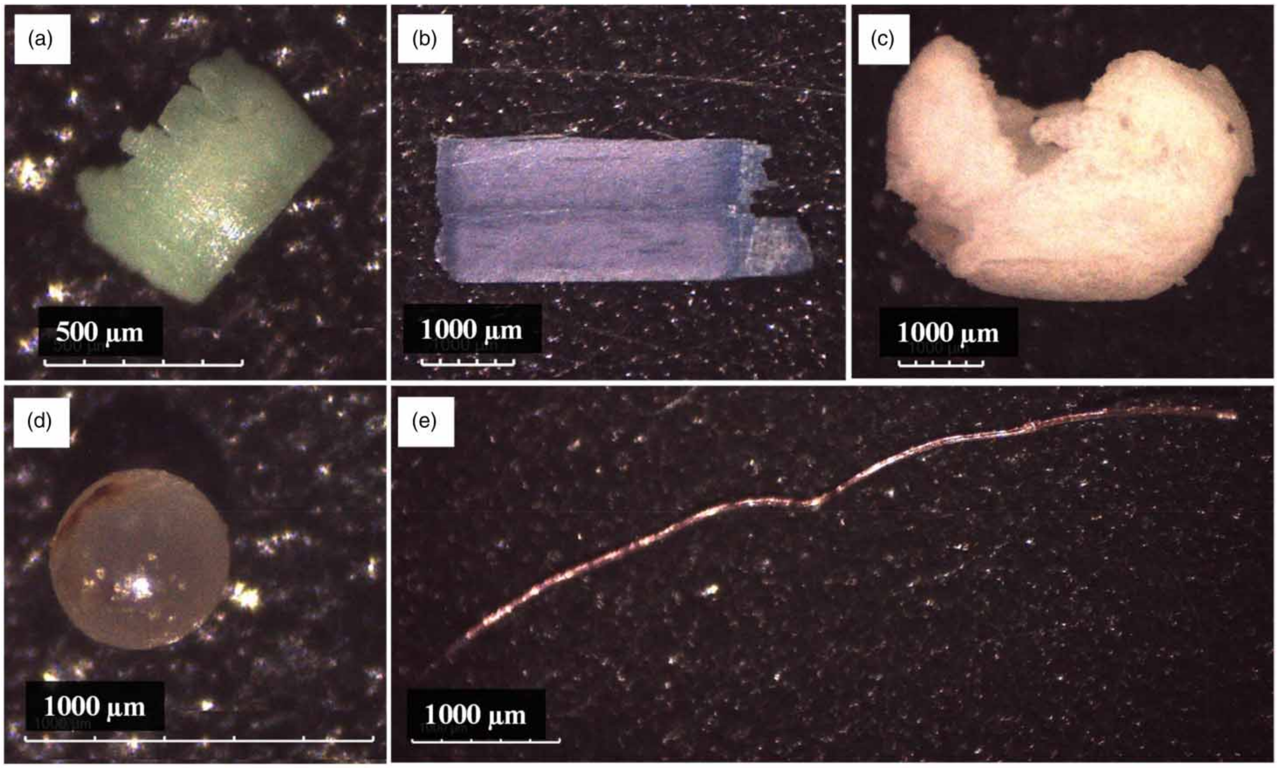


Figure 3 | Examples of MPs in different shapes: (a) fragment; (b) sheet and film; (c) foam; (d) bead; and (e) fiber.

group was found to range between 1 and 7% of all MPs and was speculated to be derived from food and protective packaging (Giacovelli 2018). These MP types can be referred to as secondary MPs, which are degraded by the weathering processes, transported by both rainwater and wind, and ultimately accumulate in the river before being discharged to the sea. Meanwhile, fiber and bead/pellet demonstrated that primary MPs as fibers probably resulted from small synthetic fibers released from domestic washing. Bead MPs are also regarded as primary MPs and are typically used in personal care and cosmetic products, especially rinse-off products such as facial scrubs, body scrubs, and toothpastes. Both fibers and beads are discharged from household activities, and a certain portion remains in the effluent after wastewater treatment processes and is eventually discharged into the river and accumulated in the environment (Kalčíková *et al.* 2017). In this study, both bead and fiber MPs were detected at points S4–S1, and accounted for approximately 0.13–1.58 and 0.19–1.38% of total MPs, respectively. The detection of microbeads and microfibers corresponded to the location of WWTPs along the Chao Phraya River in the Bangkok area, as the WWTPs at Rattanakosin, Si Phraya, and Chongnonsi are located upstream of points S4, S3, and S1, respectively. Additionally, industrial feedstock pellets (PE, shape of bead with a size of >1 mm) were found only at S2 and are hypothesized to be related to the commercial use area at S2.

3.2.2. MP composition

The composition of MPs can be determined by matching the FT-IR results of the samples with the spectrum of known polymers from the libraries. The majority were composed of PP which accounted for 46.8–76.4% of MPs found at all locations, while PE and low-density polyethylene (LDPE) comprised 5.6–13.2 and 4.7–14.3% of MPs. PP, PE, and LDPE are the main materials used in single-use plastics and plastic packaging. Additionally, a substantial amount of PE/PP blend materials was detected, constituting 5.8–23.4% of MPs, in all locations. The PE/PP blend consisted of ethylene/propylene copolymer (EPC), ethylene/propylene/diene rubber (EPDM), and isotactic polypropylene/ethylene-co-propylene (iPP/EPR). These PE/PP blend materials are preferred for their relatively high toughness and stability. They are referred to as synthetic rubbers, and are commonly used as flexible seals for automobiles, wire and cable insulation, weather stripping, tire sidewalls,

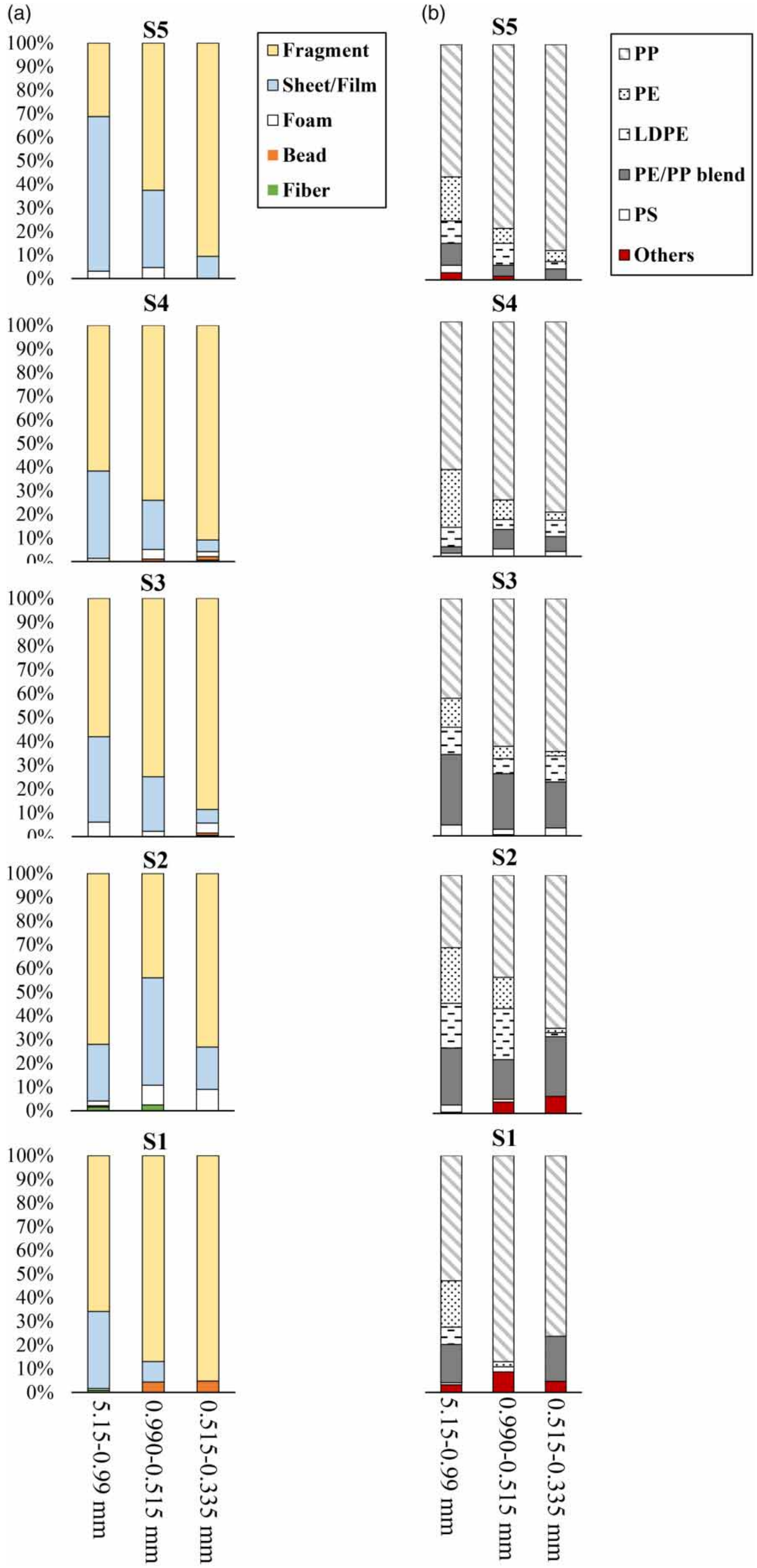


Figure 4 | Distribution of (a) MP shapes and (b) polymer types in all size ranges.

hoses, and roofing films (Datta 2016). Polystyrene (PS) accounted for 0.8–3.3% of MPs and includes foam-type MPs, which are commonly used for food and protective packaging. Other compositions, including cellophane, polyether urethane (PUR), poly (vinyl stearate), poly (methacrylate), and poly (butadiene:MMA), comprised between 0.2–4.7% of MPs at all locations except S4. Cellophane is combined with synthetic polymers and used as a coating material for food packaging, cigarette wrappers, and as a release agent for fiberglass and rubber product production. PUR is a form of flexible foam used as a popular material in home furnishings, and the detection of PUR therefore indicates MP pollution from furniture waste into rivers. Therefore, large or bulky solid waste in the Chao Phraya River in the Bangkok area cause contamination.

3.2.3. Distributions of MP shape and composition in each size range

The shape and composition of MPs at each sampling point were categorized into three size ranges based on the sieving processes: 5.15–0.99, 0.990–0.515, and 0.515–0.335 mm from upstream to downstream locations (S5–S1), as shown in Figure 4.

In Figure 4(a), fragment MPs tended to be high in proportion as size ranges decreased, while sheet/film MPs tended to be high in proportion as size ranges increased, except for point S2. Therefore, fragmented MPs might be degraded and fragmented into smaller sizes more rapidly than sheet MPs. Bead MPs were found only at the 0.990–0.515 and 0.515–0.335 mm size ranges, corresponding to the size range of reported microbeads found in personal care products: 24–800 mm in facial scrubs (Kwan & Fok 2017) and 110–970 mm in shower gels (Lei *et al.* 2017). Meanwhile, the low detection of fiber MPs in this study (0.5–2.4%), despite the high quantity of fiber MPs reported in previous studies (between 172,000 and 519,000 particles/m^3 in the surface water of the Saigon River, Vietnam (Lahens *et al.* 2018)), and the dominance of fibers in the surface water of the Ciwalengke River, Indonesia (Alam *et al.* 2019), indicates that the fiber MP level in the study area is lower than that reported for Vietnam and Indonesia. Therefore, considerable amounts of fiber MPs might be underestimated and need to be investigated in further studies.

As shown in Figure 4(b), the distributions of MP composition in each size range varied across S5–S1. The distribution patterns were similar at S5 and S4, with PP being dominant, while the PE/PP blend portion increased significantly at S3, S2, and S1. The increase in the PE/PP blend portion may have been caused by the MPs from the road. In a previous study (Yukioka *et al.* 2020), MPs found in road dust had similar compositions (easy processing channel black, styrene butadiene rubber, ethylenepropylenediene rubber, and PUR), which were called rubber MPs, in the urban cities of developing countries in Asia, 23% in Da Nang, Vietnam, and 17% in Kathmandu, Nepal. Therefore, the PE/PP blend might originate from road dust in highly populated areas near S3 and be discharged as direct runoff to the river. Only a small portion of other compositions of MPs was found at S5 (overall 1.3%) and S3 (overall 0.2%), slightly increasing at S2 and S1 (overall 4.5 and 4.7%), while none was detected at S4. In this study PP was dominant among MPs, indicating a different profile from other urban rivers; in the Saigon River, Vietnam, PP and PE were dominant (Lahens *et al.* 2018), PE in the Netravathi River, India (Amrutha & Warrier 2020), and PE and EPC in the Haihe River, northern China (Liu *et al.* 2020). Despite the high production of PP and PE in Thailand, high rates of observed PP contamination could be attributed to more effective management of PE (both HDPE and LDPE) under the waste management program in Thailand than PP (Wichai-utcha & Chavalparit 2019), which might explain the high rates of PP contamination observed. However, the pathway of MPs from land to rivers and to the sea consists of several steps. MPs can be discharged from treated wastewater and combined sewage overflows, soil erosion and runoff, direct input, wind transport, or atmospheric fallout, and certain MPs remain in the river sediment (Horton *et al.* 2017). Therefore, further investigation of MPs from different sources is required to understand the pathways of MPs in the lower Chao Phraya River.

As shown in Table 3, comparison of previous study findings on MP pollution in each continent showed that fragment shaped, PP, and PE types were the most abundant types of MPs; they are the most commonly used materials for single-use plastics and plastic packaging. According to Ounjai *et al.* (2020), the occurrence of MPs is linked to anthropogenic activities, with urbanization and population density being related to an increase in MP abundance. In addition, source and emission, legislation and regulation affect MP abundance. As shown in Table 3, MPs were found to be more abundant in Asia and Africa than in Europe and North America. Regulation of the production and use of plastic through to the management of plastic waste, such as bans on the production of single-use plastic bags in the US (California), and on non-biodegradable plastic bags in Italy, may affect the reduction of plastic waste contamination in the environment (Xanthos & Walker 2017; Rist & Hartmann 2018). Therefore, regulation and public awareness, as well as additional research on the removal of MPs from the environment, may contribute to the mitigation of plastic pollution.

Table 3 | Studies on MP in freshwater environment in different continents

Continent	Country	Sampling	Method for collecting MPs	Abundance (items/m^3)	Majority shape	Majority type	References
Asia	Thailand	Chao Phraya River	Trawling with a 335-μm manta net	3.7–40.2	Fragment	PP and PE	This study
	Thailand	Chao Phraya River	Trawling with a 300-μm manta net	80 ± 60	Fragment	PP and PE	Babel *et al.* (2022)
	Viet Nam	Saigon River		68 ± 20	Fiber	PP and PE	
	Indonesia	Citarum River		12 ± 6	Fragment	PP and PE	
Africa	Garna	Akora River	Trawling with a 300- neuston net	12.5–23.9	Fragment and sheet	PE	Adu-Boahen *et al.* (2020)
Europe	France	Seine River	Trawling with a 330-μm manta net	0.28–0.47	Fiber	–	Dris *et al.* (2015)
	Italy	Ofanto River	Trawling with a 333-μm plankton net	0.9 ± 0.4–13 ± 5	Fragment and flake	PE	Campanale *et al.* (2020)
North America	USA	Milwaukee River Basin	Trawling with a 333-μm neuston net	0.54–11.6	Foam and fiber	PP	Lenaker *et al.* (2019)

4. CONCLUSIONS

This study discusses MP pollution in the surface water of the lower Chao Phraya River, Thailand. The survey considered significant sampling points throughout Bangkok City. MPs were observed in all sampling locations (S5–S1) at concentrations ranging between 4–40 particle/m^3. The concentration of MPs peaked at S3, which was surrounded by highly populated areas and high anthropogenic activity. Of the three MP size ranges considered based on the size of MPs observed, major MP sizes fall within the range of 0.335–0.515 and 0.515–0.990 mm. Most MPs were found in fragments and sheet/film shapes, and the dominant composition was PP, indicating the presence of secondary MPs from human activities in urban areas. Concerning the plastic waste problem, Thailand's plastic waste management framework was set up for 2018–2030 to reduce plastic waste contamination and conserve marine resources by eliminating the use of single-use plastics such as plastic cap seals, plastic microbeads, and thin plastic bags, and replacing them with environmentally-friendly products as well as transporting all plastic wastes to the appropriate waste recycling sector. However, the remediation of the environment from MP contamination will take a long time owing to their structure and size ranges, which facilitate MP accumulation in every ecosystem. In conclusion, this study provides information on MP pollution in the Chao Phraya River in the urban area of Bangkok City and provides important data for further research on MPs in freshwater environments, transportation pathways, and their sources in urban cities.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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