Microplastics Contamination in a High Population Density Area of the Chao Phraya River, Bangkok

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Highlights:

- MPs were detected in both surface water and sediment samples in the Tha Prachan area, Chao Phraya River.
- The total number and concentration of MPs in the water samples were found to be 104 particles/m^3 and 805.20 mg/m^3, respectively.
- The total number and concentration of MPs in the sediment samples were 2,290 particles/kg and 650 mg/kg, respectively.
- MP fragments of PP, PE, and PS were dominant in both the water and the sediment samples.

Abstract. Microplastics (MPs) are distributed globally, including in aquatic environments. While a large number of studies on MPs in marine environments have been performed, few studies are available in freshwater environments. Therefore, the distribution of MPs in surface water and sediment from the Chao Phraya River at Tha Prachan, a high population density area of Bangkok, was investigated. Water samples were collected by a manta trawl with a net mesh size of 300 μm. Sediment samples were collected by a Van Veen grab sampler. The total number and concentration of MPs in the water samples were found to be 104 particles/m^3 and 805.20 mg/m^3, respectively. The dominant MPs were fragments, 0.5 to 1.0 mm in size, for the water samples. In the sediment, MPs were detected only in a size range of 0.053 to 0.5 mm with a total number and concentration of 2,290 particles/kg and 650 mg/kg, respectively. The presence of different types of MPs was confirmed by Fourier-transform infrared spectroscopy with a dominant abundance of polypropylene, polyethylene, and polystyrene. In brief, this study suggests that high levels of MPs occur not only in the water but also in the sediment of the Chao Phraya River at Tha Prachan area.

Keywords: *Bangkok; Chao Phraya River; microplastics; plastic waste; water security*.

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1 Introduction

In recent years, the presence of smaller pieces of plastic debris known as MPs, including those not visible to the naked eye, has raised increasing concern. The term MPs has been defined differently by various researchers. However, most researchers define MPs as plastic particles that are smaller than 5 mm [1-4]. MPs can be generated from the breakdown of larger plastics by UV degradation, wind impact, or wave impact. They can also be generated by road abrasion of larger plastic items through damage by vehicles and be transported along concrete pathways [5, 6]. Microbeads (such as polyethylene and polypropylene) used in cosmetics have also been identified as important contributors [7, 8]. Moreover, textile laundering facilities and sandblasting are other major sources of MPs [9, 10]. These pollutants get washed down the sink as they are too small to be filtered out by sewage treatment plants. They consequently end up in river systems and ultimately in the ocean. The effects of MPs on the aquatic environment and humans are still being studied. However, there is much evidence for significant harm to wildlife and human health. The potential effects of MPs on aquatic organisms are as follows: physical effects such as obstruction; chemical effects due to the transportation of toxic chemicals; impaired health impacts on populations and ecosystems; and dispersal of damaging pathogens [11]. Over 280 marine species have been found to ingest MPs, including many with important roles in food chains and the functioning of marine ecosystems, such as mussels, crabs, zooplankton, and sea squirts [12, 13]. Related to human health, MPs have been found in seafood sold for human consumption [14]. The pollutants are typically found in the gut of aquatic organisms such as shellfish.

Currently, there is insufficient knowledge on the accumulation and effects of MPs in Thailand. Some studies have been conducted in marine environments. According to Yukari, *et al.* [15], MPs in the surface sediment in the Gulf of Thailand (2004) varied from 100 to 300 items/kg (dry weight) in core samples. There was a significant increase in the abundance of MPs in sediment and surface layers over time. A study on sessile and intertidal invertebrates in Chonburi province (Thailand) indicated a significant accumulation of MPs at 0.2 to 0.6 items/g [16].

The current situation shows the necessity to investigate MP concentrations in freshwater systems in Thailand, especially in rivers that play an important role in the local water supply. Thus, this study investigated the concentrations and types of MPs in surface water and sediment from the Chao Phraya River that flows through the city of Bangkok, Thailand (Tha Prachan area). This study yielded background data for the determination of MP pollution and potential environmental risks.

2 Methodology

2.1 Sampling

MPs were investigated from surface water and sediment of the Chao Phraya River in the Tha Prachan area, Bangkok (13°44.448'N and 100°29.652'E). The study area was located in a famous tourist attraction of the Bangkok capital with a high population density. In August 2018 (wet season in Bangkok), water and sediment samples were collected. Surface water samples were collected from the bank of the river by a manta trawl with a rectangular opening of 20 cm high x 50 cm wide. A 2-m long net with a mesh size of 300 μm and a 25 cm high x 10 cm diameter cod-end was connected to the frame of the manta trawl. The volume filtered by the manta net was recorded by a Hydrobios flow meter (model 438110) mounted at the net opening. This enables the filtered water volume to be normalized to calculate the concentrations of MPs per unit water volume. The manta net trawled on the surface of the river and outside of the wake zone adjacent to the research boat for 30 min for each sample. The trawling speed depended on weather conditions and currents but usually ranged between 1.8 and 9.3 km/h. Two sediment samples were collected from a depth of about 2 to 3 m below the surface water by a 10-liter Van Veen grab sampler. Both the water and the sediment samples were kept at 4 °C in a laboratory for further analysis.

2.2 Analysis of Microplastics

The MPs were analyzed based on the method suggested by Masura, *et al*. [17], with modifications. The water samples were directly sieved through stainless steel sieves with mesh sizes of 5.0, 1.0, 0.5, and 0.05 mm to separate the solids into different sizes. Sodium iodide solution with a density of 1.5 g/cm^3 was used to float the MPs in the sample matrix before sieving. The solids that remained on the sieves were treated with hydrogen peroxide (30%) and an iron (II) catalyst to remove organic compounds that could affect the visual sorting of the MPs under a microscope.

After digestion by peroxide, the solids were dried at 60 °C for 24 h. Potential MPs were inspected and counted under an Olympus microscope (DP20) at 10x magnification. After inspection by the microscope, MPs (50 particles, each size range) were randomly chosen to be inspected by (Nicolet) Fourier-transform infrared spectroscopy (FTIR) with a resolution of 8 cm^{-1}, using a diamond micro-tip. For the sediment samples, 20-gram wet-sediment samples (duplicates) were used for MP analysis. The samples were dried in an oven at 60 °C and the total solids were determined. Due to the complexity of the sediment samples, plastic debris was extracted from the sediment by flotation in NaI solution with a density of 1.5 g/cm^3. The dried sediment was mixed with 200 mL of the NaI solution in

a beaker for 5 min by a magnetic stirrer. After settling for 24 h, the floating particles were collected and treated the same as the surface water samples.

3 Results and Discussions

3.1 Abundances of Microplastics In the Chao Phraya River, Bangkok Area

3.1.1 Water Samples

MPs were found in the surface water with morphologies of fragments, pellets, fibers, and film. As shown in Figure 1, MP fragments found in the study area were more abundant than the other particle types. This is in line with the findings of Hidalgo-Ruz, *et al*. [18] and Zbyszewski and Corcoran [19]. They proposed the breakdown of larger particles as the most important source of MPs in freshwater and oceanic environments. The MPs found in the study area had various colors, e.g. green, blue, red, white, transparent, etc. The origin of the MPs is suspected to be from commercial plastic products.

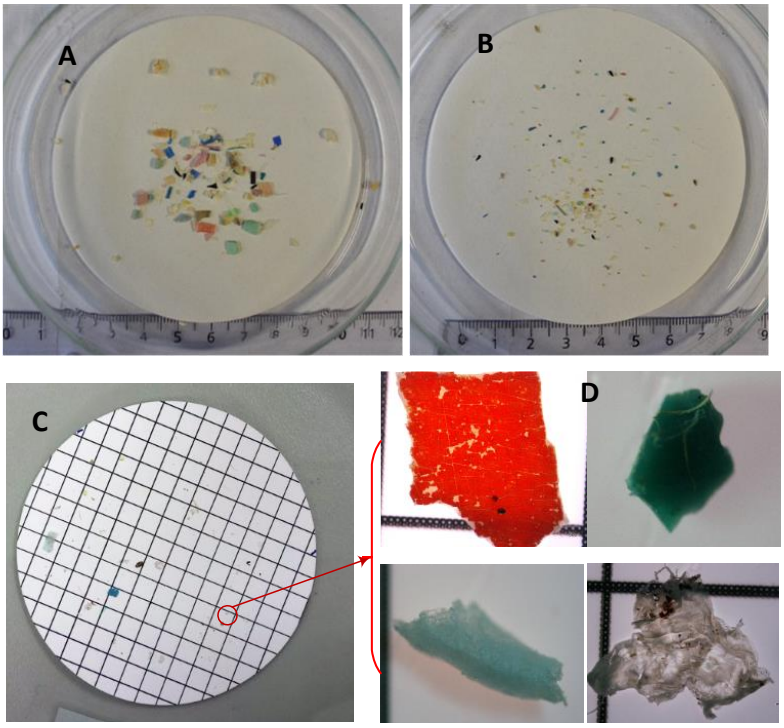

Figure 1 Microplastics of different size ranges (A) 1-5 mm, (B) 0.5-1 mm, (C) 0.053-0.5 mm, (D) MPs under a microscope at 10x magnification.

The number and concentration of MPs found in the study area are shown in Table 1. MPs were found at a total number and concentration of 104 particles/m^3 and 805.20 mg/m^3, respectively. MPs with a size range of 0.5 to 1.0 mm were dominant in both the number and weight fractions. As shown in Figure 2, the size range of 0.5 to 1.0 mm accounted for 68.74% and 88.69% for the number and weight fractions, respectively. MPs in the size range of 1.0 to 5.0 mm had the lowest number and concentration in the Chao Phraya River in the Tha Prachan area.

Table 1 MPs inspected in the Tha Prachan area, Chao Phraya River, Bangkok.

Sample type	**Size range** (mm)	**Number** (particles/m^3) [(a)] (particles/kg) (DW)[(b)]	**Concentration** (mg/m^3) [(a)] (mg/kg) (DW)[(b)]
Surface water	1.0-5.0	7	12.35
	0.5-1.0	72	714.14
	0.053-0.5	25	78.71
Total		104	805.20
Sediment	0.053-0.5	2290	650.00

[(a)]: unit for surface water; [(b)]: unit for sediment; DW: dry weight.

In the Tha Prachan area, the plastics found in the Chao Phraya River come mainly from tourism and urban activities. In this area, the river may carry pollutants from the millions of people who reside along the river basin. Many canals discharge water that carries wastewater and suspended debris from other municipalities in Bangkok and the upper provinces. As mentioned above, MP fragments are dominant in the study area. Thus, the high appearance of MPs in the size range of 0.5 to 1.0 mm may indicate that the plastics have had enough time to break down from larger sizes. According to Song, *et al*. [20], polyethylene (PE), polypropylene (PP) resin pellets, and polystyrene (PS) spherules can be fragmented into micro sizes smaller than 1 mm after 12 months of exposure to ultraviolet irradiation and mechanical abrasion by sand. Therefore, it may be concluded that the MP fragments in the Chao Phraya River that flow through the Tha Prachan area have been exposed to UV and abrasion for at least 12 months.

In this study, MPs were sampled by a manta trawl net with a mesh size of 300 μm. However, as shown in Table 1, MPs smaller than 300 μm were still detected in the samples. These smaller MPs may be stuck to larger particles due to cake filtration or agglomeration in the aquatic environment and remain in the samples. Therefore, the number and concentration of MPs smaller than 300 μm may be lower than the number and concentration in the river.

The results show that the extent of MP pollution in the Chao Phraya River in the Tha Prachan area was in the same concentration range that has recently been reported for the surface water of other rivers. A comparable amount of MP particles was identified in the River Seine, where 3 to 108 particles/m^3 were found in the surface water [21]. However, the concentration of MPs in this study was significantly higher than the number of MPs found in the Danube River, 0.32 particles/m^3 [22]. A possible explanation is the differences in the methodological approaches, as Lechner, *et al.* [22] included only <2-mm particles in their study. Another study (also conducted on the Chao Phraya River in an agriculture area in Ang Thong province) found a total number and concentration of MPs of 16.48 particles/m^3 and 0.64 mg/m^3, respectively [23].

These results are much lower than those of the current study in the Tha Prachan area. This indicates that the abundance of MPs may be positively correlated with the population density and the proportion of urban/suburban development in watersheds. Comparing the data from our study with other studies was challenging due to the differences in sampling methods used, size ranges investigated, and the reporting units that were employed. Therefore, the development of standard methods for sampling and reporting MPs is required so that the results can be compared globally.

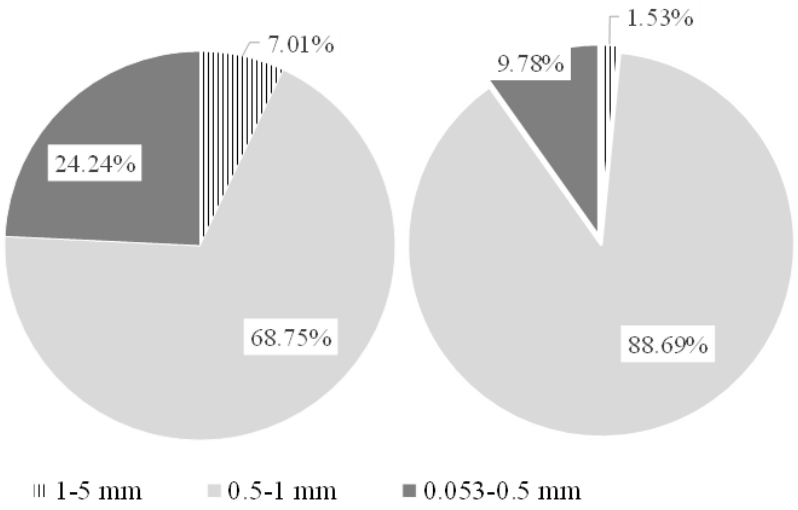

Figure 2 Relative abundance of MPs at Tha Prachan: (A) by weight, (B) by size range.

3.1.2 Sediment Samples

In the Tha Prachan area, MPs in the sediment were found only in the size range of 0.053 to 0.5 mm. Similar to the surface water, fragments were found as the major morphology in sediment, as presented in Figure 3. However, many black particles were also detected, which were mostly confirmed as ash particles by FTIR. As shown in Table 1, the total number and concentration of MPs was 2290 particles/kg and 650 mg/kg, respectively. The number and concentration of MPs in the sediment samples from this study were smaller than the number and concentration found in the Rhine River, Germany (i.e. 3763 particles/kg and 932 mg/kg, respectively) [24]. However, they were higher than the results for the Beijing River, China with 544 particles/kg [25].

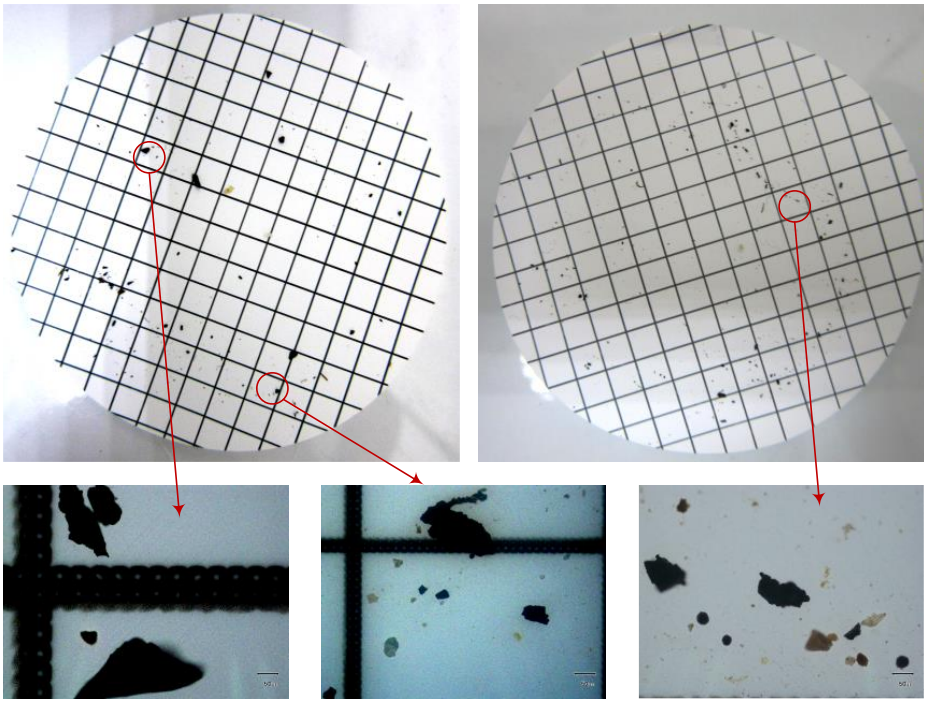

Figure 3 Microplastics (size range 0.053 to 0.5 mm) found in sediment samples under a microscope at 10x magnification.

3.2 Polymer Composition of Separated Microplastics

3.2.1 Water Samples

Figure 4 presents the polymer types of MPs found in the Tha Prachan area. As shown in the figure, PP and PE were the dominant MPs found in the size ranges

of 0.5 to 1 and 0.053 to 0.5 mm. The size range of 1 to 5 mm was dominated by PS and PE. In general, polymers of PP, PE, and PS made up more than 85% of all MPs identified in the samples. This result can be explained as follows. The high quantity of production of PP, PE, and PS in Thailand is the main reason for their large abundance. These types of polymers are widely used to produce plastic products for daily use in cities in Thailand.

The low specific densities of the polymer particles allow for widespread distribution in aqueous systems, as they float on the water surface. In addition to the plastics mentioned above, small amounts of ethylene-vinyl acetate copolymers (EVA), cellophane, and polytetrafluoroethylene (PTFE) were also identified. The amount of the other polymers was lower due to their less frequent usage. Briefly, it can be concluded that the MPs found in this study area originated mainly from commercial plastic products. These plastic products may have been disposed of improperly after reaching the end of their useful life.

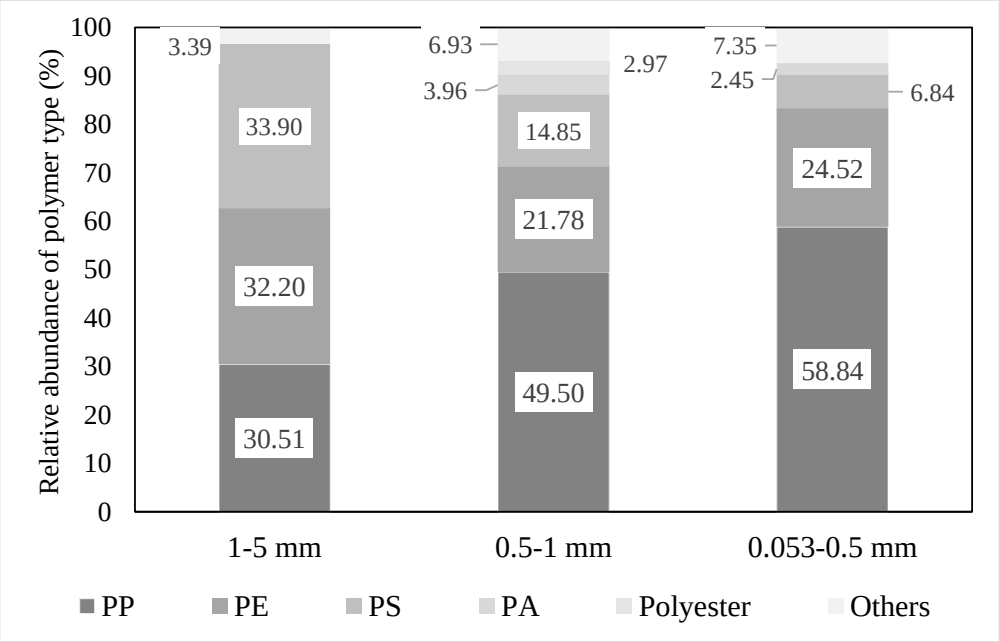

Figure 4 Characteristics of MPs in different size ranges in the Tha Prachan area.

3.2.2 Sediment Samples

The polymer types found in sediment were similar to those that were detected in surface water. PE, PP, and PS were dominant. However, the percentages of polymer types were different between the sediment and the surface water samples. As shown in Figure 5, most MPs in the sediment samples in the Tha

Prachan area were PE, while MPs in surface water in the same size range were dominated by PP.

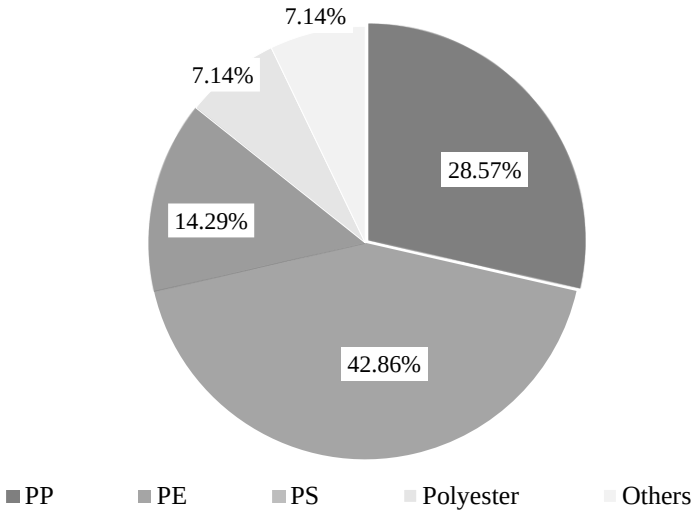

Figure 5 Characteristics of MPs in sediment samples in the Tha Prachan area.

4 Conclusions

This paper presented a preliminary assessment of MP pollution in the surface water and sediment of the Chao Phraya River in the Tha Prachan area, Bangkok. MPs in a size range of 0.5 to 1 mm were found at a higher concentration than other sizes in the surface water. However, in the sediment samples, MPs were only detected in a size range of 0.053 to 0.5 mm. According to Lusher, *et al.* [26], MPs with size up to 0.15 mm have found in the gut and lymphatic system of mammals. Currently, human data on the absorption of MPs are not available. However, the translocation of MPs across the digestive tract into the lymphatic system of humans has been demonstrated [27]. This suggests that freshwater systems, such as rivers, are severely polluted by MPs. MP fragments of PP, PE, and PS were dominant in the samples. These fragments are suspected to originate from daily-use plastic products. The results of this study indicate a high level of contamination in the Chao Phraya River, which can pose potential health risks to the population. This study also yielded background data for further studies on MPs pollution and potential environmental risk in the Chao Phraya River and other regions.

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