EnvironmentAsia
The international journal by the Thai Society of Higher Education Institutes on Environment

EnvironmentAsia 12 (Special issue) (2019) 48-53
DOI 10.14456/ea.2019.62
ISSN 1906-1714; ONLINE ISSN: 2586-8861

Microplastic Pollution in Surface Water of the Chao Phraya River in Ang Thong Area

Anh Ta and Sandhya Babel*

School of Biochemical Engineering and Technology, Sirindhorn International Institute of Technology, Thammasat University, P.O. Box 22, Pathum Thani 12121, Thailand

*Corresponding author: sandhya@siit.tu.ac.th

Abstract

As the top country for plastic production and consumption, Thailand generated more than 3 million tonnes of plastic waste in 2016. As a result of improper management, 0.15 to 0.41 million tonnes of plastic waste entered annually in the aquatic environment in Thailand. In recent years, a small size of plastic waste in term of microplastics (MPs) became a significant concern due to their persistence, ubiquity and potential to play as vectors for transfer organic pollutants to human and biota. This study reports the concentration of MPs of the Chao Phraya River at Pa Mok District – a huge agricultural area of Ang Thong Province. MPs were sampled on the river by a manta trawl with the mesh size of 300 microns. The samples were treated by hydrogen peroxide with the iron (II) sulfate as a catalyst to remove organic components and inspected under a microscope with different size ranges. The total number of MPs were found to be 41.77 particles/m^3. The presence of different types of MPs was confirmed by FTIR spectroscopy, with a predominant abundance of polypropylene, polyamide 6, and polyethylene. Potential origins of these type of polymers are from plastic nets of aquatic farms and plastic films from mulching employed for cultivation.

Keywords: Microplastic, Chao Phraya River, Plastic waste, Ang Thong

1. Introduction

Plastics have become an indispensable part of urban life due to their convenience and tenacity. In Thailand, more than four million tonnes of plastics were produced per year but only half of the amount goes for reuse or recycling (PCD 2017). The mismanagement of the waste in the country makes 1.03 million tonnes of plastic entering into the aquatic environment annually (Jambeck *et al.* 2015).

In recent years, a particular concern is the occurrence of smaller pieces of plastic debris including those not visible to a naked eye, known as MPs. The term MPs has been defined differently by various researches. However, most researchers defined MPs as plastic particles in size range between 5 mm and 1 μm (Fendall and Sewell 2009; Moore 2008; Parliament 2008). MPs can generate from primary sources that produced in micro sizes such as plastic resins and microbead in cosmetic products and plastic resins. The secondary sources of MPs can generate from the breakdown of larger plastics by UV degradation combined with wind and wave impact or road abrasion of larger plastic items through damage by vehicles and transport along with concrete pathways (Barnes *et al.* 2009; Gregory and Andrady 2003). Moreover, textile laundering facilities and sandblasting are other sources of MPs (Browne *et al*. 2011; Napper and Thompson 2016). These pollutants, which are typically sub-millimeter in size, get washed down the sink as they are too small to be filtered by sewage-treatment plants consequently ending up in the river systems and ultimately in the oceans.

The effects of MPs on the aquatic environment and human are still being studied. However, there is much evidence for significant harm of the pollution on wildlife and human health. Small pieces of plastic as MPs are more likely to be ingested by wildlife, and have a greater surface area which can transfer chemicals to and from the aquatic environment (Mato *et al*. 2001). Toxicity of the pollutants could be caused by the plastic polymer itself, the additives it contains, or by other chemicals that associate with MPs. The potential effects of MPs on aquatic organisms can be physical effects such as obstruction; chemical effects due to the transportation of toxic chemicals; impaired health; impacts on population and ecosystems; and dispersal of damaging pathogens (Wright *et al*. 2013). 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 (Committee 2016). For human health, MPs were found in seafood sold for human consumption (Rochman *et al*. 2015). The pollutants are typically found in the gut of aquatic organisms such as shellfish. According to Cauwenberghe *et al.* (Van Cauwenberghe and Janssen 2014), consuming large quantities of mussels could present an exposure pathway. It is uncertain whether MPs that are ingested by humans can be transported into tissues. However, it is reported that MPs are widely used as carriers to deliver medicines into tissues in humans where they want them to be active. If MPs used in medicine can transfer to certain tissues to deliver the medicine, then MP waste could also transfer to the tissues (Committee 2016). Once inside tissues, it is theoretically possible for MPs to interact with biological tissues in a toxic manner.

In Thailand, knowledge on the accumulation and effects of MPs is insufficient. Currently, some studies are on the marine environment. According to Yukari *et al* (Matsuguma *et al*. 2017), MPs in surface sediment in the Gulf of Thailand in 2004 varied from 100 to 300 items/ kg – dry sediment in core samples. There was a significant increase in abundance of MPs in sediment and surface layer over the time. The study on three sessile and intertidal invertebrates in Chonburi province, Thailand, indicated significant accumulation of MPs at rates of 0.2–0.6 items/g (Thushari *et al*. 2017). Polyamide and polyethylene terephthalate were major types detected in the biota, while polystyrene were found in lower amounts.

There have been no studies of MPs on freshwater environments in Thailand, especially on rivers that play an important role for water supply in the country. The aim of this study was to investigate the concentration and types of MPs on the Chao Phraya River at an important area for agricultural and water security of Thailand - Ang Thong Province.

2. Materials and Methods

2.1 Sampling

MPs were investigated on surface water from the Chao Phraya River at Pa Mok district, Ang Thong province (14°26.536′N and 100°28.073′E) by volume-reduced sample. The study area is located in the central region and plays an important role in agriculture of Thailand. Water samples were collected by a manta trawl that has a rectangular opening of 20 cm high × 50 cm wide. A 2 m long net with the mesh size of 300 microns and a 25 cm high × 10 cm diameter cod end was connected to the frame of manta trawl. The volume filtered by the manta net was recorded by a Hydrobios flow meter 438 110 mounted at the net opening, enabling the normalization to the filtered water volume and thus a calculation of concentrations of MPs per unit water volume. The manta net trawled on surface of the river and outside of wake zone beside a research boat for 15 minutes for each sample. The trawling speed depends on weather conditions and currents, but usually ranging between 1.8 and 9.3 km/h.

2.2 Analysis of microplastic

MPs were analyzed based on the method suggested by Masura *et al.* (2015) with modifications. Samples were directly sieved through stainless steel sieves with mesh sizes in the order of 0.05, 0.5, 1.0, and 5.0 mm to separate the solids into different sizes. NaI solution with a density of 1.5 g/cm^3 was used to float out the MPs in the sample matrix before sieving. Solids remain on the sieves were treated by hydrogen peroxide (30%) with a Fe (II) catalysis to remove organic compounds that can affect the visual sorting of MPs under a microscope. The solids after digestion by peroxide were dried at 60°C for 24 hours. Potential MPs were inspected under the Olympus microscope DP20 at 10x magnification. After inspecting on the microscope, MPs (50 particles each size range) were randomly chosen to inspect on a Nicolet Fourier-transform infrared spectroscopy (FTIR) with a resolution of 8 cm^{-1} using a diamond micro-tip.

3. Results and Discussion

3.1 Abundances of microplastic in Chao Phraya River - Ang Thong area

MPs particles were presented in different sizes and as shown in Figure 1. MPs were found at a total concentration of 41.77 particles/m^3 at the Ang Thong area of the Chao Phraya River. The number and concentration of MPs by size is shown in Table 1. The most abundant weight fractions in the sample are MPs with a size range of 0.5 – 1.0 mm (Figure 2A). However, the most numerical abundance in the sample are MPs with a size range of 0.053 – 0.5 mm (Figure 2B).

The results in our study show that the extent of MPs pollution of rivers is in the same concentration range that has recently been reported for surface water of rivers. A

Table 1. MPs found on Chao Phraya River –Pa Mok area, Ang Thong

Size range (mm)	Number (particle/m^3)	Concentration (mg/m^3)
1 - 5	13.07	0.41
0.5 - 1	12.22	1.67
0.053 – 0.5	16.48	0.64

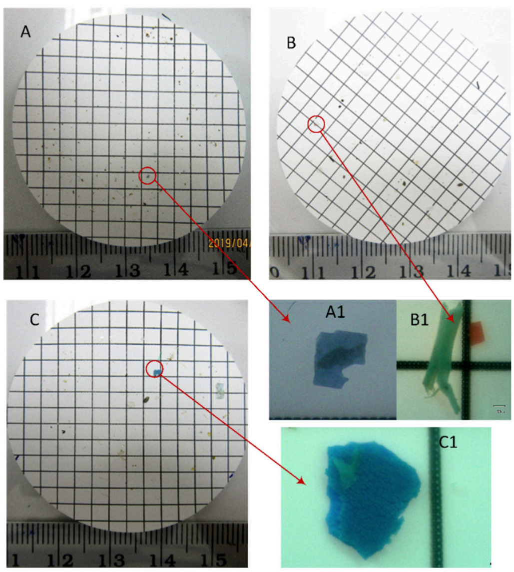

Figure 1. Microplastics at different size ranges (A): 0.053 – 0.5 mm, (B): 0.5 – 1 mm, (C): 1 – 5 mm, (A1, B1, C1): MPs under microscopes 10x.

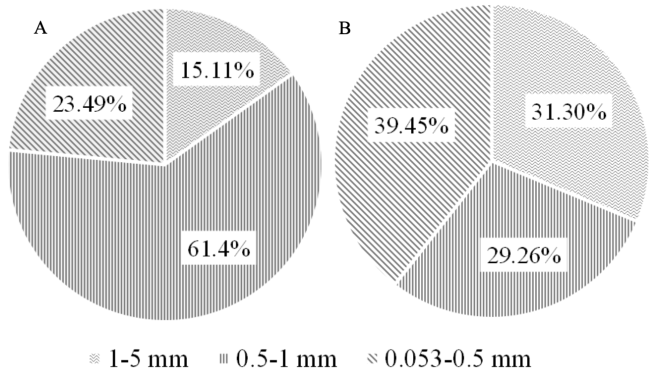

Figure 2. Relative abundance of MPs (A): by weight, (B): by size range.

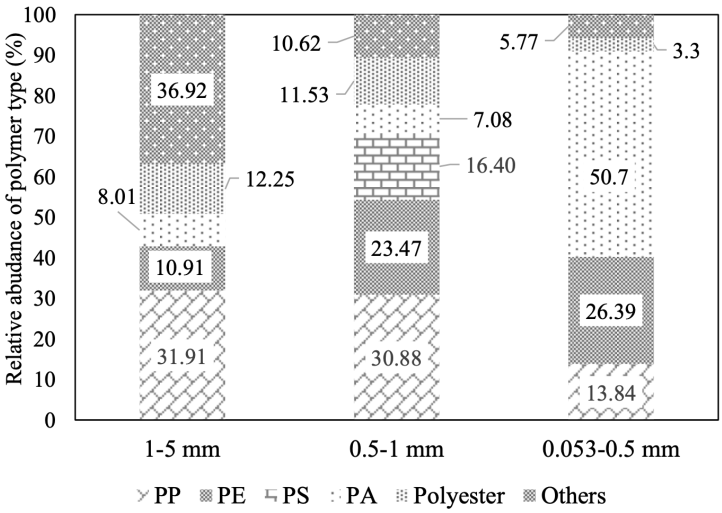

Figure 3. Composition of separated MPs by particle number.

comparable amount of MPs particles were identified in River Seine, where 3 – 108 particles/m^3 were found in surface water (Dris *et al*. 2015). The concentration of MPs in the study is significantly higher than the number of MPs found in the Danube River 0.32 particles/m^3 (Lechner *et al*. 2014). Possible explanations for an increasing level of plastic pollution in the past several years are differences in the methodological approaches, as Lechner *et al*. included only <2 mm particles in their study.

3.2 Validation of polymer composition of separated microplastics

FTIR analysis of the 0.5 – 1 mm size fractions that >60% of the total plastic weight and majority was polypropylene (PP) as shown in Figure 3. The largest abundance in term of particle number of the size range 0.053 – 0.5 mm was also contributed by polyethylene (PE), and polyamide (PA). In general, polymers of PP, PA-6, and PE made up 49.06% of all MPs identified in the samples. This result can be explained by the following reasons. On one hand, the high quantity of production of PP, PA-6, and PE in Thailand is a reason for their large abundance. On the other hand, the low specific densities of the polymer particles allow the widespread distribution in aqueous systems. Moreover, the study area is mainly used for agriculture and aquatic farming. PP nets are widely used for fabricating of fish cages. While PA-6 and PE particles may come from plastic covers of greenhouse or plastic films of mulching for cultivation.

In addition to the plastics mentioned above, ethylene vinyl acetate (PEVA), cellophane, and polytetrafluoroethylene (PTFE) were identified. The abundance of the other polymers is possibly caused by their less frequent usage but could also be explained by different transport mechanisms in water systems. Polystyrene (PS) particles was found only in the size range of 0.5 -1 mm. This may originate from foam products used in aquatic farms at the study area of the Chao Phraya River.

4. Conclusions

In this study, a preliminary assessment of MPs pollution in the surface water from the Ang Thong area of Chao Phraya River was presented. It shows that freshwater systems like rivers are severely influenced by MPs. The high concentration of MPs is related to agricultural activities on land and aquatic farms on the surface water in the area. These findings emphasize the urgency to mitigate the MPs contamination of the aquatic environment in the near future. Moreover, this study also indicated the high potential risks of MPs for human due to the appearance of the pollutant in the area that cultivating human food.

Acknowledgements

The PhD scholarship provided to first author by the Thailand Research Fund (PHD/0241/2560). This study was also partially supported by Asia-Pacific Network for Global Change Research (APN).

References

Barnes DK, Galgani F, Thompson RC, Barlaz M. Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of the Royal Society of London B: Biological Sciences. 2009: 364(1526); 1985-1998.

Browne MA, *et al*. Accumulation of microplastic on shorelines woldwide: sources and sinks. Environmental science & technology. 2011: 45(21); 9175-9179.

Committee HoCEA. (2016). Environmental impact of microplastics. Fourth Report of Session 2016–2017.

Dris R, Gasperi J, Rocher V, Saad M, Renault N, Tassin B. Microplastic contamination in an urban area: a case study in Greater Paris. Environmental Chemistry. 2015: 12(5); 592-599.

Fendall LS, Sewell MA. Contributing to marine pollution by washing your face: microplastics in facial cleansers. Marine pollution bulletin. 2009: 58(8); 1225-1228.

Gregory MR, Andrady AL.Plastics in the marine environment. Plastics and the Environment. 2003: 379; 389-390.

Jambeck JR, *et al.* Plastic waste inputs from land into the ocean. Science. 2015: 347(6223); 768-771.

Lechner A, *et al*. The Danube so colourful: a potpourri of plastic litter outnumbers fish larvae in Europe's second largest river. Environmental Pollution. 2014: 188; 177-181.

Masura J, Baker JE, Foster GD, Arthur C, Herring C. Labo ratory methods for the analysis of microplastics in the marine environment: recommendations for quantifying synthetic particles in waters and sediments. 2015.

Mato Y, Isobe T, Takada H, Kanehiro H, Ohtake C, Kaminuma T. Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. Environmental science & technology. 2001: 35(2); 318-324.

Matsuguma Y, *et al*. Microplastics in Sediment Cores from Asia and Africa as Indicators of Temporal Trends in Plastic Pollution. Archives of Environmental Contamination and Toxicology. 2017: 1-10.

Moore CJ. Synthetic polymers in the marine environment: a rapidly increasing, long-term threat. Environmental research. 2008: 108(2); 131-139.

Napper IE, Thompson RC. Release of synthetic microplastic plastic fibres from domestic washing machines: effects of fabric type and washing conditions. Marine pollution bulletin. 2016: 112(1-2); 39-45.

Parliament E. Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Official Journal of the European Union L. 2008: 164; 19-40.

PCD. (2017). Thailand State of Pollution Report 2016. Pollution Control Department, Ministry of Natural Resources Bangkok, Thailand.

Rochman CM, *et al*. Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption. Scientific reports. 2015: 5; 14340

Thushari GGN, Senevirathna JDM, Yakupitiyage A, Chavanich S. Effects of microplastics on sessile invertebrates in the eastern coast of Thailand: An approach to coastal zone conservation. Marine pollution bulletin. 2017: 124(1); 349-355.

Van Cauwenberghe L, Janssen CR. Microplastics in bivalves cultured for human consumption. Environmental pollution. 2014: 193; 65-70.

Wright SL, Thompson RC, Galloway TS. The physical impacts of microplastics on marine organisms: a review. Environmental pollution. 2013: 178; 483-492.