



Identification of Micro-plastic Contamination in Drinking Water Treatment Plants in Phnom Penh, Cambodia

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Highlights:

- Two main drinking water treatment plants in Phnom Penh city were investigated for microplastics removal efficiency.
- Micro-plastics were found in all samples collected at different locations of both treatment plants.
- Small particles of 6.5-20 μm predominated in all samples.
- Polyethylene terephthalate and polyethylene were the most abundant.

Abstract. Micro-plastics (MP) contamination in drinking water has become a global concern. Its negative impacts on human health have been reported. This study identified the presence of MP in two different drinking water treatment plants (WTP) in Phnom Penh, Cambodia, and investigated their removal efficiency. Samples were collected from the inlet, sedimentation, sand filtration, and distribution tank to quantify the removal by each unit. An optical microscope and a fluorescence microscope were used to detect the MP in four size fractions: 6.5-20, 20-53, 53-500, and >500 μm . Fourier transform infrared spectroscopy (FT-IR) was used to identify the polymer type for particles with size fractions of 53-500 and >500 μm . The results showed that the MP counted in WTP1 were 1180.5 ± 158 p/L in the inlet and 521 ± 61 p/L in the distribution tank. In WTP2, the MP counted were 1463 ± 126 p/L in the inlet and 617 ± 147 p/L in the distribution tank. The smaller size fraction of 6.5-20 μm predominated at each sampling location. Fragments were the most abundant morphology compared to fibers in all sampling points of both plants. PET predominated and the overall percentages for the inlet tank were 28.8% and 26%, followed by PE with 27.1% and 20.8% in WTP1 and WTP2, respectively. Other common polymer types were PP, PA, PES, and cellophane, while all others accounted for less than 5%. The results of the study showed that a significant number of MP remained in the water distribution system.

Keywords: *drinking water treatment plant; fluorescent microscope; FT-IR; morphology; Mekong River; Tonle Sap Lake.*

Received October 20th, 2020, 1st Revision January 7th, 2021, 2nd Revision March 18th, 2021, Accepted for publication March 28th, 2021.

Copyright ©2021 Published by ITB Institute for Research and Community Services, ISSN: 2337-5779, DOI: 10.5614/j.eng.technol.sci.2021.53.3.7

1 Introduction

Plastic debris is one of the most serious contaminants in the environment, especially in aquatic systems. Large plastic debris (macro-plastics) can eventually break down into smaller fractions under environmental conditions to form micro-plastics (MP) [1]. MP are defined as plastic particles of <5 mm in diameter, while a smaller size is rarely mentioned in most studies [2,3]. Due to their small size, MP can easily be ingested by aquatic microorganisms and transfer to humans through food consumption [4]. Studies have reported the presence of MP in some commercial seafood, including fish (*Rutilus rutilus*) [5], mollusks [6], crabs (*Carcinus maenas*), and shrimps (*Crangon crangon*) [7]. The ingestion of MP has been reported by Christopher Blair Crawford [8] to have significant impacts on human health. MP can accelerate the transit time of food through the gastrointestinal system. This process can reduce the absorption of vital nutrients and eventually cause nutritional deficits. Waring, *et al.* [9] also mention the adverse effects of MP due to physical properties. MP induce damage by oxidative stress in cerebral and epithelial human-cell lines, which can increase gut inflammation. MP have been found widely in environmental samples such as surface water [10-14], marine environment [13], sediment and ambient air [15] samples, and in drinking water [2, 16-18]. The presence of MP in drinking water treatment plants can be one of the main sources for direct and indirect ingestion of MP in humans and is a concern.

The studies of Maocai Shen [19] and Novotna [20] tried to correlate the fate of MP and removal trends in drinking water treatment plants. However, they also reported that studies in this area are still relatively scarce. The lowest amount of MP detected in a WTP was 0-7 particles per cubic meter (p/m^3) [2], where the source of water was groundwater. Martin, *et al.* [18] found MP in drinking water treatment plants at 3605 ± 497 p/L in raw water and 628 ± 28 p/L in treated water. The result of the same study indicated small-size MP (<10 μm) as the predominant particles in both raw and treated water. They reported the presence of polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET) in the treatment plants. Wang, *et al.* [17] researched MP removal in advanced drinking water treatment plants based on different removal techniques. With a combination of coagulation, sedimentation, and granular activated carbon filtration (GAC) they observed a high rate of MP removal (56.8-60.9%). They also suggested that MP removal depends on the physical properties of the particles, including size and shape. Ding, *et al.* [21] discussed the possibility of MP and nanoplastics (NP) that may be released from drinking water treatment plants with a membrane treatment system. Their study revealed that membrane filtration systems can release NP and MP into drinking water due to the effects of mechanical stress, aging, physical cleaning, and application of chemical agents for cleaning.

A research study on the presence of MP in drinking water treatment plants (WTP) in Phnom Penh, Cambodia has not yet been conducted, while a study in a neighboring country is currently in progress [22]. Thus, the lack of information could lead to misunderstandings about the MP situation in Cambodia, which is important for future MP management. This study identified the MP removal from two WTP in Phnom Penh, where the water supply is from two different sources, the Mekong River and Tonle Sap Lake. Although both plants use the same treatment methods, the removal efficiency of each plant may be different as the source of water is different. The results of this study provide baseline data for the Phnom Penh Water Supply Authority (PPWSA) and the government of Cambodia for future MP management. Since knowledge on MP in WTP is lacking, this study provides information on MP contamination and removal in WTP, encouraging further research in this area.

2 Materials and Methods

2.1 Sample Collection

There are four main treatment plants in Phnom Penh city. Treated water from these plants is distributed to 405,627 users (households, commercial users, autonomous state authorities, wholesalers, representatives, and rented rooms) [23]. Water samples in this study were collected from two main WTPs, Chroy Chongva (WTP1) and Phum Prek (WTP2), where the water sources are the Mekong River and Tonle Sap Lake, respectively (Figure 1). The selected treatment plants cover more than 50% of water supply. WTP1 possesses a treatment capacity of 150,000 m³/day, while WTP2 has a capacity of 140,000 m³/day. Both WTP1 and WTP2 use the same treatment techniques, i.e. hydraulic mixing, flocculation, sedimentation, rapid sand filtration, disinfection (post-chlorination), and storage/distribution. In each treatment plant, samples were collected by using grab sampling at the following locations: inlet, sedimentation (outlet), sand filtration (outlet), and distribution tank (Figure 2). Each sample was 1 L by volume. This method was also adopted by Martin, *et al.* [18], Kankanige & Babel [22], and Wang, *et al.* [17]. As the study focused on two treatment plants, the total number of collected samples was 8. Samples were collected in duplicate from each location and stored in a refrigerator at 4 °C [18] until further analysis.

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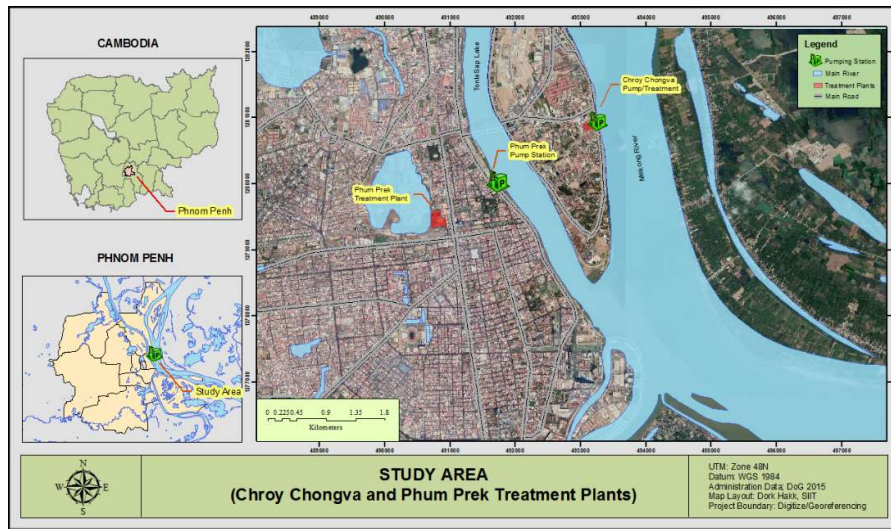


Figure 1 Map showing the locations of Chroy Chongva and Phum Prek WTP.

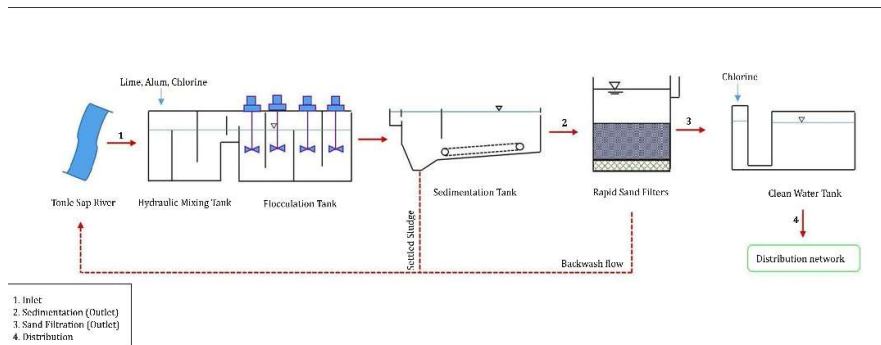


Figure 2 Water treatment process and sampling points.

2.2 Sample Pre-treatment

Samples from the field may contain organic materials that could hinder analysis [10]. Studies have suggested different methods to digest organics such as acids, alkali, oxidation (using H_2O_2 as oxidizing agent) [24,25], and enzymes [25]. In this study, the H_2O_2 (30%) method was adopted since it has higher efficiency in terms of particle recovery compared to other chemicals such as sodium hydroxide (NaOH) and hydrochloric acid (HCl) [25]. Fenton solution was made by the reaction of hydrogen peroxide (Merck, Germany) and iron (II) sulfate heptahydrate (Nacalai, Japan)[24]. To increase the digestion efficiency, the

digestion solution was not applied directly to the whole sample volume. The samples were rinsed in a clean glass beaker and dried in an oven at 70 °C to minimize the water volume before conducting organic digestion.

2.3 Size Fraction

From each 1 L of sample, MP were separated into four size fractions using sieving and filtration: >500 µm, 53-500 µm, 20-53 µm, and 0.45-20 µm. The pre-treated samples from the previous process were first passed through stainless steel sieves of 500 µm and 53 µm mesh sizes to obtain the first two studied size ranges. Sieve stacks were arranged in descending order from larger-size to smaller-size fractions. To obtain the two other particle size fractions of 20-53 µm and 6.5-20 µm, the samples were filtrated through 20 µm and 0.45 µm cellulose nitrate filter membranes (Sartorius, Germany, 47 mm) [26-28]. MP smaller than 53 µm were stained with Nile Red (NR) (Acros, Germany) prior to analysis under a fluorescence microscope (GE Healthcare, Deltavision Elite, USA). For this, the previous filtrated samples (20-53 µm and 6.5-20 µm) were poured back into a beaker at a minimal volume of 50 ml (not limited). NR solution with a concentration of 10 µg/mL was applied to the beaker by using a micro-pipet. Then, the samples were incubated for 30 minutes for a better balance of visibility, speed, and background signal [28]. Since particles of <6.5 µm cannot be credibly analyzed by fluorescence microscopy, the 0.45 to <6.5 µm size fraction was excluded [29].

2.4 Identification

Quantification of MP was conducted by visual sorting under an optical microscope (Olympus CX41) at 4x and 10x magnification for particle size fractions of 53-500 µm and >500 µm. The number of particles was counted one-by-one using a manual counter from the top to the bottom and from the left to right side of every grid [30]. With this method, the morphologies of the counted particles were also observed. The classification of particle types was limited to fibers and fragments. Adding other unclear shapes may lead to under- or over-estimation. In this case, particles with pellets and films were included in the fragments type. MP fibers were defined as elongated and slender in appearance, while fragments were defined as incomplete parts of large plastic debris.

Using an optical microscope, the images were insufficient and/or unclear when the particle size decreased to a few micrometers. Thus, the particles with a size fraction of 20-53 µm and 6.5-20 µm were stained by NR and identified under a fluorescence microscope. NR was reported to provide the most promising staining protocol for MP, with recovery rates up to 96.6% [24]. Plastics can emit the fluorescent shift well compared to biogenic materials [24], hence making the NR stain method more reliable. Shim, *et al.* [31] reported similar advantages of

the NR stain method and considered it a straightforward and quick method for quantification. Practically, the stained filters were scanned with blue fluorescence (DAPI, excitation 318/18 nm, emission 435/48 nm). Quantification of MP using a fluorescence microscope is more convenient than visual sorting under an optical microscope. In this case, the TIF files were counted by using the Image J application and confirmed by a manual count when needed.

Particles from optical microscope observation (53-500 μm and $>500 \mu\text{m}$) were randomly chosen to identify for polymer types under a Fourier transform infrared (FT-IR) spectroscopy (Nicolet iS50, Thermo Fisher Scientific, USA). The same method was also adopted by Kankanige & Babel [29] and Mintenig, *et al.* [2] to identify polymer types with comparable size fractions. The FT-IR in this study was set to a resolution of 8 cm^{-1} , it had a diamond micro-tip with a range of 4000 to 650 cm^{-1} , and each spectrum was taken as an average of 128 scans. The collected data were processed by Omnic Software (Thermo Fisher Science, USA). The composition of the particles was determined by comparing the obtained spectra to an existing reference database [18]. FT-IR is a common method in most MP studies for characterizing polymer types.

2.5 Contamination Prevention

Since MP are widely present in the environment, the preparation/pre-treatment process may be vulnerable to contamination. In this regard, contamination prevention was carefully conducted from sample collection to identification. Non-plastic materials were used as much as possible. Cotton laboratory coats were worn all the time. Glassware and some of the other materials were thoroughly cleaned by ethanol (50%) and washed several times by DI water. The filter membrane used in this study was known to be an ash-less grade product, beneficial for quantification purposes. The sample treatment was conducted in a laminar flow box to avoid air-borne MP contamination, while filtrated samples were stored in closed glass petri dishes. Treated/filtrated samples were transferred to a covered (aluminum foil) petri dish and dried in an oven at a controlled temperature of $60 \text{ }^{\circ}\text{C}$.

Blank samples using deionized (DI) water (1 L) were analyzed in parallel, following the same procedure as the real samples in the laboratory. This was done to find airborne contamination. The results from the blank samples were subtracted from the real samples to avoid over-estimating the number of MP.

3 Results and Discussion

3.1 Micro-plastic Distribution

Table 1 shows the particle distribution in the blank samples. The results of the blank were subtracted from the samples collected from the treatment plants to find the actual concentration.

Table 1 Particles distributed in blank samples from WTP1 and WTP2.

Size (µm)	WTP1 (p/L)				WTP2 (p/L)			
	Inlet	Sedimentation	Sand Filtration	Distribution	Inlet	Sedimentation	Sand Filtration	Distribution
>500	16	22	9	8	13	18	10	8
53-500	21	18	15	13	15	16	8	12
20-53	19	22	14	21	20	22	8	12
6.5-20	27	25	19	20	29	21	14	15
Total	83	87	57	62	77	77	40	47

MP were found in every sample collected from both WTP. The inlet tank had the highest number of MP compared to the other locations in the treatment plants, as shown in Figure 3. The total number of MP (every size fraction) in the inlet tank were 1180.5 ± 158 p/L in WTP1 and 1463 ± 126 p/L in WTP2. The results of this study are comparable to those of Kankanige & Babel [22], who observed MP contamination in a conventional drinking water treatment plant sourced from the Chao Phraya River, Thailand. Size fractions and geographical conditions were similar to this study. Their study reported MP at the inlet as 1796.6 p/L in the rainy season and 1385 p/L in the dry season.

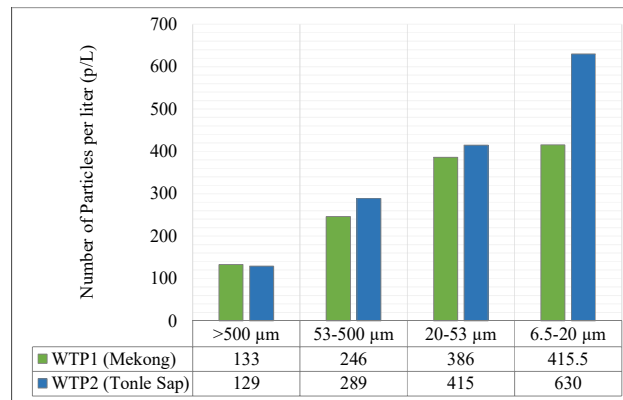


Figure 3 Size-based particle distribution in the inlet tank of WTP1 (Mekong) and WTP2 (Tonle Sap).

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The above results also show that water from Tonle Sap Lake had higher MP than the Mekong River. The water source of the Mekong River originates in the Tibetan plateau, China, flowing downward and crossing Myanmar, Thailand, and Laos before entering Cambodia [32]. However, Tonle Sap Lake is surrounded by five of Cambodia's major cities and may have been influenced by residential wastewater discharge. Most of the residential areas in Cambodia, including Phnom Penh, do not have wastewater treatment facilities. Wastewater is directly discharged into water bodies without treatment, which increases the chance of contamination [33]. Murphy, *et al.* [34] estimated that from a wastewater treatment plant 65,238,500 MP particles were released daily into the final effluent, equivalent to 23 billion particles annually. Pivokonský, *et al.* [35] observed the MP concentration in two different drinking water treatment plants with the same river as the water source. The treatment plant located downstream showed a higher MP concentration, which was suggested to be influenced by several towns through which the river flows [35].

Among the four size fractions as mentioned above, MP with a smaller size fraction predominated in every treatment unit of both plants (Table 2). The particle distribution was lower when increasing the size fraction to 20-53 μm , 53-500 μm , and >500 μm . A similar pattern of small-size MP predomination was also noticed in WTP2. For instance, the number of particles with a size fraction of 6.5-20 μm was up to 630 ± 55 p/L, while particles with a size fraction of >500 μm were distributed only at 129 ± 10 p/L in the inlet tank.

Table 2 Particle distribution (number of particles) in both WTPs.

Size (μm)	WTP1 (p/L)				WTP2 (p/L)			
	Inlet	Sedimentation	Sand filtration	Distribution	Inlet	Sedimentation	Sand filtration	Distribution
>500	133	104.5	64	59	129	104	61	56
53-500	246	185	112.5	103	289	220.5	136	123
20-53	386	259	192	169	415	268	203	179
6.5-20	415.5	277.5	209.5	190	630	395	293	259
Total	1180.5	826	578	521	1463	987.5	693	617

The fact that small-size particles predominated in every treatment unit of both plants is in line with the results from the study of Martin, *et al.* [18]. They reported that the 5-10 μm size accounted for 30-40%, as observed under a scanning electron microscope (SEM). The same study also suggested that MP were the least plentiful at a size fraction of >100 μm . Wang, *et al.* [17] used the same method of SEM to quantify MP with five different size fractions: 1-5 μm , 5-10 μm , 10-50 μm , 50-100 μm , and >100 μm . Although their size separation differed from this study, they also claimed that small-size MP, with a size fraction of 1-5 μm and 5-10 μm , predominated at 54.6-58% and 20-27.6%, respectively [17]. Sun, *et al.* [36] observed a higher MP concentration due to their finer mesh size.

Their findings suggest that plastics could eventually degrade under environmental conditions to smaller size fractions.

3.2 Morphology-based Micro-Plastic Distribution

Morphology identification of MP is significant since it affects the removal of WTP and correlates to the origin of the MP [36]. As can be seen from Figure 4, fragments were present in higher amounts than fibers in all treatment units of both treatment plants. There was not much difference in the morphology distribution when considering the size fractions of 53-500 μm and $>500 \mu\text{m}$. For instance, fragments with a size fraction of 53-500 μm accounted for 59.8%, while MP with a size fraction of $>500 \mu\text{m}$ accounted for 54.9% in the inlet tank of WTP1. Similar trends were also observed in the inlet tank of WTP2, at 59.7% and 55.7% for particle size fractions of 53-500 μm and $>500 \mu\text{m}$, respectively.

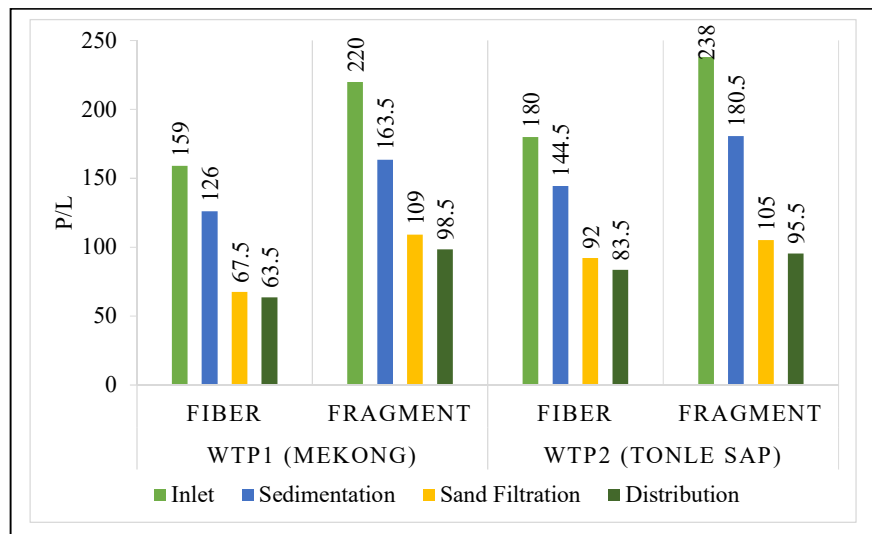


Figure 4 Morphology-based MP distribution in both treatment plants.

The total number of fragments counted in the distribution tank was 98.5 ± 25 p/L (60.8%) in WTP1 and 95.5 ± 24 (53.4%) in WTP2. Fragments also predominated compared to fibers in the sedimentation and sand filtration tanks of both treatment plants (Figure 4). Martin, *et al.* [18] found 42-48% of fragments distributed in raw and treated water of their WTP3 (sourced from a river) as the highest proportion compared to other morphologies. The same study also found 7-20% of spherical-shape particles as the least abundant in both raw and treated water. The summation of percentages for the fragment and spherical particles found in

the study of Martin, *et al.* [18] was closer to this study. It is assumed that fragments originating from the degradation of macro-plastic materials under environmental conditions become secondary MP [37]. However, Wang, *et al.* [17] found that fibers were the predominant particles in each treatment unit, at 53.9% in raw water and 73.9% in treated water. Sun *et al.* [36] and Napper & Thompson [38] found that fibers were predominant in wastewater at 52.7%. These fibers may be released from domestic washing machines or the manufacture of synthetic cloth.

3.3 Removal Efficiency

The MP removal in treatment plants was observed. Figure 5 shows the MP-removal trends in both treatment plants. The total particles counted in the inlet tank of WTP1 decreased from 1180.5 ± 158 p/L to 521 ± 61 p/L in the distribution tank. This indicates 55.9% removal efficiency in WTP1, while WTP2 showed 57.8% removal efficiency. These trends of removal efficiency are comparable with the study of Wang, *et al.* [17], who observed 58.9-70.5% removal in a conventional treatment plant (including coagulation/flocculation, sedimentation, and sand filtration). Kankanige & Babel [22] reported seasonal trends of MP distribution in a conventional drinking water treatment plant in Thailand. The removal rate for the dry and rainy seasons was 67.6% and 57.2%, respectively. Moreover, the average numerical data of particle distribution was 1590.8 ± 148.8 p/L and 609.1 ± 84.7 p/L in raw and treated water, respectively, as mentioned in Table 3. However, trends of removal efficiency in this study were lower compared to the study of Martin, *et al.* [18], who found an average removal rate of from 70 to 83%. Compared to this study, Martin, *et al.* [18] introduced an additional treatment technique, i.e. granular activated carbon (GAC), in their study, while the size fraction also differed. Zhang, *et al.* [39] suggested that a combination of coagulation, flocculation, and sedimentation may not effectively remove MP and NPs. Removal percentages of either sedimentation or sand filtration tanks in WTP1 were 30%, while in WTP2 they were 32.5% and 29.8%, respectively (Figure 6). However, the removal trends seemed to vary based on the particle sizes found in each tank. In sedimentation tanks, small particles with a size fraction of 6.5-20 μm and 20-53 μm showed a higher removal rate compared to larger particles (53-500 μm and >500 μm). Based on this finding, smaller-size particles may become flocs and settle eventually.

Smaller particles have a lower removal rate in sand filtration tanks. Some particles may be able to flow through porous sand and gravel tanks, leading to lower removal efficiency. Zhang, *et al.* [39] have suggested that filtration may not be able to filter out all MP, particularly for a size range from 1 μm to 10-20 μm found in the effluent. According to the Phnom Penh Water Supply Authority (PPWSA), filtration tanks for both plants are equipped with 0.9-1.2 mm diameter

sand media of 0.95-m depth, while the filtration speed was 6.89-8 m/h. A gravel layer with a diameter of 3.2 mm was used with this tank (PPWSA [40]). Kaminski, *et al.* [41] observed different sizes of particles for removal using similar conditions of sand filtration. Sand grains of 1.1 and 1.5 mm were used as the filter media, while the set filtration rate was 5-20 m/h. At 5 m/h (comparable to the present study), particles with a size fraction of 5-10 μm had a removal percentage of 20%, and the removal efficiency gradually increased with increasing particle size [41].

Morphologically, fragment removal in WTP1 was 25.7% in the sedimentation tank and 33.3% in the sand filtration tank. Fibers were found to have a lower removal rate in the sedimentation tank (20.8%) but a higher rate in the sand filtration tank (46.4%). Similar trends were noticed in WTP2. The morphology of the particles may affect the removal efficiency in the plants. The results suggest that MP remain in every treatment unit and are not completely removed in the treatment plant. Thus, the treated water from the distribution tank may become a potential source of contamination for drinking water, such as tap water and bottled water.

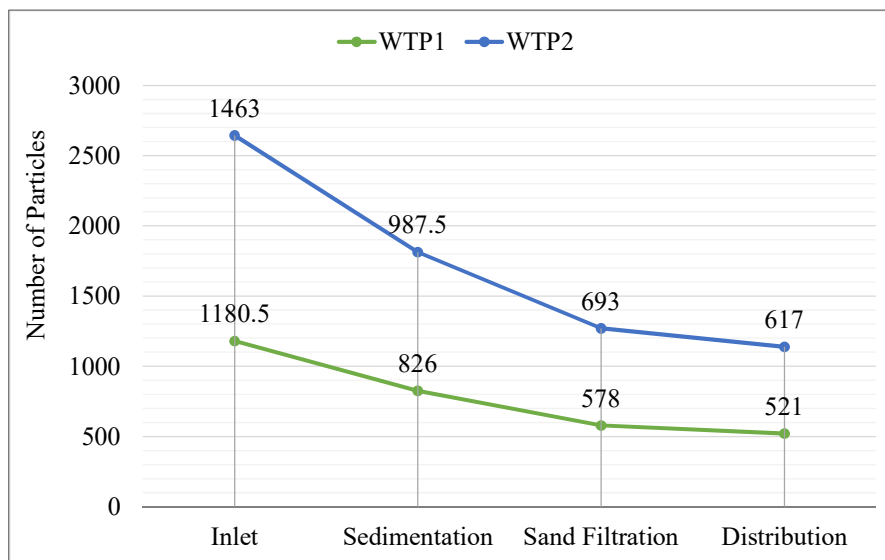


Figure 5 Micro-plastics removal by different units in both treatment plants.

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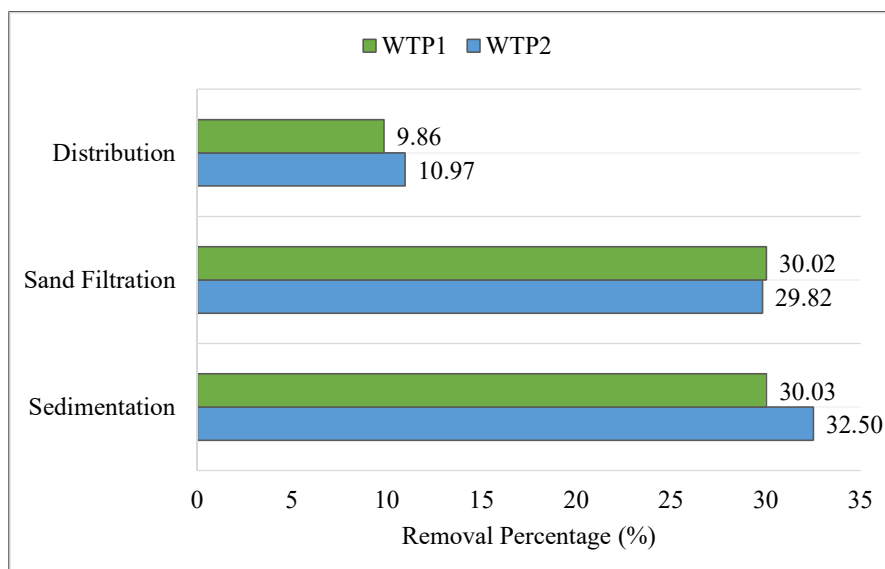


Figure 6 Removal percentage (%) in both treatment plants.

Table 3 Comparison of micro-plastics removal in drinking water treatment plants.

Source of Water	Size Range (μm)	Abundance (p/L)		Reference
		Raw Water	Treated Water	
Water reservoir, Czech Republic	>1	1473 \pm 34	443 \pm 10	Martin, <i>et al.</i> [18]
Water reservoir, Czech Republic	>1	1812 \pm 35	338 \pm 76	Martin, <i>et al.</i> [18]
River, Czech Republic	>1	3605 \pm 497	628 \pm 28	Martin, <i>et al.</i> [18]
Groundwater, Germany	>20	0.7 (p/m ³)		Mintenig <i>et al.</i> [2]
Yangtze River	>1	6614 \pm 1132	930 \pm 72	Wang, <i>et al.</i> [17]
Chao Phraya River, Thailand	>6.5	1590.8 \pm 148	609.1 \pm 84	Kankanige & Babel [22]
Úhlava River, Czech Republic (upper stream)	\geq 1	23 \pm 2	14 \pm 1	Pivokonský, <i>et al.</i> [35]
Úhlava River, Czech Republic (lower stream)	\geq 1	1296 \pm 35	151 \pm 4	Pivokonský, <i>et al.</i> [35]
Mekong River, Cambodia	>6.5	1180.5 \pm 158	521 \pm 61	This study
Tonle Sap Lake, Cambodia	>6.5	1463 \pm 126	617 \pm 147	This study

3.4 Polymer Types

A total of 397 particles of the targeted size fractions (53-500 μm and >500 μm) from both WTP were identified by FT-IR spectroscope. Polyethylene terephthalate (PET) was found in the highest abundance (both size fractions) in each treatment unit. PET was found to be 28.8% and 26% in the inlet tank of

WTP1 and WTP2, respectively, as depicted in Figure 7. PET is the most common thermoplastic polymer and is normally used in water containers, food packaging, clothing industry, etc.[42]. The study of Martin, *et al.* [18] qualified MP by FT-IR and Raman spectroscopy. Their study revealed some common polymer types such as polybutylacrylate (PBA), polyethylene (PE), poly (methyl methacrylate) (PMMA), polypropylene (PP), polystyrene (PS), polytrimethylene terephthalate (PTT), and polyvinylchloride (PVC).

Though some polymer types were different from this study, they also noticed that PET predominated the MP as 60%, 68%, and 27% in WTP1, WTP2, and WTP3, respectively. Polyethylene (PE) comprised a substantial portion of MP as 27.1% and 20.8% in the inlet tank of WTP1 and WTP2, respectively. PE is a well-known polymer that is used for plastic bags and in some clothing industries [42]. Polypropylene (PP), polyamide (PA), polyester (PES), and cellophane were other common polymer types besides PET and PE. The rest of the particles were categorized as ‘Other’, comprising 3.4% and 10.4% in the inlet tank of WTP1 and WTP2, respectively. The ‘Other’ type polymers normally provided low spectral data during identification. Hence, they are the least common polymers in daily use. Figure 8 shows the spectra of some common polymers that were identified in this study.

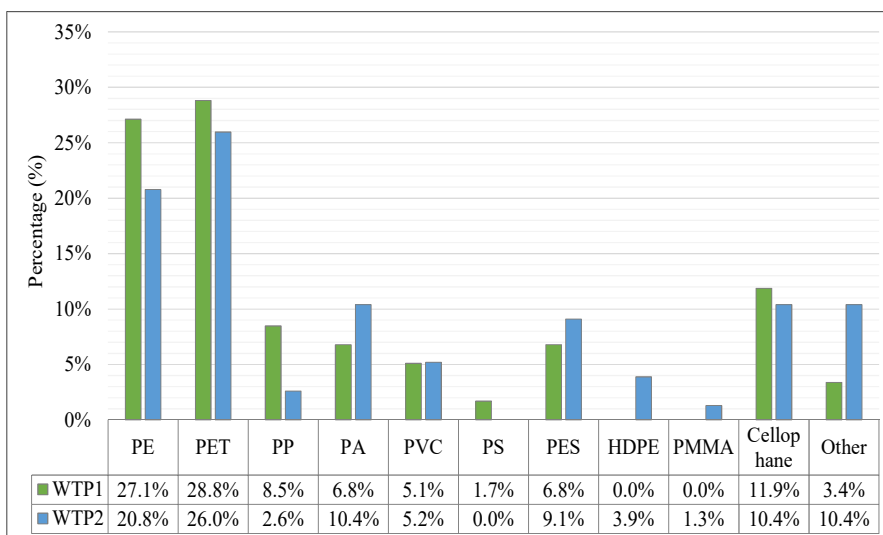


Figure 7 Distribution of polymer types in the inlet tank of both WTP plants.

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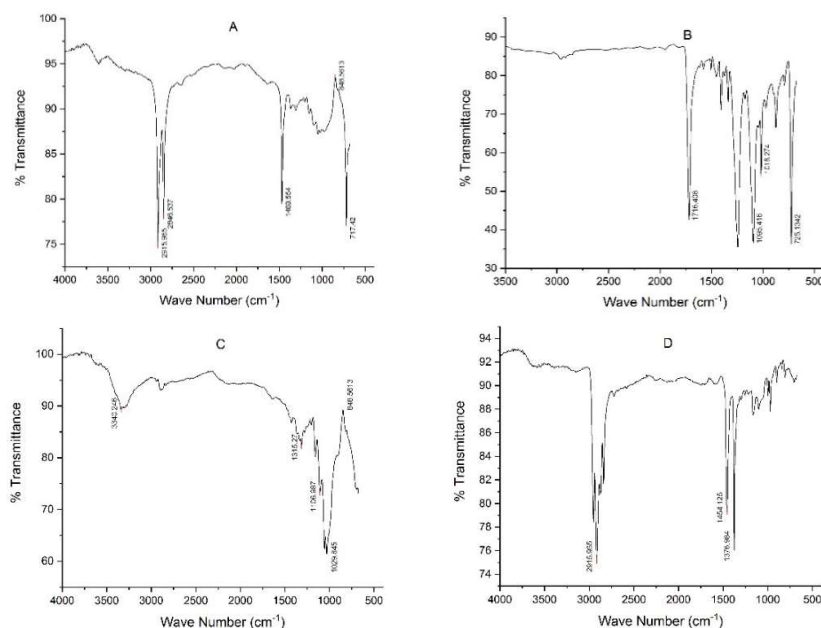


Figure 8 FT-IR spectra of some common particles identified as PE (A), PET (B), cellophane (C), and PP (D).

4 Conclusions

This study revealed the first baseline data for the presence of MP in the WTP of Phnom Penh city, Cambodia. MP were found in the raw water of both treatment plants at 1180.5 ± 158 p/L in WTP1 and 1463 ± 126 p/L in WTP2. A higher amount of MP was found in raw water from Tonle Sap Lake than in the Mekong River. Smaller particle size fractions were distributed abundantly, while fragments predominated for all size fractions in both plants. In this case, MP with a particle size fraction of $6.5\text{--}20\ \mu\text{m}$ comprised 35.2% and 43.1% in the inlet tank of WTP1 and WTP2, respectively. Sedimentation and sand filtration tanks of both treatment plants were the most efficient in removing MP. PET predominated in each treatment unit of both WTPs, followed by PE. In the inlet tank, PET accounted for 28.8% and 26% in WTP1 and WTP2, respectively. The current findings illustrate the situation of MP contamination in the WTPs in Phnom Penh, Cambodia. The above results show that the inlet water source from Tonle Sap Lake and the Mekong River contain a large number of MP. The aquatic biota in these water bodies is also vulnerable to MP contamination. Thus, further studies are required to identify suitable water sources. Since small-size MP were predominantly found, studies toward smaller size ranges are suggested to reveal

the situation. Further research should also be conducted to find reliable MP removal techniques since the standard for MP in drinking water may be set in the near future.

Acknowledgments

This study was funded by the Sirindhorn International Institute of Technology, Thammasat University under an SSNC scholarship grant. The study was also supported partially by Matching Fund between Thammasat University Research Fund and National Taipei University of Technology, Contract No. MF 3/2564. The author would like to thank the Phnom Penh Water Supply Authority, and the General Directorate of Environmental Protection (Ministry of Environment, Cambodia), for their assistance in field sample collection and laboratory facilities.

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