



Investigation of Microplastics Contamination in Domestic Wastewater

Kullatida Rajsiri* and Suchat Leungprasert

Department of Environmental Engineering, Faculty of Engineering,
Kasetsart University, Bangkok 10900, Thailand

*E-mail : kullatida.raj@ku.th

Abstract

This research aimed to study types and quantify of microplastics contaminated in domestic wastewater. For this study, two areas were studied including influent wastewater and effluent receiving canal. The first study area was the influent wastewater defined as grey water discharged from 3 residential types: dormitories, apartments, and condos. The second study area was the effluent receiving canal at the points located upstream, midstream, and downstream. Microplastics analysis was adapted from the method designated by National Oceanic and Atmospheric Administration (NOAA). The results show that the analyzed data were correlated in both (e.g., amount, color) and polymer type of microplastics. The amount of microplastics size of 300 μm was more than microplastics size of 500 μm . The amount of microplastics size of 300 μm and 500 μm were in the range of 0.43 ± 0.09 - 1.33 ± 0.36 items/L and 0.30 ± 0.05 - 1.07 ± 0.37 items/L, respectively. In addition, the amount of microplastics increased along with the distance of canal from the effluent discharge point. As the distance increases, the higher dispersion of microplastics was existed. The shapes of microplastics were found to be fiber types the most, followed by fragment types, film types, sheet types and sphere/pellet types. Transparent color was the most common color of microplastics, generated from the washing synthetic textile products. For the results of the polymer-type identification by Fourier Transform Infrared Spectroscopy (FTIR) analysis, Polyethylene (PE), Polypropylene (PP) and Polyethylene terephthalate (PET) were the polymer types found at the highest proportion in all samples.

Keywords : Microplastics; Domestic wastewater; FTIR

Introduction

Plastic is a material invented by humans and has been continuously developed with various techniques. Plastics are extensively used in our daily life (clothes, construction, agriculture, packaging) because they are lightweight, durable and cheap price [1, 2]. They are widely used whether in the household, community or industry that make plastics demand increase every year. According to the Thailand Pollution Situation Report in 2020 from the Pollution Control Department, it was found that plastic waste and residues into the sea were approximately 34,318-51,477 tons, which was about 26,800-40,200 tons more than in 2019.

Because of this, plastic waste is a problem and contaminants accumulated in the environment for a long time. Such the long time of accumulation in the environment, the large plastic items would decompose into the smaller fragments via different pathways such as photodegradation, biodegradation and weathering [3, 4], becoming as "Microplastics". Microplastics (MPs) are defined as synthetic polymers with dimensions less than 5 mm. [5, 6] In addition, microplastics could occur in another way, which were *created* by the manufacturer to be a certain *small* size for a particular purpose. The main source for the release of microplastics is domestic wastewater from human activities in daily life such as microbeads used as ingredients in cosmetics

and personal care products [7], and microfibers from washing of synthetic textiles [8]. When Microplastics entering the wastewater treatment system, which is mostly biological treatment process. The size of non-removable microplastics is 20-300 micrometers [9, 10]. It is difficult to remove by biological treatment system. Because of its small size, low density and light weight that makes release into natural water. Moreover, the characteristics of microplastics are not readily biodegradable and absorb Persistent organic pollutants (POPs) that act as vectors for the contamination of other environments. It affects to environment and human health [11-13].

Accordingly, this study aimed to investigate microplastic contamination in domestic wastewater generated from human activities in daily life. To understand the situation of microplastics contaminated in domestic wastewater and to recommend for preventing and reducing the impact of microplastics contaminated in domestic wastewater.

Material and Methods

Sampling site

To determine microplastics contaminated in domestic wastewater, It was divided into

two study areas. The sampling points are illustrated in Figure 1. The first study area was the grey water which is un-treated wastewater (e.g., washing, bathing), generated from the households, divided into 3 residential types: dormitories, apartments, and condos. The second study area was the nearby bang khen canal where received wastewater categorized as upstream, midstream, and downstream points. The length of the canal at the sampling point was 2,182.48 m. Surrounding the canal was close factories and people's residences.

Sample collection and preservation

The eleven sampling points were sampled (5 replicates per sampling point). Water samples were collected through a rotary pump 12V/DC 8A with a volume of 50L. The pump head is placed at a depth of 30 centimeters from the water surface during collection and pumped to filter the sample through a stacked arrangement of 5.6-mm (No. 3.5) and 0.3-mm (No. 50) stainless steel mesh sieves. Then, the residue on the strainer was transferred into a glass bottle. Each sample was stored at 4 °C in a refrigerator. The water samples collected during December 2021 to March 2022.

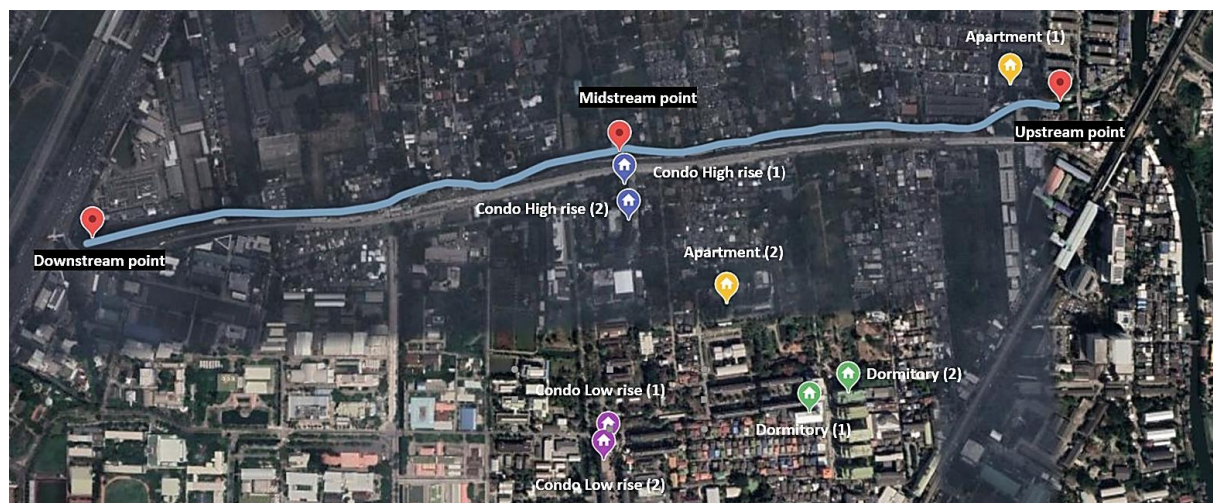


Figure 1 The sampling points of domestic wastewater and receiving to canal

Microplastics analysis

In this study, microplastic analysis was adapted from National Oceanic and Atmospheric Administration (NOAA) method [14]. After collection, Each sample was poured through a stacked arrangement of 5.6-mm (No. 3.5), 0.3-mm (No. 50) stainless steel mesh sieves and transferred all to the 400 mL beaker by distilled water. The sample beaker was dried in a 90 °C drying oven for 24 hours or longer to sample dryness. To digest the organic matter mixed into the sample, 30% Hydrogen peroxide (H_2O_2) 20 mL and 0.05 M Ferrous sulfate ($FeSO_4$) 20 mL were added to the beaker [15]. The mixtures were heated at 75 °C for 30 minutes. Then, 5M sodium chloride (NaCl) was added with the ratio of 6 grams per 20 mL of sample water into the sample beaker. The sample was transferred into the glass funnel and left overnight for settling. After that, the microplastics were floated on top of the surface and filtered through a 0.3 mm. stainless steel mesh sieve. The filtered samples were transferred to a Petri dish and dried at 90 °C for 24 hours.

Microplastics identification

All microplastic particles were examined under a stereomicroscope (Olympus, SZ61TR) at 40X magnification and identified the physical characteristics of microplastics (e.g.,

shapes, sizes and colors) and counted the amount of microplastics (Items/L) [16]. The composition of microplastic particles were identified by using Fourier transform-infrared spectrophotometry (FT-IR, Bruker Alpha II) attenuated total reflectance (ATR) technique, with 64 scans at a resolution of 8 cm^{-1} in wave range $4000\text{--}650\text{ cm}^{-1}$ [17]. It appeared as a transmission spectrum and was compared with standards of polymer spectra to define the composition of microplastic particles in a sample.

Results and Discussion

Amount of microplastics

The results of microplastic amount in domestic wastewater are shown in Table 1. The amount of microplastics were counted under a stereomicroscope (Olympus, SZ61TR) with three replicates per sample. Comparing the size and amount of microplastics found in the domestic wastewater among residential types, the amount of microplastics with size ranges $< 300\text{ }\mu\text{m}$ was more than microplastics with size range $> 500\text{ }\mu\text{m}$. For the canal water samples, at the point where the effluent discharged into the canal of such point called as upstream, midstream, and downstream points, respectively.

Table 1 Amount of microplastics found in domestic wastewater

Sample	Amount of microplastics found in domestic wastewater (items/L)		
	Size $< 300\text{ }\mu\text{m}$	Size $> 500\text{ }\mu\text{m}$	Total of mixed size
Domestic wastewaters from residential types			
dormitory (1)	0.43 ± 0.09	0.30 ± 0.05	0.37 ± 0.10
dormitory (2)	0.77 ± 0.12	0.69 ± 0.38	0.73 ± 0.27
Apartment (1)	1.33 ± 0.36	1.07 ± 0.37	0.92 ± 0.36
Apartment (2)	1.00 ± 0.22	0.71 ± 0.31	0.85 ± 0.29
Condo Low rise (1)	1.27 ± 0.46	1.01 ± 0.53	1.19 ± 0.49
Condo Low rise (2)	1.11 ± 0.34	0.69 ± 0.19	0.90 ± 0.29
Condo High rise (1)	1.08 ± 0.07	0.79 ± 0.04	1.48 ± 0.06
Condo High rise (2)	1.16 ± 0.16	0.94 ± 0.17	1.80 ± 0.19
Sampling points along the canal counted from the effluent discharge point to the canal			
Upstream point	0.55 ± 0.17	0.36 ± 0.21	0.46 ± 0.19
Midstream point	0.59 ± 0.27	0.39 ± 0.17	0.49 ± 0.24
Downstream point	0.73 ± 0.24	0.30 ± 0.06	0.52 ± 0.29

The result show that the amount of microplastics with size ranges $< 300 \mu\text{m}$ was found to be more than the amount of microplastics with size range $> 500 \mu\text{m}$. The result was in the same trend as the wastewater generated by the residential type. Consistently, the size ranges of $20\text{--}300 \mu\text{m}$ was the most size range of microplastics, followed by $300\text{--}1,000 \mu\text{m}$ and $1,000\text{--}5,000 \mu\text{m}$ [18].

Furthermore, microplastics with the size range of $20\text{--}300 \mu\text{m}$ entering to the wastewater treatment plant that could not be eliminated by the treatment process, then released into the natural water source [9, 10].

Shape of microplastics

Microplastics could be classified into six categories based on their shapes: fibers, fragments, films, sheets, granules/pellets, and foams [19]. All collected particles were visualized under a stereomicroscope (Olympus, SZ61TR).

Microplastic shapes found in domestic wastewater are shown in Figure 2. For all microplastic shapes from 3 residential types

including 8 sampling points, fiber was the most common shape type (74.9%) followed by fragment (16.84%), film (7.77%), sheet (0.99%) and granules/pellet (0.12%). For all microplastic shapes from the discharge points into the canal; fiber was the most common shape type (61%) fragment (29.98%), film (6.15%), sheet (0.97%) and granules/pellet (1.9%) in orders. The correlation for the shape of microplastics between the domestic wastewater from residential types and the discharge points into the canals were consistent. The most common types were fibers followed by fragments, films, and others. It also was consistent with the most prevalent types of microplastics observed in the water were fiber types and fiber types are the main source of primary microplastics [20, 21].

In addition, the result was similar to the fiber and fragments type the origin and pathway of microplastics could be inferred based on their shapes because certain shapes may be more prolifically shed from particular products [23–25].

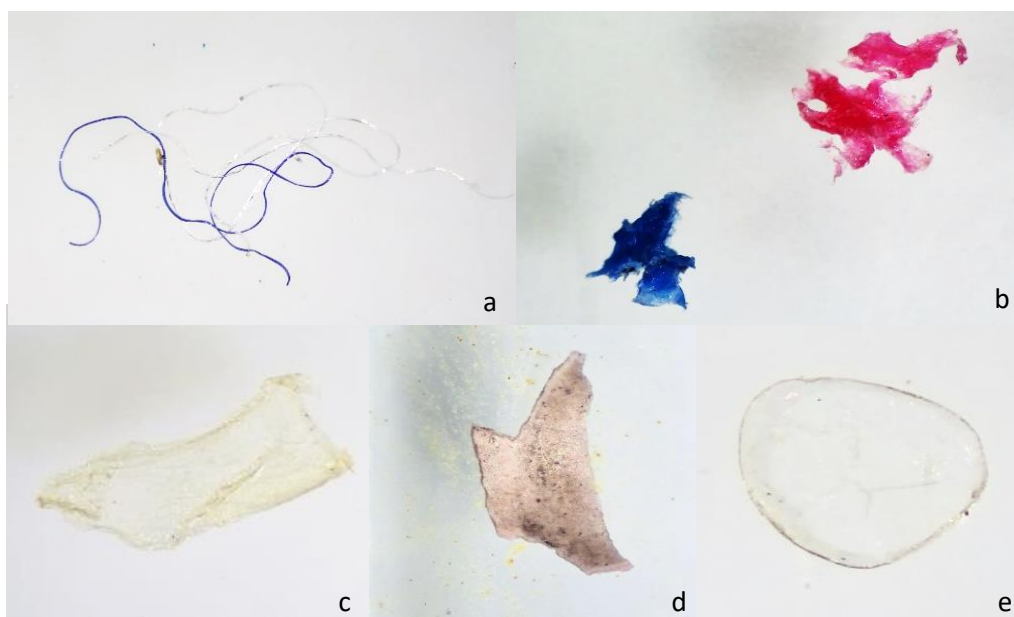


Figure 2 The shape of microplastics in the domestic wastewater: (a) Fibers, (b) Fragment, (c) Film, (d) Sheet and (e) Granule/Pellet

Fiber type originated from the synthetic fiber such as clothes and textiles could be shredded innumerable to the tiny fibers by washing in daily life [26]. Fragment type originated from packing plastic products via the physical or chemical process breaking down large plastic to small plastic pieces [27]. Film type originated from plastic wrapping [28]. In addition, this study did not find plastic microbeads generated by the personal care or cosmetic products. In consistent with the law to stop using plastic microbeads (manufacture, import, or sell) in Thailand, being effective since January 1, 2020. This law is under Thailand's Roadmap on plastic waste management 2018-2030 of the Pollution Control Department.

Color of microplastics

The color of microplastics are rarely used to identify potential sources because color can be changed due to digestion process [29]. Microplastics have been reported in a range colors, including; transparent, white, red, orange, yellow, purple, blue, grey, brown and green [30, 31]. Dark, white, and transparent particles may be underrepresented during visual inspection thus, all collected particles were visualized under a stereomicroscope (Olympus, SZ61TR).

For all microplastic colors from 3 residential types including 8 sampling points, transparent was the most common color (70.32%) followed by red (9.15%), blue (6.72%), yellow (4.44%), black (3.41%), white (3.19%), purple (2.26%) and green (1.72%), respectively. For the microplastic colors of the upstream, midstream and downstream water samples, transparent was the most common color (61%) followed by blue (9.93%), black (9.47%), white (5.69%), yellow (4.44%), red (3.75%), green (0.55%) and purple (0.54%), respectively. Correlatively, both domestic wastewater and nearby canal water (influenced by wastewater) presented the transparent as the most common color. The study results illustrated the transparent color as the most common found in domestic wastewater was alike as other research study presented the transparent color of microplastics in the oceans, where the problem was the end of microplastics pathway. In addition, color was

more likely to affect aquatic organisms such as fish because such transparent color is similar to their natural food items such as planktons [32].

Polymer types of microplastics

Fourier transform infrared Spectrophotometry (FT-IR, Bruker Alpha II) was used to identify type of polymer contained in the microplastic particles. It appeared in the form of a transmission spectrum (shown in Figure 3) and compared with the standard spectra of each polymer. For the results, Polyethylene (PE), Polypropylene (PP), and Polyethylene terephthalate (PET) were the polymer types found in the highest proportion contaminated in domestic wastewater from residential types and the canals where received the effluent.

Moreover, the type of polymers can predict their origins. For example; Polyethylene Terephthalate (PET) originated from packaging materials, produce polyester fiber, fabric, and cording for textiles. Polyethylene (PE) and Polypropylene (PP) originated from food packaging plastic packaging [33, 34]. These plastic polymers are widely used in daily life.

Conclusion

Microplastics were found in all domestic wastewater generated from households and the nearby canal where received the effluent from households. The experimental result of both study areas were consistent. The amount of microplastics with size range $< 300 \mu\text{m}$ was more than microplastics with size range $> 500 \mu\text{m}$. The shape of microplastics of samples were found for 5 types. Fiber was the most common shape type followed by fragments, films, sheets, and granules/pellets. Fibers originated from washing synthetic textile. Transparent was the most common color. For the results of the polymer-type identification by Fourier Transform Infrared Spectroscopy (FTIR) analysis, Polyethylene (PE), Polypropylene (PP) and Polyethylene terephthalate (PET) were the polymer types found in the highest proportion of all samples. These plastic polymers were widely used in daily life.

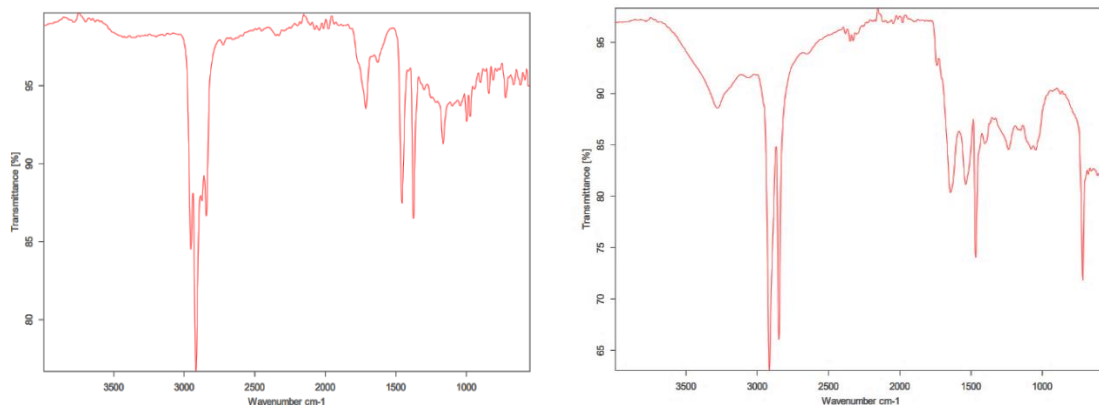


Figure 3 Examples IR spectra of microplastic particles found in domestic wastewater samples, which were identified by FTIR spectroscope

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