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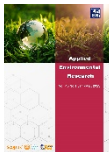

Research Article

Assessment of Microplastics in the Surface Water of Sitio Pulo, Navotas, Metro Manila

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Abstract

Microplastics are synthetic polymer particles with a length of 5 mm or less with no well-defined lower boundary. These debris particles are known to affect marine and aquatic organisms which poses a threat to biodiversity and marine resources. In this study, the isolated microplastic from the coastal and lagoon surface waters of Sitio Pulo is described. Sitio Pulo is a barrier island mangrove sanctuary located at Brgy. Tanza I, Navotas City surrounded by Manila Bay. The samples collected last July 4 and 25, 2019, were isolated, profiled, and analyzed. A total of four hundred forty-nine (449) microplastic fragments were isolated from the surface water samples with a median length of 1.096 (IQR 0.809–1.578) mm. The isolated microplastics exhibit roundness, whiteness, and yellowing indicating signs of mechanical, chemical and photodegradation. It is also noted the putative effects of the weather disturbances in accelerating the discharge of nascent microplastics in Manila Bay. The isolated microplastic composition includes the commodity polymers polyethylene (PE) and polypropylene (PP). The presence of microplastics in the surface waters of Sitio Pulo reflects the worsening plastic pollution problem in Metro Manila.

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Introduction

Plastic pollution has been considered one of the most challenging global problems. Despite the efforts of the global population to mitigate anthropological litter, a newly emerged threat closely related to plastic pollution was identified —microplastics [1]. Microplastics were synthetic polymer particles commonly found in the water column, surface waters, coastal waters, estuaries, rivers, beaches, and deep-sea sediments [2] and were classified with the aid of a microscope [3]. The length of microplastics had several definitions, such as smaller than 5.00 mm with no well-defined lower boundary size [4] and a size range of 1 nm to 5 mm [3]. Furthermore, there were two types of microplastics primary and secondary microplastics. Primary micro-plastics were plastic particles characterized by their primordial size, including scrubbers, plastic powder, microbeads, plastic nanoparticles, and spherical or cylindrical resin pellets [3]. Meanwhile, secondary microplastics were a product of mechanical photo-oxidation and/or biological degradation including textiles, paint, and tires [3–4]. The formation of secondary microplastics was caused by physical abrasion and chemical degradation. Large plastic debris throughout the world's oceans was shifted by the prevailing wind and surface currents [5]; hence, embrittlement and fragmentation of plastic debris succeeded due to the wave action and sand grinding [1]. Meanwhile, the chemical degradation of large plastic debris was a sequential event of several chemical changes that promoted mechanical disintegration and a drastic reduction of the average molecular weight of

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the material [1]. Chemical degradation was classified based on its prior causes, such as biodegradation, photodegradation, thermo-oxidative degradation, thermal degradation, and hydrolysis [6]. One of the most dominant causes of plastic chemical degradation was UV radiation, which induces synthetic polymers' photodegradation through free radical-mediated oxidation [3]. Microplastic formations are reported to be successful through controlled UV exposure and mechanical abrasion [7].

Other than the 5.25 trillion particles floating in the ocean [1], humanity produced 288 million tons of additional plastic in 2012 [5]. Moreover, it was estimated that 60–80% of the worldwide litter was plastic, and around 10% of its annual production was compiled in the ocean [1]. It was calculated that 4.8 to 12.7 million metric tons of plastic litter infiltrated the ocean in 2010 [8]. Studies show that 80% of marine plastics were determined to come mainly from land-based sources, while the other 20% was attributed to the aquaculture and fishing industries [1, 7, 9]. The continuous entry of plastic debris into the ocean and its long exposure to the environment imposed a threat since the formation of microplastics could be triggered. Several studies report the presence of microplastics in the environment. For instance, microplastics were observed on the surface water of the Gulf of Lion, which was located northwest of the Mediterranean Sea [10]. Microplastics in the environment could impose risks on the inhabiting species. One of the most common interactions of microplastics with an organism was ingestion [1]. Multiple studies suggested an occurrence of microplastics in various marine species such as Japanese anchovies [11], sea bass, sea bream, and commercial flounder [12]. There were several negative consequences of ingesting microplastics, such as loss of nutritional value on the diet, physical damage, exposure to potent pathogens, and transport of alien species on the entire organism's system [1]. Other than being a pollutant, the occurrence of microplastics was indeed a threat to the entire ecosystem. Moreover, it could also impose a risk to human health as it was reported that microplastics were isolated from drinking water [13].

In the year 2010, the Philippines, a coastal country, ranked 3rd with the most mismanaged plastic waste, producing 1.88 million metric tons per year and contributing around 0.28–0.75 million metric tons of plastic marine debris per year [8]. One of the contributors is the Pasig River with its 3.21 x 104 tons of plastics delivered to the marine environment annually [14]. Furthermore, it was reported that 4,319,981 anthropogenic litter were collected from land, underwater, and watercraft cleanups last 2017, wherein mostly were plastic debris [15] which indicated that the Philippines was no exception from the presence of microplastics. The occurrence of micro-plastics from Majalar Bay [16], Molawin watershed in Laguna [17], Laguna de Bay [18], and from the surface water of five rivers connecting to Manila Bay namely: Cacas River; Meycauayan River; Paracaque River; Pasig River; and Tullahan River [19–20] was recently determined. Microplastics were also isolated in the acid-digested mussel soft tissue of Asian green mussels cultured in Bacoor Bay [9], in detritus-feeding mullets, and herbivorous rabbit fish in Eastern Visayas [21–22]. Hence, profiling microplastic occurrences in the Philippines was valuable to look at.

Sitio Pulo was an island mangrove sanctuary situated at Brgy. Tanza I, Navotas City surrounded by Manila Bay. It was also known as Brgy. Tanza Marine Tree Park with an area of 29.47 hectares [23]. The island hosts around 20 plant species, 3 species of crabs, 14 species of shellfish, and 11 bird species, and is a hub for migratory birds such as egrets, terns, kingfishers, gulls, and plovers [24]. Furthermore, a 58% increase in waterbird sightings was recorded in 2017, which indicates regrowing biodiversity of Sitio Pulo [25].

As the information was consolidated and analyzed, this study aimed to determine the occurrence of microplastics in the Navotas-Manila Bay area, profile its characteristics, and classify its chemical composition.

Methodology

1) Sampling site map

Four (4) sites were chosen within the vicinity of Sitio Pulo, Navotas City (Figure 1). Two (2) sites were facing Manila Bay (Site A: 14°40'39.1"N, 120°55'43.0"E; and Site B: 14°40'42.4"N, 120°55'40.1"E) to collect coastal water. Two (2) more sites facing the Metro Manila mainland (Site C: 14°40'42.9"N, 120°55'40.9"E; and Site D: 14°40'39.8"N, 120°55'44.1"E) to collect the lagoon water. Both sites B and C are in the northernmost part of the island while sites A and D are in the southern-most area of the island.

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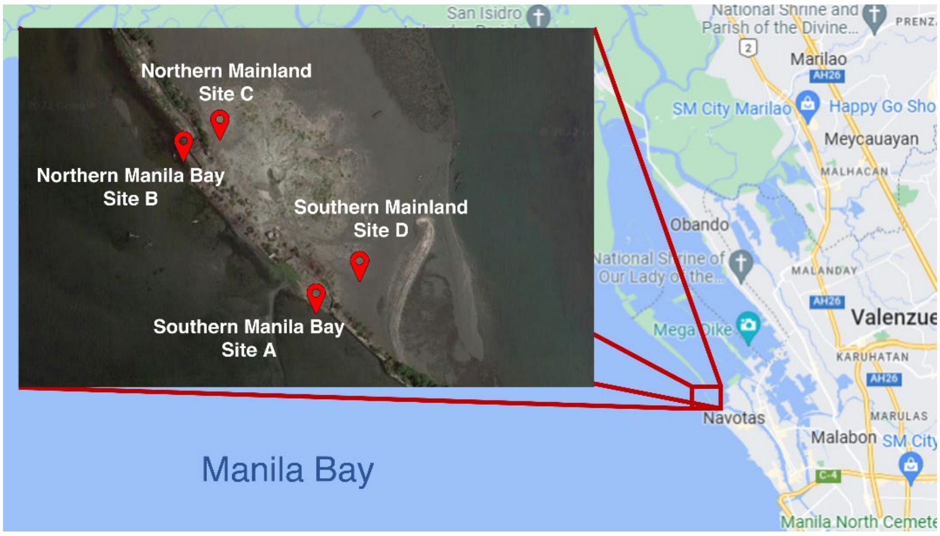

Figure 1 Google map image of sampling site map in Sitio Pulo-Manila Bay.

2) Surface water sample collection

The collection was done on July 4 and July 25, 2019. During each sampling visit, 1000 liters of surface water were gathered per site manually using 20-liter tared buckets. This method was used by Lin et al. [26] in convenience to sample large amounts of water without bringing it all to the laboratory. The water collected was filtered immediately and the solid fragments are collected. A total of 8000 liters of surface water was collected. The sample volume representing the site is similar to the study conducted by Klein et al. [27].

3) Microplastic isolation

The collected water was passed through a two-layer sieve with 4.75- and 0.355-mm mesh. Large debris trapped in the 4.75 mm mesh layer was discarded. The debris trapped in the 0.355 mm sieve was suspended in filtered water for transport back to the laboratory. The collected debris was transferred in a 250-mL beaker containing 2 M NaOH and heated to approximately 100°C until visible bioorganic materials disappeared. The length time of digestion was conducted until visible natural organic materials were completely digested.

4) Density separation

The remaining material (mostly plastics) were cleaned thoroughly and subjected to density separation. The process of determining the density of the microplastics was a modified method of Hidalgo-Ruiz et al. [28]. Instead of using different salt solutions, the plastic materials were allowed to separate by buoyancy using liquids of decreasing densities starting with 5 M NaCl solution (1.19 g cm^{-3}), water (1.00 g cm^{-3}), corn oil (0.92 g cm^{-3}), and 70% isopropyl alcohol (0.84 g cm^{-3}). A drop of dishwashing liquid detergent was added to the liquid to eliminate the surface tension of the liquid to the microplastics. The microplastics were allowed to separate in each liquid for a day. Sinking microplastics were gathered, rinsed in distilled water, and dried before the next separating liquid. After the separation, the micro-plastics were categorized into 5 density groups namely: Group I (1.01–1.19 g cm^{-3}), Group II (0.93–1.00 g cm^{-3}), Group III (0.92 g cm^{-3}), Group IV (0.85–0.91 g cm^{-3}), and Group V (0.84 g cm^{-3}).

5) Microscope and image analysis

The isolated microplastics were examined visually and with the aid of a dissecting microscope (40x total magnification). Photographs of each microplastic were taken for image analysis. The length, aspect ratio, and circularity of each microplastic fragment were measured from the photographs using the Image J software version 1.52a [29]. The roundness score was estimated using the formula of Takashimizu & Iiyoshi which is based on the aspect ratio and circularity measurements [30]. A roundness score of 1 represents a perfect circle while a score of zero (0) represents a more angular shape. The color values of each microplastic fragment were expressed using the CIELAB color coordinate system. The values of each microplastic luminosity (L*), red-green (a*), and blue-yellow (b*) coordinate were measured by pixel using the "*colordistance*" package in R v.3.6.0 [31–32].

6) Attenuated Total Reflectance- Fourier Transform Infrared (ATR-FTIR) Spectroscopy

Fifty (50) selected microplastic fragments were analyzed using the Attenuated Total Reflectance-Fourier-Transform Infrared (ATR- FTIR) Spectroscopy using the Bruker Alpha 1 ATR-FTIR. The spectra obtained were matched to known plastic polymer spectra in the library database of KnowItAll software from Wiley (formerly from BioRad).

7) Data analysis

All the measurements of the microplastics including the length, roundness score, and color coordinates L*, a*, and b* deviates from the normal distribution based on the Shapiro-Wilk test (significant at $p < 0.001$) were done using R v.3.6.0. The dependence of the microplastic variables on the location and sampling visits was tested using the non-parametric Kruskal-Wallis rank-sum test. Pairwise comparison within the group was done using the Wilcoxon rank-sum test. The significance level was set at 0.05 for the non-parametric tests.

Results

A total of 449 microplastic fragments were collected from all sampling sites in Sitio Pulo, Navotas (Figure 2) of which 333 were isolated on July 4, 2019, and 116 on July 25, 2019. Two typhoons have been recorded in between the sampling visits these are tropical storm falcon (Danas) and tropical depression goring, which entered the Philippine Area of Responsibility (PAR) on July 15 and 19 respectively [33–34]. These weather disturbances may have hastened the discharge of microplastics from its river sources in the mainland to Manila Bay. The river hydrodynamics affects the distribution of microplastics in coastal areas, wherein a high river flow from heavy precipitation favors microplastic runoff [35–36]. In addition to precipitation, wind and currents affect the retention of microplastics on the coastline [36].

1) Length of the microplastics

The median length of the microplastics isolated from Sitio Pulo was 1,096 (IQR 808–1,578) μm. The microplastics in site D (lagoon at the southern end of the island) has the largest microplastics with a median length of 1,485 (IQR 804–2,564) μm. The microplastics in this site were significantly larger ($p < 0.05$) than in all other sites visited. The lagoon in site D is also the catch basin of the Batasan and Tangos Rivers which form a flood-tidal delta. As a catch basin, the newly formed microplastics remain in the lagoon for some time before being discharged to Manila Bay. Mechanical weathering such as sand grinding and the water currents induce the formation of secondary microplastics. However, mechanical weathering alone is insufficient to cause extensive fracturing of plastic materials to form particles up to 25–650 μm [7, 37]. The combined effects of mechanical, photodegradation, and chemical degradation lead to the decomposition of plastic polymers and the fragmentation of plastic material [38]. The length of the isolated microplastics does not appear to significantly change between sampling visits.

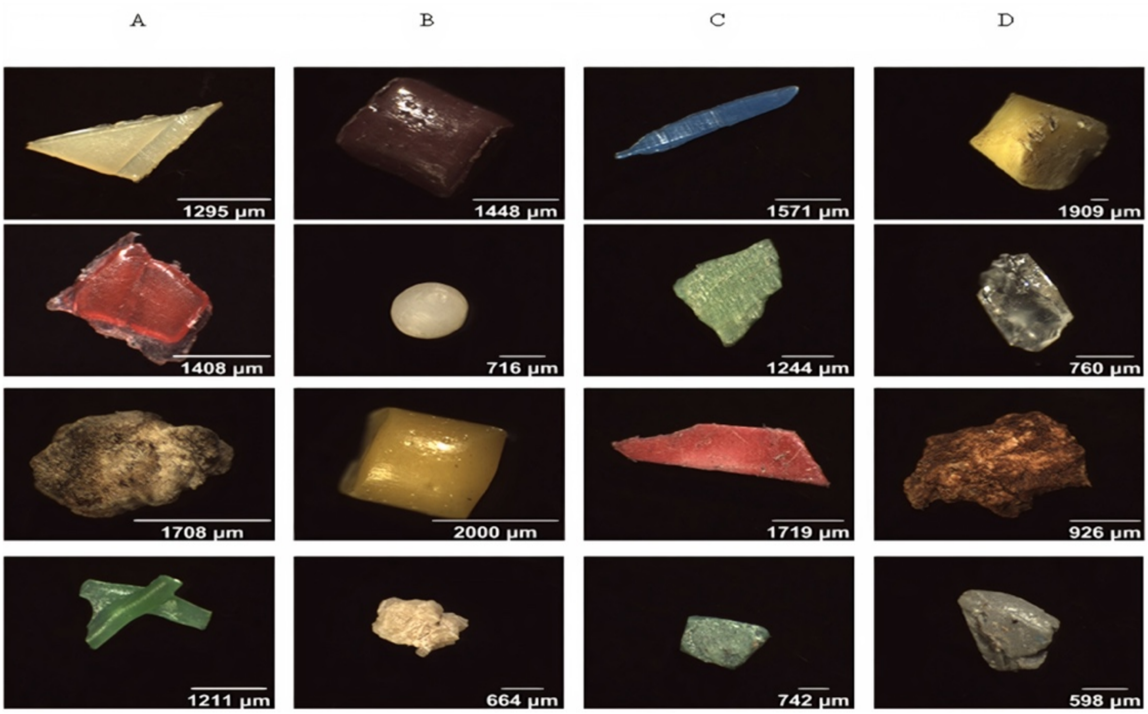

Figure 2 Photographs of selected microplastics from the surface water collected in Sitio Pulo per sampling point.

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2) Roundness of the microplastics

The shape of the microplastic fragments provides information on the origin and the type of the plastic polymer [36]. The median roundness of the isolated microplastics on both surface water was 0.603 (IQR 0.475–0.697) suggesting a slight rounding of the fragments. The roundness of the microplastic differs significantly in all sites (Table 1), it can be assumed that the differences are attributed to the current of water. Plastic debris in bodies of water is susceptible to mechanical degradation due to its collision with rocks and other hard surfaces [39]. A study by Kowalski et al, 2016, demonstrated the rounding of plastic materials after applying continuous mechanical stress [40]. The roundness of the isolated microplastics does not appear to significantly change between sampling visits.

3) CIELAB color

The color coordinates obtained from the images of the microplastics may indicate signs of photodegradation and photo-oxidation of the plastic polymers and pigments. The CIELAB color system is used in this study. This system has three coordinates: 1.) L* indicates the luminosity of the image and ranges from 0 (black) to 100 (white); 2.) a* is a scaled amount of green and red color which has a value from -128 (green) to 128 (red) and 3.) b* which represents the amount of blue and yellow colors which ranges from -128 (blue) to 128 (yellow) [41].

The microplastics in Sitio Pulo show lightness in their color with a median L* value of 70.65 (IQR 56.76– 76.60). The L* values of the microplastics were significantly different within the sites (see Table 1). Lighter microplastics were found in the surface water of the lagoon. The high L* values could be an indication of the whitening of the plastic material because of the plastic material's prolonged exposure to sunlight and air which causes photo-oxidation and photobleaching. Photo-oxidation occurs when plastic polymers were exposed to sunlight and air wherein the free-radical hydrocarbon polymers undergo oxidation. Photobleaching was a reaction wherein plastic debris was exposed in longer wavelengths (~310 nm) preceding the destruction of colored coatings and polymer bonds [42]. However, the whitening of microplastics can also be caused by the leakage of chalk and other stabilizers added to the plastic material [43].

The microplastics isolated from the first visit (July 4) appeared to be whiter having a median L* value of 73.48 (IQR 56.82–77.03). This is significantly higher ($p = 0.04$) than the microplastics isolated from the second visit (July 25) which has a median L* of 66.11 (56.27–74.91). The two weather disturbances noted in the Philippines before the second visit may have discharged new and less faded microplastics into Manila Bay and the lagoon water of Sitio Pulo.

Table 1 Profile of the isolated microplastic in different sites in Sitio Pulo, Navotas, Philippines

Description	Site A	Site B	Site C	Site D	Kruskal-Wallis's rank sum test	
	Coast	Coast	Lagoon	Lagoon		
	South Side	North Side	North Side	South Side		
Microplastics/1000 L	192	78	75	104	-	-
Length (µm)	1,055 IQR: (800–1,441)	1,103 IQR: (894–1,555)	1,078 IQR: (811–1,396)	1,485 IQR: (804–2,564)	14.505	0.002
Roundness	0.612 IQR: (0.480–0.718)	0.536 IQR: (0.45–0.65)	0.651 IQR: (0.534–0.724)	0.586 IQR: (0.458–0.662)	12.269	0.007
CIELAB L*	61.37 IQR: (38.69–66.85)	56.32 IQR: (39.37–62.98)	76.08 IQR: (74.47–77.65)	76.58 IQR: (75.42–77.62)	192.35	0.000
CIELAB b*	24.26 IQR: (12.13–30.58)	20.39 IQR: (5.32–26.15)	23.46 IQR: (23.05–23.90)	23.58 IQR: (23.19–24.02)	10.634	0.014

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The median b* values of the microplastics isolated from Sitio Pulo were 23.50 (IQR 20.11–25.25) leaning towards the yellow hue. The b* values were different for each site (Table 1). Site B had a significantly lower b* value compared to the other sites suggesting less yellowing of the isolated microplastics. The accumulation of oxidized products in the plastic material produces yellow and amber colors [44]. The photo-Fries reaction is one of the mechanisms involved in the yellowing of plastic polymers. This reaction produces a breakage of polymer linkages and free radicals induced by short UV radiation (~240 nm) in the absence of oxygen [45]. Photo-oxidation also contributes to the yellow or amber colors of the plastic material [44].

The effects of mechanical stress and photodegradation of the plastic material contribute to the variation of the microplastics isolated within the sites on the barrier island of Sitio Pulo. The water between the Metro Manila mainland and Sitio Pulo has weaker tidal currents. Weaker currents result in the retention of plastic waste in water and longer exposure to UV which causes the aging of plastics. This aging can be observed with the increasing lightness (L*) and yellowing (+b*) of the isolated microplastic images. The high currents on the opposite side (facing Manila Bay), can have fewer microplastics with smaller lengths and rounder shapes. The red-green color coordinate (a*) seems unchanged regardless of site and sampling visits. This overall supports the evident degradation of microplastics collected in Site C.

4) Categorization of microplastics through shape

The collected microplastics are categorized by their shape. These particles are divided into fiber, fragment, film, foam, and pellet, as suggested by Kumar et al. [46]. Out of 449 collected samples, Microplastic fragments showed dominance in density, covering 56.8% of the samples (255 particles). This is then followed by foams (113 particles), pellets (64 particles), films (9 particles), and fibers (8 particles). Figure 3 shows the percent frequency of the shape of microplastics per sampling point and the collection date.

The presence of fragments and foams is detected throughout all of the sampling points and dates. Mechanical and chemical degradation are the common causes of fragment formation. Possible sources of fragments are commonly manufactured plastic products such as containers, packaging materials, and cleaning media [47–48]. The abundance of these plastics can be caused by irresponsible waste disposal, which is a large problem in the Philippines, especially in highly populated areas. On the other hand, foams also show accumulation in all sampling sites. Foams are polymers with trapped air inside, commonly used for insulation and energy absorption. These are commonly used as food and product containers and as floats and rafts in fishing. According to the study of Osorio et al. [20]. Foams are abundant in Mecauayan, and Tullahan Rivers compared to other main rivers connected in Manila Bay from October 2018 to March 2019. These two rivers are located in the northern and southern areas of Sitio Pulo, respectively. Aside from Batasan and Tangos River, Mecauayan and Tullahan Rivers can also help detect the sources of microplastics that accumulates in Sitio Pulo.

The difference in the collection site and the collection date also affects the distribution of the collected sample. Fibers are only collected on sites A, B, and C. Collected fibers come from fishing nets and synthetic ropes. The sampling points facing Manila Bay (Point A and B) are more exposed to fishing activities, while Point C and D are more exposed to day-to-day human activities. In addition, Point D is part of the Tangos River Mouth, and the water flow is directed from the Navotas Residences and Navotas River to Manila Bay. Any particles from Manila Bay will experience difficulty in entering the sampling point. On the second visit, no fibers are collected for all sampling points. Fibers in small sizes can be easily swept away by the strong current of water, possibly happening during the two tropical storms that hit Metro Manila. Aside from the undetected fibers during the second visit, the accumulation of foams in site C during the second visit is observed. However, the number of collected particles in site C is few (7 particles).

The foams possibly come from both residential areas and Manila Bay, trapped during the storm. Foams are highly buoyant materials due to the air inserted during manufacturing. Thus, the transport of foam particles by wind and water currents can be achieved due to their structure.

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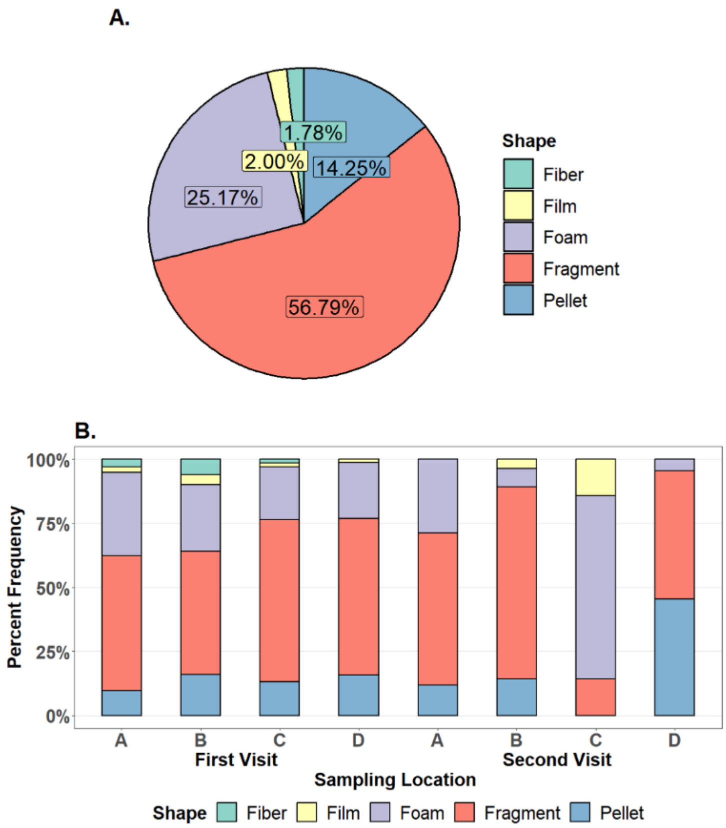

Figure 3 Distribution of microplastics' shape for (a) overall collected particles, and (b) based on the sampling point and date of collection.

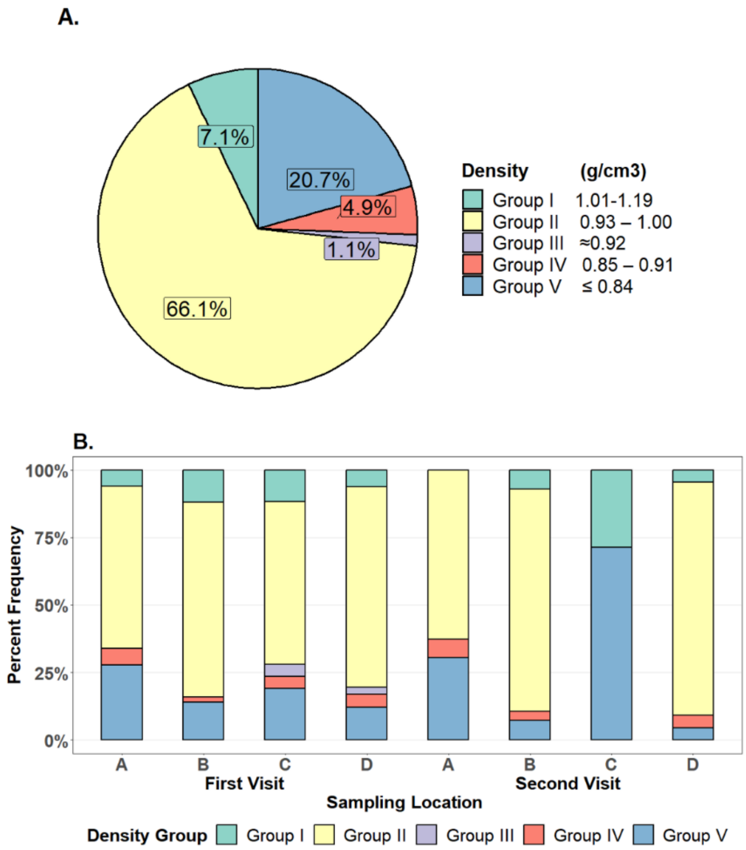

Figure 4 Distribution of microplastics' density for (a) overall collected particles, and (b) based on the sampling point and date of collection.

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Microplastic films are thin sheets of a polymer commonly used as packaging materials, bags, and low-density plastics [49]. Even though Sitio Pulo is located near a residential area, the number of films collected is few. The distribution of plastic films can be due to their physical form. Because of their thickness and lightness, plastic films such as polyethylene bags are buoyant. However, they are susceptible to biofilm formation [50], particle adsorption [51], and photo-oxidation [6] which decreases their buoyancy and later sink and mix with sediments. The sinking of Polyethylene bags to the seafloor is also affected by wind-induced downwelling [52]. From the study of Lobelle and Cunliffe [53], polyethylene bags also starts sinking after three weeks of floating in seawater [52]. This transport makes films mix with sediments before breaking them into smaller pieces. Even though it was exposed to marine sedimentary conditions for 100 days, polyethylene plastic bags show no biodegradation [54]. Thus, film microplastics can be more detectable in sediment samples than surface water. This observation supports Osorio et al. [20] study, as they found that plastic films are uncommon to surface water but more present in their sediments, especially in Mecauayan and Tullahan Rivers.

Alarmingly, microplastic pellets are collected at all sites. Pellets are primary microplastics used as raw materials to form manufactured plastic products [28]. Many plastic manufacturers are located along Navotas and its nearby cities and municipalities. These factories are actively creating plastic products and could be the source of mishandled plastic pellets that leaks into waterways to Manila Bay.

5) Categorization of microplastics through density and FTIR analysis

Density and FTIR analysis are used to determine the type of polymer present in Sitio Pulo. Based on Figure 4, most of the microplastics isolated from Sitio Pulo are less dense than water. Plastic polymers that have densities greater than 1.00 g cm^{-3} include polyethylene terephthalate (PET), polystyrene (PS), polyvinyl chloride (PVC), acrylonitrile-butadiene-styrene (ABS), polyurethane (PU), etc. Most of these polymers are considered commodity polymers based on their ubiquity in everyday products (i.e. packaging, agriculture, home products, etc.) [55–57]. Contrastingly, plastic polymers have densities lower than 1.00 g cm^{-3} including polypropylene (PP), low-density polyethylene (LDPE), high-density polyethylene (HDPE), and are also considered commodity plastics [45, 55–56].

The high number of microplastics shows densities in the range of 0.93–1.00 g cm^{-3} (297 particles). The unequal distribution of densities suggests that a large percentage of microplastics is possibly made of PE, PP, and its derivatives. Several microplastics (5 particles) have the same density as corn oil (0.92 g cm^{-3}). These particles are both found on the mainland on the first visit. In addition, the categorization of microplastics thru density separation yields less dense particles even though their polymer composition has high density. These particles are determined by their shape as foams which are commonly composed of PS and PU. Even though PS and PU have a higher density relative to water, they were usually manufactured in their expanded structure for food packaging, upholstery, and insulation. The expanded structure of PS and PU contains a lot of air pockets which makes them buoyant. The effect of buoyancy is less evident on degraded foam microplastics compared to newly produced foam microplastics. Thus, most foam particles tend to be part of the group with lower density in this setup.

The attenuated total reflectance – Fourier transform infrared (ATR-FTIR) spectroscopy revealed the polymers of selected microplastics from Sitio Pulo. From the 50 selected particles, the polymers and their copolymers matched were: polyethylene (PE), polypropylene (PP), polyurethane (PU), polystyrene (PS), and their copolymers. The most common polymer detected was Polyethylene (23 particles) which consists of high-density polyethylene (HDPE), low-density polyethylene (LDPE), and polyethylene copolymers. This was followed by polypropylene (12 particles), and polyisoprene (5 particles). Sites A, B, and C detect PE as the main contributor among the sampled particles while more particles are detected as PP in site D.

Multiple copolymers of styrene are detected such as styrene-butadiene-isoprene copolymer and Poly (Styrene-Allyl Alcohol). styrene-butadiene-isoprene copolymer is an elastomer commonly used in rubber tires, while poly(styrene-allyl alcohol) is used as surface coating and paint products [48, 58–59]. The detection of poly(styrene-allyl alcohol) in the particle can mean that the surface of the microplastic is covered in another type of polymer.

The overall collected microplastics show abundance in the low-density group compared to higher density group. These results together with the FTIR analysis deduce that common microplastics collected are composed of PE and PP polymers which are commonly used in packaging. The global use of plastics in 2015 is mainly for packaging, which accounts for 42% of the total production of non-fiber plastics [60]. Plastic packaging waste that is found in the Philippines includes PET and HDPE Bottles, LDPE bags, PP food containers, and sachets [61]. These polymers' day-to-day use in addition to mismanaged waste disposal yields the abundance of their fragments in waters. On the other hand, PET is widely used as a beverage container, but the fragments collected are low compared to polyethylene. This may be due to recycling activities as PET bottles are collected by waste pickers they can be sold in junk shops and recycling facilities [20]. Compared to other plastics, PET bottles are easier to identify as valuable plastic waste compared to other plastic products. In addition, PET bottles are the most profitable plastics which can amount from PhP 12.00 to PhP 16.00 when sold in junk shops [62].

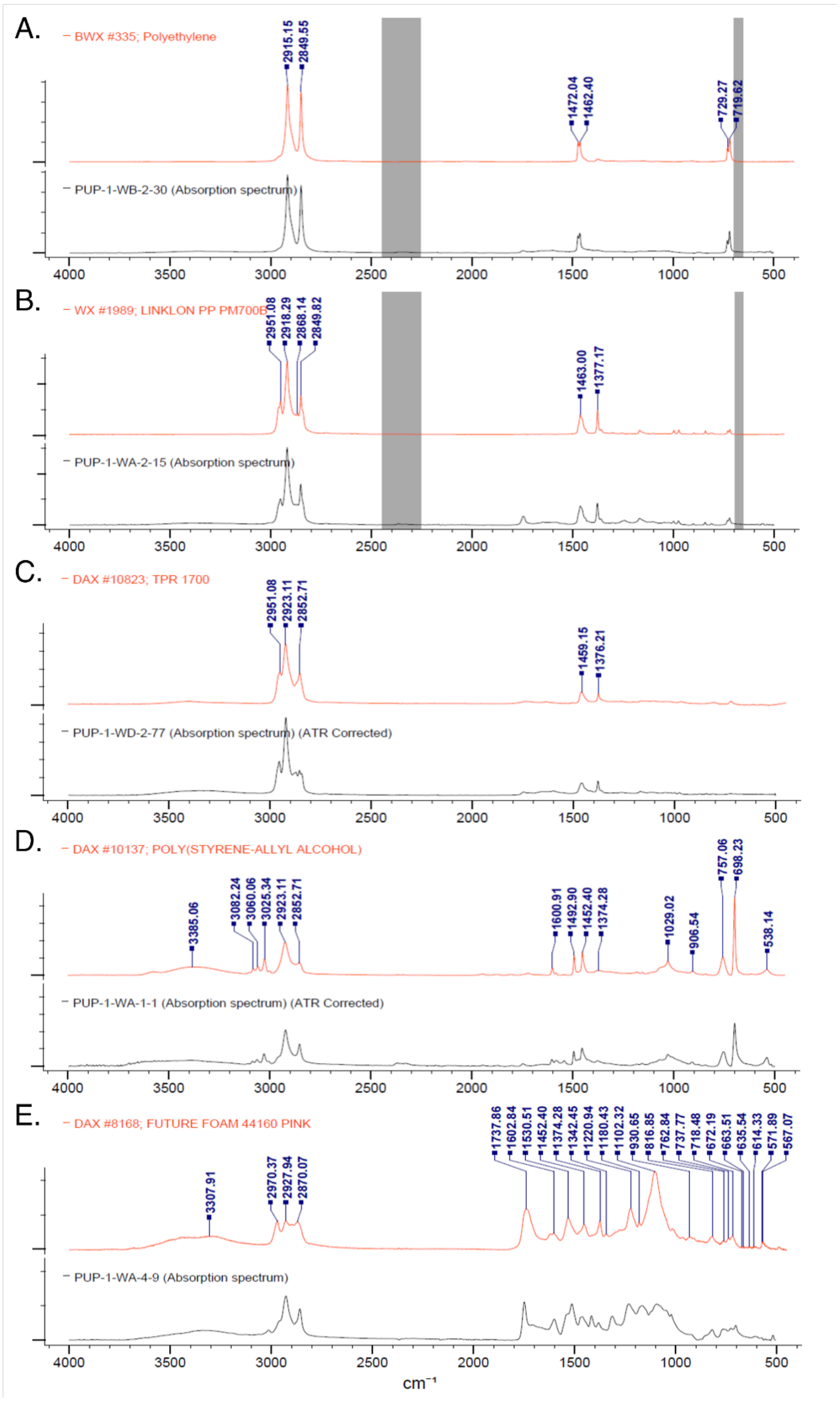

Figure 4 The ATR-FTIR spectra of Sitio Pulo microplastics. The spectra of the microplastics were matched with A) polyethylene B) polypropylene, C) polyisoprene, D) poly(styrene-allyl alcohol), and E) polyurethane.

Conclusion

Microplastics are found in the surface water of the barrier island, Sitio Pulo, Navotas City, Philippines. The measured properties of the microplastics such as length, roundness, luminosity (L*), and red-yellow color value (b*) were affected by the sampling site. Due to the weak current of the water at the lagoon (mainland side of the island) making its microplastics can be isolated in those areas larger and more angular. The stillness of the lagoon enables the water plastic to be exposed to sunlight for longer periods causing photodegradation resulting in the whitening and yellowing of the microplastics. The sampling visits appeared to affect the whiteness or luminosity (L*) of the microplastics. This decrease in the L* of the second visit is caused by the accelerated discharge of the microplastics to Manila Bay releasing unfaded and nascent microplastic fragments. Density separation and ATR-FTIR spectroscopy revealed Sitio Pulo, Navotas, Philippines microplastics composed of commodity plastic such as polyethylene, polypropylene, and polyethylene terephthalate, etc. indicating the worsening plastic pollution problem in Manila.

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