Comparison of microplastic abundance in aquaculture ponds of milkfish Chanos chanos (Forsskål, 1775) at Muara Kamal and Marunda, Jakarta Bay

V Priscilla* and M P Patria
Department of Biology, Faculty of Mathematics and Natural Science, University of Indonesia, Depok, Indonesia

*E-mail: vincentia.priscilla@ui.ac.id

Abstract. Jakarta contributes to 12% of the plastic pollution in Indonesian waters. Most of the plastic trash is mismanaged and ends up accumulating in river mouths located along Jakarta Bay. This research analyzed the abundance and types of microplastic in milkfish Chanos chanos, surface water, and sediment of milkfish aquaculture ponds in Muara Kamal and Marunda, Jakarta Bay. Samples of each subject were obtained from each location. Digestive tracts extracted from milkfish were destructed with strong nitric acid. Water samples were filtered while sediment samples were dried. Concentrated NaCl solution was used to achieve microplastic flotation. Counting of particles was done under a light microscope. Overall results from Muara Kamal showed the microplastic abundance was 9.58±3.3 particles g⁻¹ in milkfish digestive tracts, 103.8±20.7 particles L⁻¹ in water, and 111,680±13,204 particles kg⁻¹ in sediments. Microplastic abundance was found lower in samples from Marunda with 8.80±2.7 particles g⁻¹ in milkfish digestive tracts, 90.7±17.4 particles L⁻¹ in water, and 82,480±11,226 particles kg⁻¹ in sediments. These results were consistent with the water pollution levels obtained by the Living Environment Agency DKI Jakarta that states heavier pollution by Pollution Index in Muara Kamal drain than in Marunda drain.

Keywords: Chanos chanos, Jakarta Bay, microplastic, milkfish

1. Introduction

Plastic makes up 60 to 80% of the world’s trash that is released into waterbodies, reaching the open ocean (Avio et al 2016). Indonesia ranks as the second-largest contributor of plastic pollution in the world and 12% of that plastic originates from the capital megacity of Jakarta (World Bank Group 2018). Most of the plastic trash is mismanaged and ends up in the waterways, entering the 13 major rivers of Jakarta, bringing them to accumulate in the river mouths of the city located along Jakarta Bay (Trisyanti 2004, Sachoemar and Wahijono 2007). The semi-closed shape of Jakarta Bay aided by the transition from freshwater to saltwater allows for long-term accumulation of plastic trash (Sachoemar and Wahijono 2007). Some of the less dense plastic on the surface of the water gets carried by currents to the open ocean while denser pieces either remain suspended in the water column of the river mouths or sink to the bottom sediment (Zhang 2017, Atwood et al 2019). As plastics undergo transport from land to rivers and on to the ocean, it is exposed to various elements such as UV radiation, strong currents, as...
well as animal bites, causing the plastic to break apart into smaller pieces eventually forming what is known as microplastics (Avio et al, 2016, Atwood et al 2019).

The term ‘microplastic’ refers to any synthetic polymer with a size of below 5 mm (GESAMP 2015). Based on origin, microplastics may further be divided into two groups, primary microplastics, and secondary microplastics (Masura et al 2015). Primary microplastics are plastics that are originally produced with a size of below 5 mm, while secondary microplastics are formed from larger pieces of plastics that undergo degradation over time through processes mentioned above (GESAMP 2015, Masura et al 2015). These microplastics vary in color, size, and shape (Wright et al 2013). Among the most common shapes include fiber, film, fragment, and granule (Rocha-Santos and Duarte 2017). Different sizes and shapes result in varying densities of plastic particles (Wright et al 2013). Less dense particles tend to float on the surface of the water, while denser particles may be suspended along the water column and much denser particles sink to the bottom (Wright et al 2013). Over time, lighter particles may also increase in density as assortments of chemical substances and microorganisms adhere to the surface of microplastics (Avio et al 2016). Microplastics have a high affinity towards these substances and microorganisms due to its high surface to volume ratio, and hydrophilic character (Carbery et al 2018). The increase in density eventually causes particles to sink to the sediment (Avio et al 2016).

The small size of microplastics allow it to be bioavailable for ingestion by aquatic biota. Bioavailability increases as microplastic size decreases (Carbery et al 2018). Existence of particles throughout all levels of the water column further increases their bioavailability to every kind of aquatic biota, from filter feeders to deposit feeders, from small primary consumers such as zooplankton to top predators such as sharks (Avio et al 2016, Carbery et al 2018). Ingestion may occur directly from the water or sediment as in the case of filter feeders and deposit feeders or may occur through food chain transfer (Wang et al 2019, Herrera et al 2019). Microplastics accumulated in the digestive tracts of biota has been known to cause internal wounds as well as clogging of the tract, giving a false sense of hunger satiation (Wright et al 2013, Rocha-Santos and Duarte 2017). The biota then decreases food intake or ceases to eat altogether, causing malnutrition and eventual death (Rocha-Santos and Duarte 2017).

Further physiological effects may occur due to translocation of smaller microplastic particles to other organs such as the liver, or may be caused by chemical substances and/or microorganisms adhered to the surface of the plastic particles that are brought along into the biota’s body upon microplastic ingestion (Andrady 2011, Lu et al 2016, Carbery et al 2018, Wang et al 2019). Toxic compounds found on microplastics include plastic additives from its manufacturing, heavy metals from wastewater, and persistent organic pollutants (POPs) (Rocha-Santos and Duarte 2017, Wang et al 2019). Pathogenic bacteria may also accumulate on the surface of microplastics (Smith et al 2018). Physiological effects caused by these toxic substances and microorganisms may include metabolic abnormality, hormonal dysfunction, neurotoxicity, reproductive abnormality, inflammation, and even cancer (Avio et al 2016, Rocha-Santos and Duarte 2017, Wang et al 2019).

Among the biota found in Jakarta Bay are milkfish C. chanos, a common, high-protein fish usually bred for consumption (WWF Indonesia 2014, Bagarinao 1991). Indonesia is the biggest producer of milkfish in the entire world (Le Francois et al 2010). Nearly every province in the country produces milkfish for consumption, with a production amount going up each year as the demand for milkfish locally as well as for export continues to increase (Prihatiningisih et al 2016). A number of milkfish aquaculture ponds are located along the length of the Jakarta Bay coast. Two areas known for milkfish aquaculture in Jakarta Bay are Muara Kamal and Marunda. These river mouth areas are also known to be two out of three hotspots in Jakarta of plastic leakage from drainage channels to the marine environment (World Bank Group 2018).
Microplastics have previously been found in the sediment of Jakarta Bay (Manalu et al. 2017). It is assumed that with the plastic leakage in Muara Kamal and Marunda (World Bank Group 2018), microplastics are present abundantly in the waters, making it bioavailable to the milkfish in the aquaculture ponds of each area. Microplastic that may be in the commonly consumed, mass-produced fish (Priono et al. 2014) could pose as a health hazard to the people. Although it is unknown how much damage microplastics could have on humans nor how many particles would have to be ingested to cause any significant damage, the theory suggests that the health hazards microplastics cause on aquatic biota may also affect the human body (Smith et al. 2018). It was imperative to first obtain data on the presence and abundance of microplastics in these milkfish. This research analyzed the abundance and type of microplastic in milkfish *Chanos chanos*, water, and sediment of milkfish aquaculture ponds in Muara Kamal and Marunda, Jakarta Bay.

2. Materials and Methods

The research was carried out from January until May of 2019. Samples that were used to obtain the results shown in this paper were obtained in March 2019. One milkfish aquaculture pond in Muara Kamal and another in Marunda were chosen as the two sampling locations. Muara Kamal and Marunda are listed in a water survey by the Environmental Office of the Province of Capital City Jakarta as heavily polluted and mildly polluted, respectively. These locations were chosen in hopes that the difference in the water pollution levels may mean a difference in microplastic abundance as well. A GPS was used to tag the exact coordinates of the two sampling locations. Further analysis of the samples taken was done in the Marine Biology Laboratory of the Department of Biology building in the Faculty of Mathematics and Natural Sciences, University of Indonesia.

2.1. Materials

The bulk materials used in this research were strong nitric acid (HNO₃) 65% from Merck and analytic salt (NaCl) crystals from Merck. Distilled water that were filtered with Whatman filter paper grade No. 4 were also used for rinsing equipment before use. Merck’s Neutrality pH indicator paper for pH range 5.5 to 9.0 was used for field environment pH measurements. A water thermometer and refractometer were also used for field measurements. Sampling equipment included a plankton net with a 300 µm mesh size, a GPS by Garmin, and glass jars. An analog scale was used for weighing fish in the field and a digital scale by Kris was used in the laboratory. Other equipment used included a dissecting set, a paraffin dissecting board, Jisico’s drying oven, a sieve net of 5 mm mesh size, a Nikon monocular light microscope, a Leica binocular light microscope, and a Sedgwick Rafter Chamber.

2.2. Methods

Sampling of surface water, sediments, and milkfish along with measurement of environmental parameters (water pH, temperature, and salinity) were done at two locations. Samples were then stored and brought to the laboratory for further extraction, observation, and analysis.

2.2.1. Sampling. Sampling of the milkfish was done with an age criterion of 5 to 6 months old with a sample number of 6 fish from each location. The fish were obtained at random from different points in the pond, weighed immediately and then placed in a container filled with ice. The average gross body weight of fish from Muara Kamal pond and Marunda pond were 143.3±46.6 g and 218.3±16 g respectively. Surface water and sediment were taken from 5 points in the milkfish pond at each location. Measurements of environmental parameters were also done at each of the 5 points. Surface water of 20 L from each point was filtered using a plankton net with a mesh size of 300 µm. Sediment samples were taken at a 3-5 cm substrate depth. Surface water and sediment samples were placed in glass jars to be taken to the laboratory.
2.2.2. Extraction and observation. Digestive tracts were extracted from each milkfish sample and weighed. The average weight of the fish’s digestive tract from the Muara Kamal and Marunda samples are 18±9 g and 12±1.9 g respectively. They were then destructed with a strong nitric acid reagent (HNO$_3$ 65%) in the ratio 1:10 of gross weight of digestive tract (g) against volume of HNO$_3$ (mL) (Lusher et al 2017 with modifications). The resulting solution after being left for 72 hours was given concentrated NaCl solution in the ratio 1:4 of volume of HNO$_3$ (mL) used against volume of NaCl solution (mL). The concentrated salt solution allowed for flotation of microplastic particles by means of density separation. Water samples were filtered a second time with a sieve net of 5-mm mesh size and sediment samples were dried in an oven until all water content is lost. Concentrated NaCl solution was used to achieve microplastic flotation on the filtered water sample in the ratio 1:3 of water volume (mL) against volume of NaCl solution (mL). The salt solution was also used for microplastic flotation in the sediment samples. Dried sediment as much as 25 g were weighed for each sample and concentrated NaCl solution was poured in the ratio 1:4 of dry weight of sediment (g) against volume of NaCl solution (mL).

Each sample of milkfish, surface water, and sediment concentrated salt solution was left for 24 hours to allow for density separation, then 20 mL was taken from the surface of the solution for each sample and transferred into Erlenmeyer flasks for homogenization. A representative of 1 mL was taken from each Erlenmeyer flask after homogenization and transferred to a Sedgwick Rafter Chamber for counting of microplastic particles. The observation was done with a light microscope. Counting of microplastic was done for particles with a size ranging from 20 µm to 4 mm based on the particle shapes fiber, film, fragment, and granule. The total count of all microplastic particles were calculated and noted down as well. Counting of microplastic particles were done with two repetitions for each sample.

2.2.3. Analysis. An average value was obtained from two repetitions for each sample and converted to obtain the abundance value of particles L$^{-1}$ for surface water, particles kg$^{-1}$ for sediment, and particles g$^{-1}$ (of digestive tract gross weight) for milkfish. A statistical test using the Wilcoxon Rank Sum Test was done to determine if there was a difference in the data set mean for surface waters, sediment, and milkfish between the two locations. The test was done with a significance level of 0.1.

3. Results and discussion

3.1. Results

The source of water for aquaculture ponds at both locations are the nearest river mouths. These brackish water runs through an underground pipe that relies on tidal movement to push water from the river mouth through the pipe. The pipe leads to a larger open vertical pipe that spews water into in the milkfish aquaculture pond in Marunda, while in Muara Kamal, the pipe opens up to a small grated floodgate. No proper filtering system is installed in either ponds.

Microplastic types fiber, film, and fragment were found in all samples while granules were found in nearly all samples except in the surface water and milkfish from Marunda. Figure 1 shows pictures taken of the microplastic types found in this research.

Fibers were found in a high abundance in all samples, while fragment and granules were found in low abundance. The average number of each microplastic particle found in milkfish, surface water, and sediment along with the average total count and the converted abundance value obtained can be seen in table 1.
Figure 1. Documentation of microplastic particles: (a) fiber, (b) film (c) fragment (d) granule (a), (b), and (c) taken on binocular digital light microscope, (d) taken on monocular light microscope.

Table 1. Microplastic number in digestive tracts of milkfish, surface water, and sediment.

|                  | Fiber (particles) | Film (particles) | Fragment (particles) | Granule (particles) | Total (particles) | Abundance Value          |
|------------------|-------------------|------------------|----------------------|---------------------|-------------------|---------------------------|
| **Muara Kamal**  |                   |                  |                      |                     |                   |                           |
| Milkfish         | 98.42±21.2        | 39.92±5.1        | 10.83±1.5            | 1.08±1.0            | 150.25            | 9.58±3.3 particles g⁻¹    |
| Surface Water    | 55.00±11.7        | 39.60±8.4        | 8.60±1.7             | 0.60±0.5            | 103.80            | 103.8±20.7 particles L⁻¹  |
| Sediment         | 76.70±13.2        | 37.80±3.8        | 15.30±2.3            | 9.80±2.9            | 139.60            | 111,680±13,204.2 particles kg⁻¹ |
| **Marunda**      |                   |                  |                      |                     |                   |                           |
| Milkfish         | 76.33±24.7        | 23.33±4.8        | 4.83±1.9             | 0                   | 104.49            | 8.80±2.7 particles g⁻¹    |
| Surface Water    | 55.60±13.8        | 27.10±5.8        | 7.90±2.1             | 0.10±0.2            | 90.70             | 90.7±17.4 particles L⁻¹   |
| Sediment         | 60.40±10.1        | 30.50±4.3        | 10.40±2.2            | 1.80±1.0            | 103.10            | 82,480±11,226.4 particles kg⁻¹ |

Results obtained for the samples from Muara Kamal showed microplastic number of 3,005 particles per individual digestive tract of milkfish for total abundance value of 9.58±3.3 particles g⁻¹. Microplastic abundance obtained for water samples and sediment samples were 103.8±20.7 particles L⁻¹ and 111,680±13,204.2 particles kg⁻¹, respectively. An average of 2,090 particles ind⁻¹ of milkfish was recorded for samples from Marunda. Microplastic abundance was low in all samples from Marunda with 8.80±2.7 particles g⁻¹ in milkfish, 90.7±17.4 particles L⁻¹ in water, and 82,480±11,226.4 particles kg⁻¹.
kg$^{-1}$ in sediments. Conclusions drawn using the Wilcoxon Rank Sum Test stated a difference between the sediment samples as well as digestive tract of milkfish samples from Muara Kamal and Marunda, and stated no difference between the surface water samples from Muara Kamal and Marunda.

3.2. Discussion

It was assumed that microplastics enter along with the water inflow from the river mouth. No proper filtering system is installed in either ponds, hence allowing pollutants that come with the water to enter the ponds. Microplastics that accumulate in river mouths could originate from both land and sea (Zhao et al 2015). Microplastics in the open sea may enter river mouths during high tide accompanied by a strong wind that pushes microplastic particles on the water surface towards the river. However, most of the microplastic come from a land-based source (Andrady 2011, Kataoka et al 2019). Residential waste, industrial waste, farm, and agriculture, as well as wastewater management releases microplastics into river environments (Kataoka et al 2019). As the river flows through the city, it continues to pick up trash (Said 2008) including plastics and microplastics, eventually accumulating in the river mouth (Sachoemar and Wahjono 2007). These microplastics may be in the form of primary microplastics such as microbeads that are found in personal hygiene products or secondary microplastics such as textile microfibers that are released from laundry made of synthetic material (Hitchcock and Mitrovic 2019, Kataoka 2019).

A research was done by De Falco et al (2017) found that a 5 kg laundry of polyester clothing can release up to 6 million microfiber particles. It was assumed that fibers found in this research are mostly textile microfibers from untreated wastewater coming out of residential areas, hence supporting the finding of fibers in highest abundance compared to other types of microplastic particles. Jakarta as a high-cluster city (World Bank Group 2018) with dense residential areas packed around the 13 rivers flowing through could cause these microfibers to be mass-released daily into the rivers, transporting them to the river mouths of Jakarta Bay (Sachoemar and Wahjono 2007). In addition to textile microfibers, the degradation of fishing lines and nets used within the aquaculture ponds is another possible source of these fibers (Lusher et al 2017a).

Film as the second most abundant type of particle found in this research was most likely to have originated from the breakdown of plastic bags (Wicaksono 2018). It was stated in a survey by World Bank Group in 2018 that about 16% of all trash found in Jakarta’s waterways were plastic bags. These plastics get stuck in the waterways and overtime degrade, slowly being released into the environment in the form of microplastics (Kataoka et al 2019). Fragments were found in lower abundance than film, possibly because it is formed from the degradation of much denser polymers which take a longer time to break down into micro size (Wicaksono 2018). A possible source of fragment particles is plastic product packaging (Lie et al 2018).

Granules found in this research were fine, transparent, and perfectly round particles, consistent with the shape of microbeads that may be found in hygiene products and cosmetics (So et al 2018). However, the very few amounts found could mean that usage of products containing plastic microbeads is not too popular with the residents of Muara Kamal and Marunda river mouth areas. A report by the International Trade Administration (2016) states that Indonesian women tend to use herbal and natural products as compared to synthetic ones.

Microplastic fiber and film particles are known to remain for a longer period of time on the surface of the water because of their relatively low densities while fragments and granules with higher densities tend to sink (Lie et al 2018, Wicaksono 2018). This supports the findings of fragments and granules at a higher percentage in the overall composition of particles found in the sediment samples as compared
to the surface water samples, whereas the findings of fiber and film particles are at a higher percentage in the surface water samples as compared to the sediment samples.

Total microplastic abundance values for all samples from both Muara Kamal and Marunda were quite high. The abundance values of microplastic in surface water samples were only second to the abundance found in the Norwegian offshore with over 200 particles L$^{-1}$ of water (Noren and Naustvoll 2010). The sediment samples contained a microplastic abundance of over 80,000 particles kg$^{-1}$ for Marunda and over 100,000 particles kg$^{-1}$ for Muara Kamal, which were much higher than that of the abundance found in Pluit and Ancol areas of Jakarta Bay with about 38,000 particles kg$^{-1}$ (Manalu et al 2017). The microplastic amount found in the milkfish of aquaculture ponds in Marunda and Muara Kamal were also higher than that found in the milkfish of aquaculture ponds in Lorok, Semarang with only 207 particles ind$^{-1}$ (Putri 2017). Two major factors may have caused these high values. The first one being the main source of microplastics themselves which is the river mouth. River mouths as a transitional water body between freshwater and saltwater are known to be a place of trash accumulation (Atwood et al 2019). Jakarta is the number one producer of trash in the country, and Indonesia is only second to China as the world’s top contributor of plastic trash to the marine environment (World Bank Group 2018). High anthropogenic activities such as that of the industrial areas, various factories, textile plants, dense residential areas, and agriculture contribute to the released trash and wastewater (Zhao et al 2015, Hitchcock and Mitrovic 2019). Anthropogenic activity has been linked to microplastic abundance in other research that shows a positive correlation between the two (Hitchcock and Mitrovic 2019). The mismanagement of trash and lack of proper waterway infrastructure causes pollutants to be discharged directly into aquatic environments (Trisyanti 2004). The survey by World Bank Group (2018) also reports that Muara Kamal and Marunda are two of the three hotspots in Jakarta where trash leakage occurs from the waterways out to the sea. Microplastics as part of the pollutants that flow from the river can either be pushed toward the open ocean upon reaching the river mouth or remain for longer periods of time suspended in the water column (Zhang 2017). The particles could also sink directly to the river mouth substrate and then get stirred back up into the water column by bioturbation processes (Avio et al 2016). These are the particles that get transported by pipeline to reach the aquaculture ponds along with water inflow.

A second factor that may have contributed to the high abundance of microplastics found in this research lies within the aquaculture ponds themselves. These ponds have only an inlet that also doubles as an outlet, however as there is no pump, the movement of water in and out of the ponds relies solely on tidal movement. The flow of water and currents play an important role in both distribution and re-distribution of microplastics (Zhang 2017) and the ponds remain relatively still most of the time. This means that microplastics that enter the ponds are unlikely to leave. Over decades they may accumulate in the ponds and keep increasing in amount. It is important to note that these ponds are never cleaned out completely by the fish farmers, so the accumulated trash tend to stay and pile into the substrate. Over time, larger plastic trash in the ponds also breaks down, forming even more microplastics (Rocha-Santos and Duarte 2017).

Adult milkfish, the main subject of this research, acts as both filter feeder and deposit feeder, hence obtaining microplastic from both water as well as sediment (Bagarinao 1991). They were also fed pellets in the aquaculture ponds (WWF Indonesia 2014), making it possible for them to obtain microplastics from the surface of the water in the process of consuming the pellets. A high abundance of microplastics in both water and sediment causes high abundance found in the milkfish gut as well.

A secondary finding that must be mentioned is the weight of the milkfish. Milkfish of age 5-6 months in aquaculture ponds should weigh about 250 to 350 g (WWF Indonesia 2014). However, the ones from the aquaculture ponds in Muara Kamal and Marunda weighed much lighter, averaging to only 218.3$\pm$16 g for the milkfish from Marunda, and only about 143.3$\pm$46.6 g for the milkfish samples from Muara.
Kamal. The environmental parameters measured during field sampling, although not optimal, were well within the regular tolerance levels of milkfish with temperatures of 30-32°C, an average pH of 7.9, and salinities of 4 to 21 ppt which were within the euryhaline range. It was assumed that the growth abnormality may, for the most part, be due to the long-term ingestion of microplastics. A research done by Naidoo & Glassom (2019) tested the effects of microplastic exposure to fish and found that some of the energy usually used for growth and development is directed to maintaining the body’s vital functions while combating the toxicity of plastic, its additives, as well as other harmful substances and microorganisms that come with it. This abnormality is much more alarming in the milkfish of Muara Kamal that ingested a much higher abundance of microplastics than those of Marunda, while being smaller in size, meaning that it could have experienced a more delayed growth and development.

The presence, abundance, and harmful effects of microplastics in milkfish digestive tract raise concern towards what it could do to the humans that consume these milkfish. Although the gut is mostly thrown away, smaller microplastic particles are known to be able to translocate to other body parts of the fish that are eaten by man (Smith et al. 2018). A more direct hazard is the toxic substances that are likely to be brought into the milkfish by microplastics (Carbery et al. 2018, Wang et al. 2019). These substances are more likely to be digested and transferred to humans (Carbery et al. 2018). Particularly in Jakarta Bay, where the presence of heavy metals and other toxic substances have been recorded in the water (DLHP DKI Jakarta 2016), health hazards through seafood consumption are at large. It is unknown the amounts of microplastic or the process at which they may affect human health or become fatal, however a mammalian modeling system showed that the effects of microplastics towards humans may be quite similar to that towards aquatic biota (Smith et al. 2018). The long-term effects of continuous microplastic accumulation and transfer along the food chain are of great concern (Smith et al. 2018).

The Wilcoxon Rank Sum Test that was done on three data sets (milkfish, surface water, and sediment) to determine a difference between samples from Muara Kamal and samples from Marunda gave results as such: 1) a difference in the mean of microplastic abundance in milkfish samples from the two locations, 2) no difference in milkfish in the mean of microplastic abundance in surface water samples from the two locations, 3) a difference in the mean of microplastic abundance in sediment samples from the two locations. Generally, the test conclusions exhibit a difference in microplastic abundance between Muara Kamal and Marunda, however there was no difference specifically for the surface water samples. It is assumed that the existence of dense mangrove roots throughout the walls of the aquaculture pond in Muara Kamal acts as a catchment for plastics and microplastics (Martin et al. 2019), causing the number of particles floating on the surface water to be an underestimate of the total microplastic amount that has entered the pond. Plastics and microplastics may also be stuck in the grates of the floodgate through which water enters the pond in Muara Kamal. Neither dense mangrove root systems nor grated floodgates are found in the pond at Marunda, where water enters through an open pipe. Overall, the microplastic abundance remains higher in Muara Kamal than in Marunda.

The difference in microplastic abundance between the two locations may be credited to three factors. The first being the level of anthropogenic activity which releases large amounts of trash (Hitchcock and Mitrovic 2019). The population of the surrounding Tangerang area where the river terminates in Muara Kamal is larger than that of the surrounding Bekasi area where the river terminates in Marunda (Arifin 2005). The high-cluster population (World Bank Group 2018) may result in higher levels of anthropogenic activity can cause more plastic pollution to enter the waters, or in the case of household laundry, bigger population size can mean more microfibers released into the waterways daily. Another possible factor is the chain of events in Muara Kamal that led to its heavily polluted state. Local fishermen have reported the worsening of water quality along causing fish produce to also decline (Anugrahini and Adi 2018). The cause for it began with high shipping activity in the crowded shipyards of the area, then followed up by mass disposal of trash directly into the sea, and finally the extensive reclamation of Pantai Indah Kapuk area next to Muara Kamal. Algal blooms have occurred in the fish
A third factor that was assumed to have caused the difference is related to a natural factor that affects microplastic distribution. Research done by Ji & Yoo in 2018 showed the current flow of water in Jakarta Bay. The current mainly travels from the east to the west. The strong force of water pushing out from the great river Citarum on the east side of Jakarta Bay forms this current flow (Ji and Yoo 2018). Marunda lies on the eastern side of Jakarta Bay, not too far from Citarum as opposed to Muara Kamal, which sits on the western side of Jakarta Bay. It is known that as microplastics get transported, current and wind play a major factor in its distribution (Avio et al 2016), especially for less dense particles that float on the surface waters (Atwood et al 2019). The duration of time a particle remains at the river mouth before being pushed out unto the open ocean depends on several factors, one of which is the water current (Atwood et al 2019). Strong currents in Marunda as part of the eastern side of Jakarta Bay could mean that microplastic particles upon reaching the river mouth are mostly pushed out directly to the sea and do not stay long enough in the river mouth area to be transported into the nearby aquaculture ponds. The opposite is likely to be true for Muara Kamal where the current traveling has likely lost its initial power. In addition to that, the microplastics pushed out from the rivers on the eastern side may be deposited on to the western side of Jakarta Bay where Muara Kamal is situated.

To conclude, microplastics were found in high abundance in both locations. Muara Kamal has a higher microplastic abundance overall in its milkfish pond compared to Marunda. Microplastic types found in all samples were fibers, film, and fragments, while granules were found in almost all samples except milkfish and surface water from Marunda.

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