Microplastic pollution in the sediment of Jakarta Bay, Indonesia

A Azizi\textsuperscript{1,*}, W N Setyowati\textsuperscript{1}, S Fairus\textsuperscript{1}, D A Puspito\textsuperscript{1} and D S Irawan\textsuperscript{1}

\textsuperscript{1}Environmental Engineering Department, Universitas Bakrie, H.R. Rasuna Said Road, Kuningan, South Jakarta, 12920, Indonesia

*Corresponding author: aqil.azizi@bakrie.ac.id

Abstract. During the COVID-19 pandemic, the increased use of plastic for personal protective equipment (PPE), single-use plastic bags, and food packaging raised significant environmental concerns. This study aimed to investigate the shape, abundance, and type of microplastics in the sediment of Jakarta Bay, specifically Tanjung Priok, Ancol Beach, and Sunda Kelapa Port. Sediment was collected using an Ekman sediment grab sampler and was extracted using the density separation method. The microplastics were counted and categorized according to the shape under a microscope. The differences in microplastic abundance in three different stations were determined using a one-way ANOVA. The polymer of microplastics was identified using Fourier Transform Infra-Red (FTIR). The results show that the abundance of the microplastics from coastal sediment was highest in the Sunda Kelapa Port (45066.67 ± 5205.13 particle/kg dry weight), which is significantly different (p<0.05) from Tanjung Priok (40533.33 ± 2444.04 particle/kg dry weight) and Ancol Beach (34666.67 ± 2444.04 particle/kg dry weight). Fragments dominated the shape of microplastic in Tanjung Priok, Ancol Beach, and Sunda Kelapa Post, comprising 36\%, 40\%, and 38\%, respectively, followed by fiber, film, and pellet. The FT-IR tests indicated that polypropylene (PP), polyethylene (PE), polystyrene (PS), and polyamide are the most prevalent microplastic polymers.

1. Introduction
Plastic products were critical in keeping people safe during the COVID-19 pandemic. The use of personal protective equipment (PPE) has increased, as has the use of single-use plastic shopping bags and food packaging, causing significant disruption in the trash disposal system. Hundreds of millions of single-use plastics (masks, aprons, gloves, sanitizer bottles, and food packaging) have been discarded in the environment, potentially increasing the amount of plastic washing up on ocean coastlines and littering the ocean floor [1]. Plastic waste reaches the ocean in two ways: 80 percent comes from the land, mostly via rivers, and 20 percent from the sea [2]. All of it ends up in marine sediments, which serve as the ultimate sink for many pollutants [3].

By the end of 2020, Indonesia, which has the fourth-largest population globally, is expected to produce 123 million discarded facemasks every day and nearly 21 million tonnes of plastic garbage [1].
The rapid increase in plastic pollution during the COVID-19 epidemic raised significant environmental concerns regarding microplastic contamination. Due to a combination of physicochemical and mechanical conditions such as UV exposure, temperature, hydrophobicity, wind, and current, the thermoplastic polymer may break down into smaller particles known as microplastics [4]. Some microplastics, which have a higher density than seawater, may sink rapidly and settle in sediment. Degradation, aggregation, and biofouling could cause lighter microplastic particles to fall to the seafloor as marine snow [5].

Microplastic contamination is an issue in Jakarta's shoreline waterways, one of the city's most vulnerable areas. The streams are located at the mouth of a watershed that drains 13 river systems into the ocean. Jakarta Bay is a water-based region with a wide range of activities, including port, domestic, commercial, and industrial. This activity is thought to have contributed to the marine pollution in Jakarta Bay. This study aimed to identify and quantify the shape, abundance, and type of microplastic in three coastal sediments of Jakarta Bay.

2. Materials and Methods

2.1. Time and Place
The sediment sample was collected in March 2021, about a year after the Covid-19 pandemic was declared, from three locations: Tanjung Priok, Ancol Beach, and Sunda Kelapa Port, all of which are around 5 kilometers apart (see Figure 1). Further sample analysis was carried out at Environmental Engineering Laboratory, Bakrie University.

![Figure 1. Map of sampling stations](image)

2.2. Sampling Procedure
Sediment was collected in triplicate (0 – 30 cm depth) at each sampling station using Ekman grab sampler. The sediment samples were kept in an icebox, transferred to the laboratory, and kept in a -2 °C freezer before further analysis.
2.3. Isolation of Microplastics

The sediment samples were first dried for one night or until completely dry at a temperature of 60°C using the drying procedure. Then, using an analytical balance, around 20 g of dried sediment was weighed and put into a beaker. Sediment samples went through a density separation process after the pre-treatment. Density separation was used to determine the number of microplastics in sediment samples by increasing the density of the aqueous solution using sodium chloride (1.5 g/cm³). The samples were mixed with 6 g sodium chloride and stirred on a hotplate for 15 minutes. The mixture was then removed from the hotplate and coated in foil for three days. After three days, the mixture was filtered with Whatman no. 4 filter paper using a vacuum pump. The filter paper was dried for further study.

Figure 2. The mean abundance of microplastic in three different sampling stations

![Figure 2](image2.png)

Figure 3. Means with different letters are significantly different from one another

2.4. Sorting and Identification of Microplastics

Microplastic particles were visually observed and counted under a microscope stereo Olympus SZH10 with a magnification of 10 x 10 and divided into four categories: film, fiber, fragment, and pellet. The
abundance of microplastics is expressed in n/m$^3$ with a mean value and standard deviations (SDs). The difference in microplastic abundance across sampling stations was determined using one-way ANOVA, followed by Tukey's test and Post-Hoc analysis using SPSS 19 software.

Fourier Transform Infrared (FTIR) spectroscopy (NicoletTM iS50 FTIR Spectrometer with NIR Module) was conducted at the ILRC laboratory, the University of Indonesia to determine the functional groups associated with polymer chemical properties. The polymer analysis was done with a NicoletTM iS50 FTIR spectrometer. A laminated diamond crystal Thermo ScientificTM iD5 attenuated total reflectance (ATR) accessory from Thermo ScientificTM. The results were adjusted with Omnictm Software. Based on [6], the equipment was used in single reflection mode with a range of 600 to 3800 cm$^{-1}$, a resolution of 8 cm, and a scan rate of 16 scans per analysis.

3. Results and Discussion

3.1. Abundance of Microplastics

The Sunda Kelapa Port had an enormous abundance of microplastics (45066.67 ± 5205.13 particle/kg dry weight), which was significantly different (p<0.05) from Tanjung Priok (40533.33 ± 2444.04 particle/kg dry weight) and Ancol Beach (34666.67 ± 2444.04 particle/kg dry weight), as shown in Figure 2 and Figure 3. One of the sources of the highest microplastic abundance in Sunda Kelapa Port has been the confluence of the Ciliwung and Krukut rivers. Residential neighborhoods and a range of maritime transit systems, such as cargo ships and conventional boats, are all close to the region.

The number of microplastics found in this study is higher than in two previous studies. The sample sites were also near Jakarta Bay. Microplastic abundance in sediment discovered in Ancol and Pluit ranges from 18405 to 38790 particle/kg dry weight [7], whereas microplastic abundance in Pantai Indah Kapuk (PIK) was reported to be between 216.8 and 2,218.4 particle/kg dry weight [8]. The variations in abundance could be attributable to the areas' distinct characteristics and environments. Microplastic pollution is more prevalent in sampling stations that have been impacted by anthropogenic activity. In several regions, a positive correlation between microplastic abundance and population density has been reported [9]. Another aspect influencing variances in microplastic abundance in sediment is the experimental method applied in each study, which results in varied data validation, making it difficult to compare studies [10].

![Figure 4. (a) The shape of microplastic found in the sediment samples A: Fiber, B: Film, C: Pellet, D: Fragment (b) The mean percentage of microplastic shapes in the sediment of Jakarta Bay](image)
Figure 5. FTIR spectra of water sample from Tanjung Priok (a), Ancol Beach (b), and Sunda Kelapa Port (c)

3.2. Shape of Microplastics
Figure 4 (a) demonstrates the identification of microplastic samples collected from all three sampling stations, revealing four different types of microplastics: fragment, fiber, film, and pellet. Figure 4 (b)
shows the percentage shapes of microplastic discovered in the sediment of Jakarta Bay. Figure 4 (b) shows that at Tanjung Priok, Ancol Beach, and Sunda Kelapa Port, fragments dominated the shape of microplastic, accounting for 36 percent, 40 percent, and 38 percent, respectively, followed by fiber and film. Across all sites, pellets showed the lowest percentage of microplastic forms.

Several factors, including human activities, hydrodynamics, weather, and topography, influenced the shapes of microplastics discovered [11]. Fragment microplastics are formed when plastic products such as bottles, bags, pipes, and other household debris are fragmented [12].

3.3. Type of Microplastics
Polyethylene (PE), Polypropylene (PP), Polystyrene (PS), and Polyamide (PA) were the four microplastic polymers identified in Figure 5. (PA). Plastic bags, detergent wrappers, shampoo bottles, and other plastic packaging include polyethylene (PE) [13]. Polyethylene (PE) has a low density, which allows it to float in water. Polypropylene (PE), on the other hand, is a form of polymer made from strong and semi-transparent plastic [14]. When compared to polyethylene, polypropylene (PE) has a higher texture and density. Because polyethylene (PE) is regarded as more secure for food containers, it is commonly used for packaging food, beverages, and other items. Polystyrene (PS) is commonly found in styrofoam products such as food containers, plastic forks and spoons, and CD packaging. A polystyrene is a form of plastic that contains benzene, which is harmful to people [14]. Polyamide comes from fishermen's fishing gear and textile fibers leftover from washing clothing carried out to sea by currents [15].

4. Conclusion
The Sunda Kelapa Port (45066.67 ± 5205.13 particle/kg dry weight) had the largest abundance of microplastics, which was significantly different (p<0.05) from Tanjung Priok (40533.33 ± 2444.04 particle/kg dry weight) and Ancol Beach (34666.67 ± 2444.04 particle/kg dry weight). In Tanjung Priok, Ancol Beach, and Sunda Kelapa Post, fragments dominated the microplastic shape, accounting for 36%, 40%, and 38%, respectively, followed by fiber, film, and pellets. Polypropylene (PP), polyethylene (PE), polystyrene (PS), and polyamide were found to be the most common microplastic polymers in FT-IR analysis. The findings suggested that during the Covid-19 pandemic, there could be an increase in the amount of microplastic in coastal sediment.

Acknowledgments
This research was supported by The Grant of Directorate General of Higher Education (DIKTI) and Universitas Bakrie Research Grant 2021.

References
[1] Benson N U Bassey D E and Palanisami T 2021 COVID pollution: impact of COVID-19 pandemic on global plastic waste footprint *Heliyon* 7: e06343
[2] Ritchie H Roser M 2018 *Plastic pollution* Published online at OurWorldInData.org.
[3] Woodall L C, Sanchez-Vidal A, Canals M, Paterson G L J, Coppock R, Sleight V, Calafat A, Rogers A D, Narayanaswamy B E, and Thompson R C 2014 The deep sea is a major sink for microplastic debris *R. Soc. Open Sci.* 1 (4)
[4] Khoironi A Hadiyanto H Anggoro S and Sudarno S 2020 Evaluation of polypropylene plastic degradation and microplastic identification in sediments at Tambak Lorok coastal area, Semarang, Indonesia *Mar. Pollut. Bull.* 151
[5] Saipolbahri N et al 2020 Determination of Microplastics in Surface Water and Sediment of Kelantan Bay *IOP Conf. Ser.: Earth Environ. Sci.* 549
[6] Löder M G J and Gerdts G 2015 Methodology Used for the Detection and Identification of Microplastics—A Critical Appraisal *Marine Anthropogenic Litter* 201–27
[7] Manalu A A, Hariyadi S and Wardiatno Y 2017 Microplastics abundance in coastal sediments of Jakarta Bay, Indonesia. *AACL Bioflux* 10(5) 1164–1173
[8] Hastuti A R 2014 Distribusi spasial sampah laut di ekosistem mangrove Pantai Indah Kapuk Jakarta Bonorowo Wetlands 4(2) 94-107  
[9] Browne M A Crump P Niven S J Teuten E Tonkin A Galloway T Thompson R 2011 Accumulation of microplastic on shorelines worldwide: sources and sinks Environmental Science and Technology 45(21) 9175-9179  
[10] Qiu Q Peng J Yu X Chen F Wang J Dong F 2015 Occurrence of microplastics in the coastal marine environment: First observation on sediment of China. Richardson B. (ed). Journal of Marine Pollution Bulletin 98 274-280  
[11] Febriani I S Amin B and Fauzi M 2020 DEPIK Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan 9(3)  
[12] Kingfisher J 2011 Port Townsend Marine Science Center http://www.ptmsc.org/Science/plastic_project/  
[13] Viršek M K Palatinus A Koren Š Peterlin M Horvat P Kržan A 2016 Protocol for Microplastics Sampling on the Sea Surface and Sample Analysis Journal of Visualized Experiments 118: e55161  
[14] Alabi O A Ologbonjaye K I Awosolu O Olufiropo 2019 A Public and Environmental Health Effects of Plastic Wastes Disposal: A Review J. Toxicol. Risk Assess 5, 021  
[15] Pawar P R, Sanket S S and Rahul B P 2016 Plastic marine debris: Sources, distribution and impacts on coastal and ocean biodiversity Proc. Biol. Sci. 3 54-40