Abundance and distribution of microplastics in Baturusa watershed of Bangka Belitung Islands Province

R Riskiana¹,*, S Hariyadi² and H Effendi²,³

¹ Graduate Student of the Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences Faculty, IPB University (Bogor Agricultural University), Jl. Agatis, Kampus IPB Dramaga, Bogor 16680, Indonesia
² Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University (Bogor Agricultural University), Jl. Agatis, Kampus IPB Dramaga, Bogor 16680, Indonesia
³ Environmental Research Center (ERC) IPB University, Kampus IPB Darmaga, Bogor, 16680, Indonesia

*Corresponding author: refariskiana@gmail.com

Abstract. Microplastics has been found in the most water bodies since 1970s, yet its presence and understanding about the existence on the freshwater body, as well as a control upon its abundance is still very limited. Whereas the river became a very potential channel for microplastics in contaminating the environment. Microplastics is term refer to plastic particles which diameter less than 5 mm. Microplastics could act as an absorbent of chemicals from the environment, and also a carrier of additive chemicals added during the process of plastic manufacturing to the organisms. It can potentially affect the organisms through the aquatic food web. This study aims to figure out the abundance and distribution of microplastics in Baturusa watershed. The research was carried out from November 2019 to August 2020. Samples were collected using plankton net of 30µm mesh size, from seven sites represent upstream, downstream, and tributaries, then analyzed using an ocular microscope. The microplastics particles type found are sheets, films, fibers, and fragments. The average microplastics abundance was 2209–5569 particles m⁻³, the highest abundance was found in Rangkui River estuary about 5647 particles m⁻³, and the lowest was in Selindung River. This reveals that the more abundance of microplastics in the waters was correlated to the more human activities surroundings.

Keywords: Bangka Belitung Island; Baturusa watershed; microplastic; water pollution

1. Introduction
The use of plastics in the world has increased, annual plastic production in the 1950s was 1.5 million tons [1] and reached 335 million tons in 2016 [2]. The durable, lightweight, strong, and malleable properties of plastics, its low production costs [1-5], combined with mass production techniques make plastics one of the popular materials [6]. Plastics are not biodegradable [3], but undergo physical degradation by abrasion and heating, photodegradation by UV radiation, and chemical degradation [7] so that they become smaller polymer fragments known as microplastics [3, 8]. Holland et al. [9] stated
that humans have released plastic debris into the environment since the early 1900s, and nowadays plastic has become a serious threat to the environment.

Microplastic pollution in the marine environment has been widely observed, however, the presence of microplastics in freshwater and the understanding of its presence as well as the control over their abundance is still very limited [3]. Most of the microplastic research in freshwater focuses on lentic water systems, namely lakes [6], however, lotic waters such as rivers are still less observed. In fact, rivers, WWTP (wastewater treatment plants), and runoff are potential channels for the entry of microplastics into the environment [6, 11].

Based on the source, microplastics can be divided into primary microplastics and secondary microplastics. Primary microplastics is a type of plastic that is produced in microscopic sizes for various applications, in the type of microbeads and pellets [10]. Secondary microplastics are microplastics resulted from the degradation of bigger size plastics [5]. The morphological characteristics of microplastics used are size, color, and type [12]. Microplastics can act as absorber of chemicals from the environment as well as carriers of chemical additives intentionally added during the plastic manufacturing process into organisms [13] and potentially affect organisms through the aquatic food web [1]. Microplastics can accumulate POPs (Persistent Organic Pollutant) in waters including pesticides, solvents, and pharmaceutical products which in turn can cause endocrine disruption and morbidity [12].

The composition rate of plastic waste in Bangka Belitung Islands Province is 17.33%, which is greater than the national plastic waste rate, which is 15% [14], and waste processing capability through TPST3R (integrated waste management and 3R) is 53.6 kg/day [15]. Baturusa watershed is the longest watershed in Bangka Island [16]. Activities around the Baturusa River are ferry and loading ports, shipyards, power plants, fish landings, community settlements and so on. These activities put pressure on the Baturusa River that greatly affects the river water quality. This study aims to figure out the abundance and composition of microplastics in the rivers of Baturusa watershed.

2. Methods

2.1. Site and time of study
The research is conducted in November 2019 – August 2020 at seven stations in Baturusa watershed figure 1, with different characteristics in table 1. Sampling was carried out four times, on weekdays (represent Monday, Tuesday, Wednesday, and Thursday) and weekends (represent Friday, Saturday, and Sunday) in November and December 2019. Microplastics identification was conducted at the Water Resources Management Laboratory, Bangka Belitung University and Micro Biology Laboratory, Aquatic Resources Management, Fisheries and Marine Science Faculty, IPB University.
Figure 1. Location sampling map in Baturusa watershed (1. Mabet River; 2. Limbung River; 3. Baturusa River; 4. Selindung River Estuary; 5. Pangkalbalam River; 6. Rangkui River Estuary; 7. Selindung River).

Table 1. Characteristics of sampling sites.

| No. | Stations                  | Coordinate               | Characteristics                                         |
|-----|---------------------------|--------------------------|---------------------------------------------------------|
| 1   | Mabet River               | S. 01°54′57.8″E. 105°55′50.4″ | Located near community settlements and palm oil plantations, it is used for bathing, washing, and toilet activities. |
| 2   | Limbung River             | S. 02°00′46.4″E. 106°02′07.8″ | Located near plantations and forests, the surrounding community uses it as a fishing ground area, influenced by tides. |
| 3   | Baturusa River            | S. 02°01′44″E. 106°06′44.1″ | Located near community settlements, which is oil ship traffic route, around a diesel power plant. |
| 4   | Selindung River estuary   | S. 02°04′13.7″E. 106°06′42.9″ | It is a ship traffic route, there is a gas refueling station (SPBG), lift net fishing and illegal mining. |
| 5   | Pangkalbalam River        | S. 02°05′43.8″E. 106°07′39″ | There are freight and passenger ports, fish landing, ship traffic flow, shipyard industries, tin smelters. |
| 6   | Rangkui River             | S. 02°05′43.8″E. 106°07′39″ | Located near industrial areas, settlements, boat traffic, fish landings. |
| 7   | Selindung River           | S. 02°04′13.7″E. 106°06′42.9″ | Boat traffic route, fishermen’s lift net, there is mangrove ecosystem. |
2.2. Procedure

Water samples are taken using plankton net (18 cm in diameter and 30 μm mesh size) from three depth levels, water surface, 50 cm depth and 100 cm depth [17] for five minutes to obtain a sample of river water. The samples collected were 200 ml and 90 grams of NaCl were added to increase the density of samples [18] so that the plastic particles float easier. Microplastics identification is conducted using an optical microscope (magnification 4 x 10), SRC (Sedgewick rafter counting cell), and the micrometer used to measure the size of microplastic particles. The identification process is carried out through microplastic counting with the sweeping method. The results obtained are data on the abundance of microplastics, which are differentiated into types and sizes through the equation according to APHA [1] as follows:

\[ N = \frac{c \times V_s}{V_o \times V_a} \]

**Explanation:**

- \( N \) = The abundance of particle (particle/m³)
- \( c \) = The number of particles observed at the SRC
- \( V_s \) = Volume of sample (ml)
- \( V_o \) = Volume of observed water at SRC (ml)
- \( V_a \) = Volume of filtered water (m³)

Visual identification of microplastics is carried out by classifying particles according to their morphological characters, shape or type, and size [12]. The classification of microplastics based on type varies due to the absence of standard protocol. The grouping of microplastic particles in the Baturusa watershed was carried out based on Wu et al. [20], which divided microplastics type into six groups, namely sheets, films, fibers, fragments, pellets, and foams. Visual identification of microplastic particles was carried out using an ocular microscope, the quality and magnification of the microscope used affected the analysis results [21]. Identification of microplastics in water samples must be able to distinguish microplastic particles from litter or other impurities. The criteria used in visually identifying microplastics are the absence of structures derived from living things, fiber particles must have the same thickness, are clear and have a homogeneous color [12, 22]. Microplastic particle size is determined based on the longest particle dimensions [12]. At this time, there is no standard provision for particle size grouping, so that the grouping of microplastic particle sizes varies [20]. The microplastic size used in this study in Baturusa watershed is based on Nor & Obbard [25] that classify the particle sizes into 7 groups.

2.3 Statistical analysis

Data analysis using non-parametric statistics by performing the normality test followed by Kruskal Wallis test. Non-parametric statistics can be used to test classified and categorical data (nominal scale) and to test if the data come from observations taken from different populations. Kruskal Wallis test was used to test the differences of more than two free samples [23].

3. Results and Discussion

3.1. Abundance of microplastics

The sampling locations are seven stations representing the upstream, tributary, and downstream segments. Microplastic particles were found at each observation station in different numbers. The abundance of microplastic particles in the rivers of Baturusa watershed ranges from 1159-5647 particles m⁻³, with an average abundance ranges 2209–5569 particles m⁻³. This value is higher than the abundance of microplastics in the Cimandiri watershed, 685- 7444 particles m⁻³ [24], but is not much different from the abundance of microplastics in Jakarta Bay, which is 2881-7472 particles m⁻³ [25]. Microplastics are also found in rivers in various countries, for example in the Yangtze River Estuary,
China with an average particle of 4147 items m$^{-3}$ [26], and 100.6 ± 99.9 fiber m$^{-3}$ in Marne River, Paris, France [11]. The various values of microplastic abundance in the river indicate that microplastic particles in the river have a heterogeneous and varied concentration [27].

The highest abundance of microplastics in the Baturusa watershed are at Rangkui river estuary with an average of 5520 particles m$^{-3}$, and the lowest in Selindung River with an average of 2243 particles m$^{-3}$, both locations are tributaries with different characteristics. The fluctuations in the abundance of microplastics in the Baturusa watershed is presented in figure 2. The Rangkui River estuary is a river that divides Pangkalpinang City and crosses urban areas, markets, and industrial areas, while the Selindung River has mangrove vegetation and is located on the outskirts of the city. Rivers that lie around densely populated areas have higher concentrations of microplastics [13, 28, 29], this indicates that plastic waste in water comes from inland community activities [30].

There is also a high abundance of microplastics in the Pangkalbalam River (5th station), which is the downstream part of the Baturusa watershed as well as the closest station to the sea. This is consistent with the study which stated that the concentration of microplastics downstream of the river is higher than the upstream [3, 27]. The Kruskal-Wallis statistical test on the abundance of microplastics at each location showed a P value of 0.008, which means that at least two locations were statistically different, while based on the time of sampling, the P value was 0.748, which means that there was no statistical difference in the sampling time. The difference in abundance of microplastics at each station is also influenced by specific characteristics of the sampling location which are the physical forces in the degradation and dispersion of microplastics [10, 13].

3.2 Particles type
There are four types of microplastics particle type in Baturusa watershed, namely sheet, film, fiber, and fragment figure 3. The grouping of microplastic particles based on shape or type potentially indicate the origin of those particles [20]. Pellet-type microplastics are resins used to make other plastics or primary microplastics [31]. Microplastic pellets are not found in the Baturusa watershed, this is because there is no plastic manufacture or plastic ore industry in Bangka Island [32]. Pellet microplastic particles are raw materials that are usually found in waters around the plastic industry [13] or it can also come from plastic particles in cosmetics that are used as body scrubs or exfoliators.

Figure 2. Abundance of microplastics in the Baturusa watershed (1) Mabet River, (2) Limbung River (3) Baturusa River (4) Selindung River Estuary (5) Pangkalbalam River (6) Rangkui River Estuary (7) Selindung River; (●) sampling 1 (■) Sampling 2 (▲) Sampling 3 (X) Sampling 4.
so that they are carried away from domestic wastewater from households [5]. Fiber-type microplastics usually come from textiles and fishing equipment, while films, sheets, and fragments come from the degradation and fragmentation of plastic wrap [20] also known as secondary microplastics.

Figure 3. Microplastic particles found in the Baturusa watershed (a) sheet (b) film (c) fiber (d) fragment.

Figure 4. a. The composition of the abundance of microplastic particles based on the types in the Baturusa watershed b. The average abundance of microplastic particles by type; 1. Mabet 2. Limbung 3. Baturusa 4. Selindung estuary 5. Pangkalbalam 6. Rangkui estuary 7. Selinding.

The Kruskal-Wallis test shows that there is significant difference (p <0.05) between type of the microplastic particles found. The most common particle type found in all locations a film at 55%, while the least particle is fragments (1.46%) figure 4. These results indicate that most of the incoming plastic waste to the waters of Baturusa watershed comes from plastic packaging and plastic bags.
Another microplastic source that contributes to the high level of sheet and film type microplastic particles comes from the degradation of ship paint during cleaning and maintenance of vessels [13], as in the Pangkalbalam River and Rangkui River estuary there are several shipyard industries and fishing boat landing sites.

### 3.3. Particles size

Another parameter measured in the visual identification of microplastics is particle size. In total, based on the size of the highest abundance of microplastic particles, particles in size 41-60µm is 34.32%, followed by sized particles 21-40µm 32.35%, while the lowest abundance is particles sized 1000-5000µm figure 5. The Kruskal-Wallis test shows that there is a significant difference in the size of microplastic particles (p <0.05). This value is different from the abundance of microplastics in the Cimandiri watershed indicating that the most abundant particle size is 1001-2000 µm [24], but in the fresh waters of Wuhan, China the highest abundance of particle size is 50-500 µm [34].

![Figure 5.](image)

**Figure 5.** Microplastic composition based on size (■ 20-40µm □ 41-60µm □ 61-80µm □ 81-100µm □ 101-500µm ■ 501-1000µm ■ 1001-5000µm).

Smaller plastic particles will stay on the surface water longer than larger size particles in the same composition and type [28]. Besides that, smaller microplastics particles are more easily eaten by various microorganisms including plankton and fish could cause bioaccumulation through the food web and trophic transfer [35], thereby reducing nutrient assimilation due to buildup in the digestive tract and irritation of the epithelial layer [29]. Figure 6 shown shows the average abundance of microplastic particles based on the type and size of the particle size groups.

Microplastics contain additives added during the manufacture process to improve the properties desired in plastic products. These additives are hazardous and toxic materials and can be leached from the plastic surface [5]. Plastics have an affinity for certain essential microelements, for example polychlorinated biphenyls (PCB), DDT, dioxins, PAHs, PBDE, hexachlorocyclohexane isomers, Cyclodienes, mirex, aliphatic hydrocarbons, hexachlorobenzene, bisphenol A, perfluorinated compounds (PCFs), and others [6, 9, 36]. Digestion of microplastics has been reported in more than 600 taxa, and fish is the most affected taxa [1]. Microplastic particles are also translocated from the digestive system to the circulatory system of *M. edulis* [13]. Microplastics can affect aquatic, although it is difficult to identify with current methods [6].

The high abundance of microplastic particles in Baturusa watershed is an issue that must be handled immediately so that the government and the community must take mitigation steps. The four main solutions that have a major impact in preventing the formation of microplastics start with identifying and knowing the sources of microplastics in the land, applying a zero-waste strategy, encouraging the application of EPR (extended producer responsibility), and developing new environmentally friendly business solutions [37]. Technically, mitigation of microplastics in the environment can be done by removing microbeads from personal care products and using
Biodegradable materials [38] as well as improving plastic waste management with 3R systems [39]. Appendix III of Regulation of the Minister of Environment No. 13 of 2012 [40] describes the integration of waste banks with the application of EPR, the obligation of producers to be responsible for the entire product life cycle and/or packaging of the produced products. From the producer’s point of view, a waste bank is a collection or dropping point designed as a starting point for the process of recalling products and/or packaging that have expired and are subject to EPR provisions.

Figure 6. An average number of particles based on type and size a. Sheet b. Film c. Fiber d. Fragment; 1. 20-40 μm 2. 41-60 μm 3. 61-80 μm 4. 81-100μm 5. 101-500 μm 6. 501-1000μm 7. 1001-5000 μm.

4. Conclusion
The abundance of microplastics in rivers in the Baturusa watershed ranges from 2209–5569 m³ particles. The highest abundance is at Rangkui River estuary, while the lowest abundance is at the Selindung River station. Community activities around the river affected the high abundance of microplastics in the waters. Most microplastic particles found are in the type of sheets and films, which presumably represent that the plastic used comes from plastic bags or plastic wrap. The high abundance of microplastics at several stations in the Baturusa watershed is related to the activities of the surrounding community. The location that is around densely populated settlements and industrial activities have a higher abundance of microplastics. This also indicates that plastic waste management is not going well. Mitigation action must be implemented to reduce the abundance of microplastics in the waters, including by increasing the 3R efforts and implementing EPR.

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