4. Research Report

Title of Research Project:
Investigation of the Existence of Fresh Water MP (Micro Plastic) in Indonesian Lake: A Case of Various Cirata Reservoirs Water Utilization Clusters

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Research Background:

Plastic is a material that cannot be separated from human life. According to Yong *et al*., (2020), plastic is one of the most non-natural products made by humans that has penetrated the earth's surface environment. Plastic has many advantages, including low price, light weight, flexibility, and strength, so it is the material of choice for most tools, equipment, and packaging. Plastic production has increased rapidly in the last few decades, reaching 367 million metric tons in 2020, giving rise to environmental problems when plastic becomes waste when it is no longer used (Gambino *et al*., 2022). Research results place Indonesia as the second largest contributor to marine plastic waste after China (Jambeck *et al*., 2015; Lebreton *et al*., 2017). SIPSN data for 2022 states that plastic waste is the type with the second largest percentage after food waste, namely 18.12%. Plastic waste does not decompose easily, it takes hundreds of years to decompose naturally. Most waste thrown away is mixed (not sorted) so the waste processing process, including plastic waste, is not optimal, and much of it still ends up at the final processing site of the municipal dumpsite.

The big and important agenda of the Indonesian government now is to implement national planning to reduce plastic waste by 70% between 2018-2025, besides that, it also wants to achieve zero plastic pollution in Indonesia by 2040. This is because plastic is the most dangerous waste. After all, 80% of the amount of waste from land will reach the ocean. Organic waste is the most common because plastic waste is very difficult to degrade naturally, causing a build-up of waste on land and seas. Naturally, plastic can degrade and break due to various factors such as the intensity of sunlight, dissolution in water, heat effects, and other physicochemical mechanisms (Lestari *et al*., 2021). Changes in the shape of plastic due to physicochemical mechanisms from large (macro) sizes to small (micro) sizes so that the degradation of these plastics into microplastic forms has become a major concern for pollution of the world's waters (Alimba and Faggio, 2019). Microplastics are plastic particles smaller than 5 mm (Lambert *et al*.,2018; Klein *et al*.,2018). Microplastics can come from primary sources (application of household products and personal care products) or secondary (breakdown of larger plastic particles) (Horton *et al*.,2017; Kooi *et al*.,2018). Microplastics can be identified based on size, shape, color, and polymer density (Peng *et al*..2017). These characteristics can influence their distribution in different environmental compartments and create particles that are susceptible to ingestion by biota (De Sá *et al*. 2018; Anderson *et al*. 2016).

Microplastic units have unique physical characteristics, are widely distributed, and can harm organisms through direct pathways from the environment and indirectly through ingestion, bioaccumulation, and biomagnification (Miller *et al*., 2021; Cole *et al*., 2011; Cole *et al*., 2014; Sfriso *et al*., 2020; Walkinshaw *et al*., 2020). Microplastics that have been dispersed into the environment function as a basis for the adsorption of other pollutants, namely persistent organic pollutants, and heavy metals as well as various kinds of pathogens (Lee *et al*., 2014; Purwiyanto *et al*., 2020; Feng *et al*., 2020). This causes microplastics to potentially pose a threat to the environment due to the release of specific additives they contain (Celino and Brady *et al*., 2021) and pose a threat to human health due to their ability to move through the food supply chain to reach the highest consumers (Hartmann *et al*., 2019).

Therefore, it is very important to understand the existence, abundance, behavior, and fate of microplastics in the natural environment, including the presence of microplastics in river water and lake water which are used for various activities, namely for public consumption, floating net cage fish farming, hydroelectric power plants, tourism, and so on. This research aims to detect the presence and abundance of microplastic contamination in Cirata reservoir water one of the very important reservoirs in Indonesia, where there are several clusters of reservoir water utilization for floating net cages, solar power plants, hydroelectric power plants, and water tourism.

Cirata Reservoir is a reservoir located in three districts in West Java, namely Purwakarta, Cianjur, and West Bandung. Cirata Reservoir is an interesting area because of the background of the reservoir, apart from being a hydroelectric power plant and solar power plant, Cirata Reservoir is also filled with floating net cages for cultivating fish and is used as a tourist attraction, especially for fishing hobbyists. Geographically, the Cirata Reservoir is located in intensively managed industrial, agricultural, and plantation areas. Apart from that, in an area not far from the reservoir inlet, there is a final waste disposal site as a municipal waste dumpsite which is still operating today.

Internally, the Cirata Reservoir gets its pollution load from utilization activities, while externally it gets pollution from the river. Currently, the condition of the Cirata Reservoir has experienced degradation. According to Garno (2005), the reservoir area is increasingly narrowing and the water depth is decreasing. Apart from that, the quality of water bodies is also decreasing. Cirata Reservoir is experiencing a decline in water quality, the cause of the decline in water quality is the influx of waste originating from agricultural, domestic, industrial, transportation, livestock, and fisheries waste. There are types of waste that enter the waters containing various kinds of heavy metal lead, such as industrial waste, transportation waste, and agricultural waste. The Cirata Reservoir has experienced a decrease in its usability due to environmental influences that are too severe, such as the large amount of organic and inorganic waste that is dumped directly into the Cirata Reservoir. This decrease in usability can take the form of a physical, chemical, or biological decline in water quality (Saputra, 2009). This decrease in water quality is caused by the fact that the reservoir directly receives various waste inputs that are disposed of from textile factories, metal plating, food, drink, paper, plastic, and various kinds of waste originating from domestic waste disposal and agricultural land (Saputra, 2009). Apart from that, the increasingly uncontrolled cultivation of floating net cages has also caused a decline in the quality of reservoir waters. This pollution impacts the corrosiveness of hydropower turbines and reduces fish production in marine cage cultivation (BPWC, 2003). Information regarding traces of toxic contaminants including Microplastic (MP) is still limited or unavailable.

Aims

This research aims to determine the content and type of microplastic (MP) in one of most reservoirs in Indonesia (Cirata Reservoir) with the objectives to: (a) understand its presence, abundance, distribution, and source, and (b) characterize the size and type as well as the morphology of the polymer. This study will be the first report on microplastics in freshwater reservoirs in Indonesia particularly in Cirata Reservoir which can then be used as input in determining environmental management model options related to plastic pollution. Furthermore, scientifically this research will enrich scientific knowledge through scientific publications in international journals and dissemination at scientific conferences.

Materials and Method

Material

This research used H_2O_2 30% solution to remove organic contaminants from the sample. Samples were filtered using Whatman glass microfiber filters with a diameter of 47 mm.

Method

Research Area

Samples were taken from the Cirata Reservoirs at 7 locations along the reservoirs, from the mouth of the 4 River (Cikundul, Cibalagong, Cisokan, and Citarum) to the outlet of Cirata reservoirs. As shown on the location map of Figure 1.

Sampling and Sample Identification

This research will be carried out by taking water samples from the Cirata reservoir and analyzing microplastic in the laboratory. Sampling locations will be selected according to the location of Cirata reservoir utilization, including an area of fish-farmed cage by floating net cage, river mouth to the reservoir, and others. A total of 7 (seven) water quality monitoring points, at 3 (three) duplicates representative water samples will be taken along the Cirata reservoir. Initial sampling will be carried out in August 2024 by our research group at BRIN, stored at BRIN, and analyzed in the laboratory.

Microplastic sampling uses a plankton net of 200 µm and an opening diameter of 20 cm. The plankton net is pulled above the water surface of the Cirata reservoir using a 20 m rope so that the volume of water entering the plankton net is:

$$V = \pi r^2 . t$$
$$V = 3{,}14 \times 0{,}1 \text{ m} \times 20 \text{ m}$$
$$V = 6{,}28 \text{ m}^3$$

Where is V = Volume of water (m^3)

π = phi value

r = Radius of plankton net (m)

t = Length of rope (m)

The volume of water collected in the plankton net bucket is put into a 250 ml sample bottle and 2-3 drops of 30% H_2O_2 solution are added. The samples were taken to the laboratory and then filtered with a glass vacuum filtration set using 0.45 µm filter paper (GF/F, 47 mm Ø, Whatman). Observe microplastic samples under a microscope Olympus SZ61 to determine the abundance, size, color, shape and analyze the type of microplastic using FTIR IRAffinity 1-S Shimadzu and measure MP with 3R AnityWifiMicroscope. A total of 7 filter paper samples were analyzed at the Laboratory of Dr. Tomoya Kataoka, Department of Civil & Environmental Engineering, Graduate School of Science and Engineering, Ehime University.

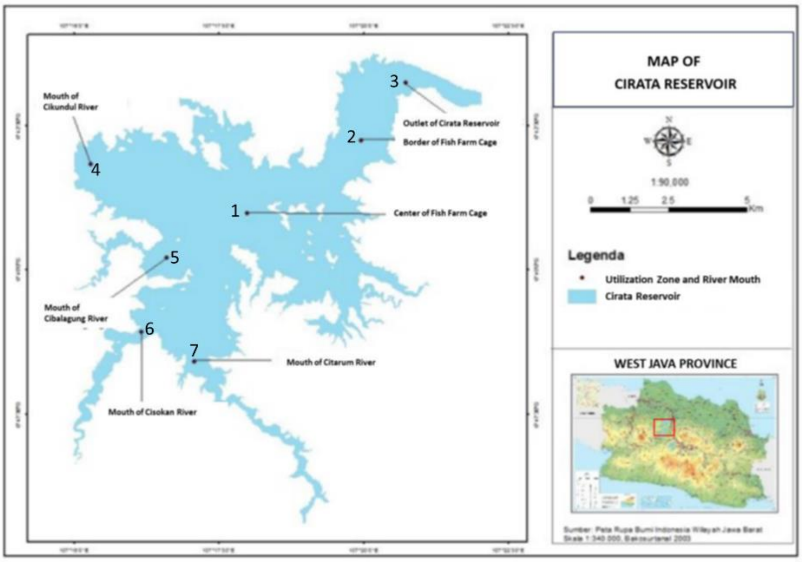

Figure 1. Map of microplastic sampling locations in the Cirata reservoir (Shofia, 2014)

Data Analysis

The abundance of microplastics can be calculated by comparing the number of particles found with the volume of filtered water. The following is a formula for calculating the abundance of microplastics.

$$MP\ abundance = \frac{Number\ of\ MP\ particle}{Volume\ of\ filtered\ water}$$

Results

Abundance of Microplastics

Based on the results of digital microscope analysis with a magnification of 50 to 100x, at each sampling location in the Cirata reservoir microplastics were found in the form of spheres, fragments, sheets, and fibers. The results of observations of samples on a quarter of the filter paper at 7 research locations found 356 microplastic particles (MP) and 188 non-microplastic, with an abundance of MP in the waters of the Cirata reservoir of 8.10 particles/m^3 (Table 1 and Figure 2).

Table 1. Amount of Microplastic (MP) in the Cirata Reservoir

Location	MP	Non MP	Volume (m^3)	(Particle MP/m^3)
Cirata 1A	56	60	6.28	8.92
Cirata 2B	48	4	6.28	7.64
Cirata 3A	88	16	6.28	14.01
Cirata 4B	60	0	6.28	9.55
Cirata 5A	40	52	6.28	6.37
Cirata 6A	48	16	6.28	7.64
Cirata 7A	16	40	6.28	2.55
Total	356	188	43.96	8.10

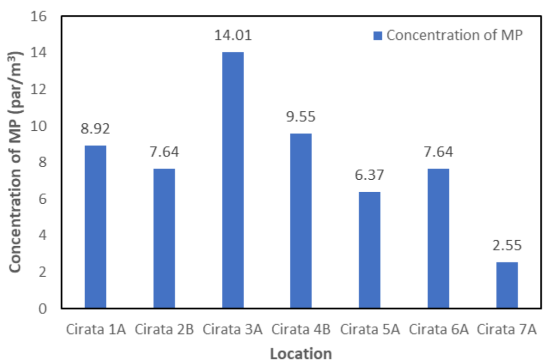

Figure 2. The abundance of Microplastic (MP) in the Cirata Reservoir

Microplastics Based on Shape and Colour

The Cirata Reservoir water samples observed found 4 types of microplastics, namely fibers, fragments, spheres, and sheets. According to McCormick *et al* (2016), the types of microplastics that are very often found on the surface of the water are in the form of fibers, fragments, and sheets. The abundance of microplastics in the waters of Cirata reservoir is mostly in the form of fibers at point 3A amounting to 10.83 particles/L, fragments at point 6A amounting to 3.82 particles/L, spheres and sheets at points 2B, 4B, and 6A amounting to 1.27 particles/L (Table 2 and Figure 3). The total percentage abundance of microplastics in this study was fibers of 71.91%, fragments of 21.35%, sheets of 4.49%, and spheres of 2.25%. The Cirata reservoir outlet as the 3A sampling location provided the largest contribution to the total microplastics detected in these waters.

Table 2. Amount of Microplastic (MP) Based on Shape

Sampel	Abundance (particle/m^3)			
	Sphere	Fragment	Sheet	Fiber
Cirata 1A	0	0	0	8.92
Cirata 2B	0	1.27	1.27	5.10
Cirata 3A	0	3.18	0	10.83
Cirata 4B	1.27	2.55	0	5.73
Cirata 5A	0	1.27	0	5.10
Cirata 6A	0	3.82	1.27	2.55
Cirata 7A	0	0	0	2.55

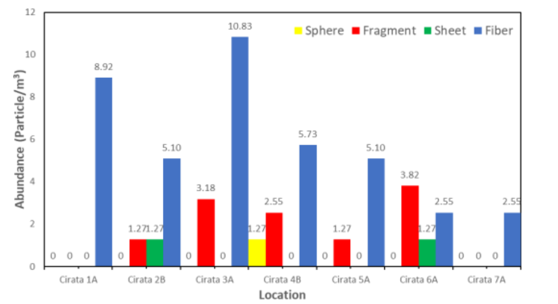

Figure 3. The Abundance of Microplastic (MP) Based on Shape

The amount of microplastics in the waters increases as the distance from the estuaries of the Citarum, Cisokan, Cibalagung, and Cikundul rivers increases. The amount of microplastics in the aquatic environment is mainly influenced by the amount of microplastic waste that enters the aquatic environment. Along with water flow, microplastics can accumulate in various ecosystem components. This accumulation process can reduce the abundance of microplastics in water bodies because it moves away from sources of input of microplastic pollutants.

The majority of the types of microplastics in the Cirata Reservoir are fiber types found at point 3A with black, brown, red/pink, yellow and blue colors (Table 3). The dominant microplastic colors found were brown and black with a percentage of 28.09% and 26.97%, followed by blue and yellow at 19.10%, red 4.49% and green 2.25% (Figure 4). The colors of microplastics can come from floating net cages, while the black (dark) color of microplastics is defined as microplastics that do not experience significant color changes. On the other hand, the transparent color of microplastics can indicate when the microplastics are photographically degraded by UV light (Hiwari et al., 2019).

Tabel 3. Microplastic (MP) Color Composition in Cirata Reservoir

Location	Black	Brown	Red/Pink	Yellow	Blue	Green	Total
Cirata 1A	3	0	3	0	7	1	14
Cirata 2B	2	4	0	2	3	1	12
Cirata 3A	4	7	1	7	3	0	22
Cirata 4B	9	3	0	2	1	0	15
Cirata 5A	2	4	0	4	0	0	10
Cirata 6A	3	4	0	2	3	0	12
Cirata 7A	1	3	0	0	0	0	4

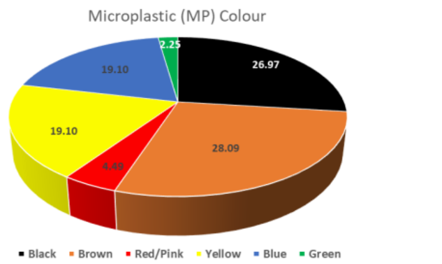

Figure 4. Percentage of Microplastic Color Composition in Cirata Reservoir

Types of Microplastic Polymers

There are 10 types of microplastic polymers found in the Cirata reservoir, namely polyethylene (PE), polypropylene (PP), polystyrene (PS), polyethylene-polypropylene (PEPP), polyethylene terephthalate (Pes/PET), acrylonitrile butadiene styrene (ABS), acryl polyamide (PA) ethylene vinyl acetate copolymer (EVA) and other thermoplastics (Figure 5). The largest percentage is microplastic polyethylene (PE) 22.47%, polyethylene-polypropylene (PEPP) 21.35%, polyamide (PA) 19.10% and other thermoplastic 19.10% (Figure 6).

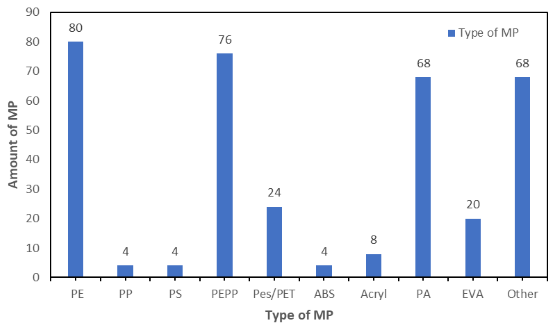

Figure 5. Type of Microplastic (MP) in Cirata Reservoirs

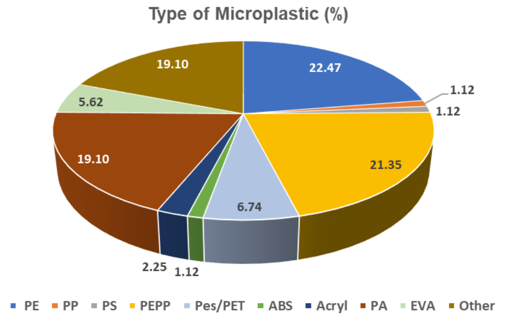

Figure 6. Percentage of Microplastic Type Composition in Cirata Reservoir

Future Challenges

This study generally identified the presence of various types of microplastics in the waters of the Cirata reservoir and found 10 types of microplastic polymers in various shapes and colors. The presence of microplastics in the waters of the Cirata reservoir indicates that there is a content of plastic waste which is generally caused by anthropogenic activities. With a large number of freshwater fish farms using the floating net cage system in the Cirata reservoir, it is very possible that microplastic contamination can be transferred to fish farms for human consumption because microplastics can endanger health because they can disrupt the respiratory, reproductive and endocrine systems. In the long term, this needs serious attention. Therefore, it is necessary to carry out more effective measures to reduce plastic waste disposal as well as long-term monitoring studies of microplastic contamination.

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