

STUDY OF MICROPLASTIC CONCENTRATIONS AT THE DRINKING WATER DEPOT IN SUMBERSARI VILLAGE, JEMBER REGENCY

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ABSTRACT

Study of Microplastic Concentrations at the Drinking Water Depot in Summersari Village, Jember Regency. Microplastics are a new pollutant that has become a global problem and requires treatment as soon as possible. Microplastics are plastic waste that degrades into small particles measuring <5 mm. Until now, microplastics have not only been found in the environment but also in drinking water. Based on the results of field studies, it is known that drinking water refills at drinking water depots (DAM) are an alternative option used by the people of the Summersari sub-district to meet their drinking water needs. This paper examines the presence of microplastics in refillable drinking water, including the characteristics, concentration, and exposure to microplastics in consumers of refillable drinking water. This observational study uses descriptive methods to systematically examine and present facts regarding microplastics and exposure to microplastics in DAM in the Summersari sub-district. The research showed that microplastics had contaminated 12 DAM with an average microplastic concentration of 7.1 particles/liter. The forms or types of microplastics found were fibers and fragments with sizes ranging from 0.01 mm to <5 mm and the colors most found were blue, black, red, gray, and transparent. The measurement results also explain that consumers of refillable drinking water will be exposed to microplastics of at least 5.61 particles/liter/day and a maximum of 15.98 particles/liter/day, depending on the amount of drinking water consumed daily.

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INTRODUCTION

The accumulation of plastic waste in the environment has become a cause of environmental pollution that requires treatment as soon as possible ⁽¹⁾. Plastic waste is difficult to decompose and takes hundreds of years to degrade in the environment. Society's massive consumption of plastic, which is not balanced with plastic waste management, is also responsible for the accumulation of plastic waste in the environment ⁽²⁾. The accumulation of plastic waste in the environment is also supported by the nature of plastic, which takes hundreds to thousands of years to degrade in nature ⁽³⁾. Incomplete plastic degradation only makes the plastic more susceptible to fragmentation, thus forming smaller fragments ⁽⁴⁾. The oxidative degradation of polymers in plastic waste by ultraviolet radiation can one day produce microscopic-sized particles, currently known as microplastics ⁽⁵⁾.

Microplastics are plastic fragments that measure less than 5 mm ⁽⁶⁾. Microplastics are made from two sources, namely primary and secondary microplastics ⁽⁷⁾. Microbeads in facial cleansing soap containing scrubs, glitter in make-up, and detergents are the main sources of primary microplastics ⁽⁸⁾. Following their dissolution in water, primary microplastics enter the environment. Meanwhile, fragmentation of large plastics into fragments, fibres, films, and granules is the main source of secondary microplastics ⁽⁹⁾. Microplastics, like their original product, plastic waste, possess an adhesive power that attracts bacteria to form biofilms on their surfaces. Microplastics can also bind to organic pollutants such as polycyclic hydrocarbons, insecticides, and heavy metals due to their hydrophobic properties ⁽¹⁰⁾.

Until this research was carried out, microplastic contaminants had been found in various environments, such as soil, air, sea water, and fresh water ⁽¹¹⁾. In aquatic ecosystems, microplastics have been found in the organs of aquatic biota, whether in biota consumed by humans or not, such as fish, shellfish, shrimp, snails, etc. Apart from that, microplastics have also been found in food and drinking water, such as bottled drinking water and refillable drinking water ⁽¹²⁾. The latest pollution in drinking water is the presence of microplastics contained in drinking water, both bottled drinking water and refillable drinking water ⁽¹³⁾. Microplastics found in refillable drinking water can come from the water source used, management processes that use equipment or pipes made of plastic, and containers or gallons that are used continuously ⁽¹⁴⁾. Microplastic particles enter the human body every year through consumption (digestion) and inhalation. Microplastics are primarily transferred through drinking water contaminated with microplastics ⁽¹⁵⁾.

Despite the fact that no experimental studies on humans have been conducted to determine the exact cause of the negative effects of microplastics on human health, exposure to microplastics allows for long-term effects on human health, given one of the cumulative properties of microplastics ⁽¹³⁾. Research on fish and invertebrates shows that microplastics with a size of less than 500 µm are possible to pass through the intestinal wall. Meanwhile, experiments on mice revealed that microplastics measuring less than 20 µm could accumulate in mice's liver, kidneys, and intestines ⁽⁴⁾.

Until now, research on microplastic concentrations focused on drinking water has not been comprehensive enough to be used as an accurate reference for handling problems related to microplastic contaminants in drinking water. Research on microplastics in drinking water is crucial because of the negative impacts they have, especially on humans. Drinking water that is not safe from dangerous contamination, such as microplastics, is a reference for conducting research on the concentration of microplastics at the Drinking Water Depot (DAM) in Summersari Village.

MATERIALS AND RESEARCH METHODS

This research method is observational research using a descriptive approach. This research used 12 samples of drinking water depots and 30 respondents who were consumers of refillable drinking water. Using the accidental sampling method, the number of samples was determined. The research will be conducted in Summersari Village, Jember Regency, in May 2023. The techniques used for data collection are observation, interviews, and laboratory tests. Drinking water samples were taken from a gallon containing 19 litres of drinking water and then filtered using a 400-mesh filter. Then it was rinsed with distilled water and put into a vial.

The tools and materials used in the research, which included taking analytical samples in the laboratory, were millimetre blocks, Erlenmeyer tubes, funnels, Petri dishes, Whatman filter paper, stereo microscopes, distilled water, vials, section tools (needles), writing instruments, and drinking water samples. refillable. Procedures for microplastic laboratory testing are as follows: The water samples that have been collected are then prepared. Clear water samples do not need to be destroyed for organic matter, so they can be filtered directly using Whatman paper, then dried on Whatman paper by placing it on a petri dish and leaving it for

24 hours at room temperature. Then, observe the microplastics under a stereo microscope. We observed the characteristics of microplastics under a stereo microscope, which included size, shape, and color, and grouped them into several criteria. 1) Form (fragment, fibre, film, and pellet); 2) Size (0.01-0.1 mm, > 0.1-0.5 mm).

>0.5–1 mm, >1–5 mm); and 3) the color of the microplastic (blue, red, clear, purple, black, yellow, orange, green, brown, and grey).

Descriptive analysis is the data analysis used. Descriptive analysis aims to describe or explain the characteristics of each research variable. The following formula is used to identify the abundance of microplastics at drinking water depots (DAM):

$$K = \frac{n}{v}$$

Information:

K : Microplastic concentration

(particles/l) n : number of microplastics (particles)

v : Sample volume (l)

Crosstabs analysis was also used to determine whether there was a relationship between a variable in DAM characteristics and the presence of microplastics in DAM samples. Meanwhile, to calculate the estimated exposure to microplastics in consumers of refilled drinking water, we modified the US Environmental Protection Agency (EPA) (2019) calculation of exposure through ingestion using the following formula:

$$Pm = (K)(V)$$

Information

Pm: Exposure to microplastics (particles/person/day)

K : Concentration of microplastics in refillable drinking water (particles/liter)

V: The number of refills of drinking water consumed in one day (litres/person/day)

RESEARCH RESULTS AND DISCUSSION

Microplastic form

Results Laboratory test results of the form of microplastics can be seen in Table 1.

Table 1. Forms of Microplastics						
No	Code Sample	Form Microplastics (Particles)				Amount
		Fiber	Filament	Fragment	Granule	(Particle)
1	D1	130	-	55	-	184
2	D2	71	-	52	-	123
3	D3	57	-	90	-	147
4	D4	64	-	25	-	89
5	D5	97	-	33	-	130
6	D6	18	-	23	-	41
7	D7	88	-	52	-	138
8	D8	62	-	53	-	115
9	D9	78	-	112	-	190
10	D10	94	-	58	-	152
11	D11	73	-	71	-	144
12	D12	59	-	97	-	156
Total		891		718		1609

Samples taken at 12 DAMs in Summersari subdistrict, as shown in Table 1, show two forms of microplastic particles, namely fibres and fragments. The fibre form was found more frequently in 8 DAM samples, while the fragment form was more frequently found in 4 DAM samples.

Microplastic size

The results of microplastic testing on DAM samples carried out at the Biology Laboratory of FKIP Jember University with microplastic sizes can be seen in Table 2.

Table 2: Size of Microplastics Found in DAM

Sample Code		Size Microplastics (mm)			
		0.01 - 0.1	> 0.1 - 0.5	> 0.5 - 1	> 1 - 5
1.	D1	-	49	74	61
2.	D2	-	43	47	33
3.	D3	1	36	36	74
4.	D4	-	37	27	25
5.	D5	-	36	42	52
6.	D6	2	9	14	16
7.	D7	-	35	78	25
8.	D8	-	40	39	36
9.	D9	6	47	72	65
10.	D10	2	33	65	52
11.	D11	-	49	54	41
12.	D12	-	34	76	46
Total		11	448	624	526

Table 2 explains the size of the microplastics found in the 12 DAM samples. The size of the most commonly found microplastics was in the range of more than 0.5 to 1 mm, namely 624 particles. The results of microplastic measurements also showed that there were only 4 DAM samples in which microplastics measuring 0.01 to 0.1 mm were found.

Microplastic color

Figure 1 shows the results of microplastic testing on DAM samples carried out at the FKIP Biology Laboratory, Jember University, in terms of the color and number of microplastic particles found.

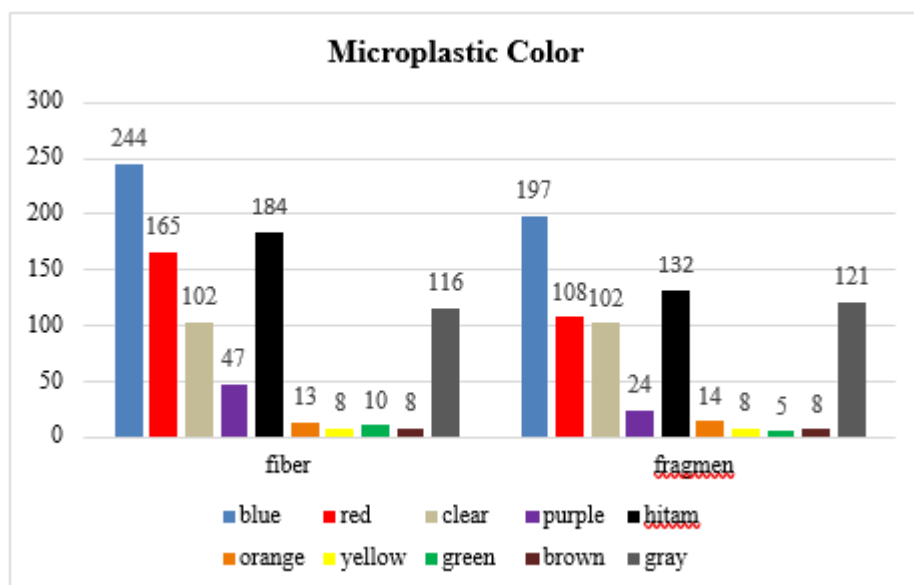


Figure 1 Color of Microplastics Found in DAM

The results of observing the colour of microplastics in Figure 1 show that blue, red, clear, black, and grey are the most abundant or dominant colours found in DAM samples.

Microplastic Concentration

The results of calculating microplastic concentrations in 12 DAM are presented in Table 3.

Table 3 shows the concentration of microplastics in DAM

Sample Code	Number of Microplastics	ConcentrationMicroplastics (Particles/L)
D1	184	9.7
D2	123	6.5
D3	147	7.7
D4	89	4.7
D5	130	6.8
D6	41	2.2
D7	138	7.3
D8	115	6.1
D9	190	10.0
D10	152	8.0
D11	144	7.6
D12	156	8.2
Average Microplastic Concentration		7.1

The highest microplastic concentration from the research results was shown by sample D9 at 10 particles/litre, while the lowest microplastic concentration could be found in sample D6, namely 2.2 particles/litre. Meanwhile, at 12 DAM, the average microplastic concentration was 7.1 particles per liter. High and low concentrations

The number of microplastics in DAM samples depends on the number of microplastics found in the sample.

Exposure to Microplastics in Drinking Water Consumers

The results of interviews with 30 respondents who consumed refillable drinking water regarding their daily consumption levels of refillable drinking water are in Table 4.

Table 4. Average Drinking Water Consumption among DAM Consumers

Drink (Liter/day)	Number of people	Percentage (%)
0.79	7	23.33%
1.59	13	43.33%
2.00	6	20.00%
2.25	4	13.33%
Total	30	100.00%

The results of research conducted on drinking water consumers shown in Table 4 explain that there are several differences in the average daily consumption of respondents. The average daily drinking water consumption is used to identify the number of microplastics that people ingest every day. Table 4.8 shows the average exposure to microplastics ingested per day by consumers of refillable drinking water.

Microplastic form

The forms of microplastic found in 12 locations were fibres and fragments, with the total number of each form being 891 fibres and 721 fragments. Therefore, fibre-shaped microplastic particles were the most frequently found in this study.

Fibre-shaped microplastics that are often found in research samples may come from human activities such as throwing away clothes or synthetic textile products or waste contamination from clothes washing activities, thereby polluting the environment where raw water sources exist ⁽¹⁶⁾. The results of this research are also the same as those carried out by Singh in 2022, who explained that the most common form of microplastic found was the fibre form, namely 13.2 microplastic particles in every litre ⁽¹⁷⁾. Mintenig's (2019) research also showed the same results, namely that the form of microplastic most commonly found in refillable drinking water was fibre ⁽¹⁸⁾.

Apart from fiber, the large number of microplastic fragments found in the samples is thought to have come from larger plastic fragments such as drinking bottles.

Food packaging has the potential to contaminate raw water sources used for refillable drinking water ⁽¹⁹⁾. The results of interviews and observations suggest that brushing gallons, which may not be sufficiently cleaned after rinsing, can also produce microplastic fragments, leaving behind microplastic particles that contaminate refillable drinking water. These microplastic fragments are thought to originate from polyethylene and polypropylene plastics ⁽²⁰⁾.

Microplastic Size

Microplastics are plastic waste fragments that are smaller than 5 mm and are classified into two main sources: primary and secondary. The primary source of microplastics is the industrial production of cosmetics in the form of microbeads and synthetic clothing fibers ⁽²¹⁾.

According to several studies, microplastics come in a variety of sizes. The most widely used size is less than 5 mm, as defined by the National Oceanographic and Atmospheric Association. However, there is no minimum limit for determining the size of microplastics. Even plastics measuring less than 0.1 μm , which are usually called nanoplastics, are also a type of microplastic. The existence of differences in the size of microplastics has led many other studies to use other measurements to determine the size of a plastic particle, which can be described as a microplastic ⁽²²⁾.

In this study, the overall size of microplastics in drinking water samples was less than 5 mm, and the smallest size was 0.01 mm, or 10 μm . Based on research, it is clear that the number of microfilters in the filtration device influences the amount of microplastics in refillable drinking water. DAM with more than 1 microfilter tends to contain smaller microplastics than DAM with only 1 microfilter ⁽²⁰⁾. Based on the observation results, it was not stated how many microfilters were installed in the 12 DAM samples. This could potentially explain the presence of microplastics ranging in size from 0.01 mm to 5 mm.

Microplastic Color

Microplastics have a variety of characteristics that differ based on their source. One of these differences is due to the color of the microplastics ⁽²³⁾. The colour of the microplastics found can be used as a guess in initial research regarding the type of plastic polymer and the source of the waste ⁽²⁴⁾. In this study, blue, red, clear, black, and grey were the colours that were more abundant or dominant in the DAM samples.

The colour differences in microplastics are thought to be caused by the origin of the colour of waste or synthetic materials, the result of anthropogenic activities, and degradation by continuous sunlight, which forms microplastic particles. Blue is the most dominant colour found in the samples, both in fibre and fragment form. The blue color is usually caused by laundry residue, clothing threads, and plastic degradation by sunlight. Apart from blue, there are also black and grey (dark), which are often found in drinking water samples ⁽¹³⁾. The black

colour of microplastic particles indicates that many contaminants are absorbed in microplastics and other organic particles. Black microplastics also have the ability to absorb high levels of pollutants and affect the texture of the microplastics ⁽²⁵⁾.

Microplastic Concentration

Refillable drinking water is one of the drinking waters contaminated by microplastics. Research conducted by the Spanish Catalonia Drinking Water Depot showed that of the 3 drinking water depots taken as samples, all contained microplastics with concentrations ranging from 1.26 to 4.23.

Particles per liter of water. Meanwhile, research also states that of the 9 samples of drinking water refills at DAM in Flanders, Belgium, all of them contained microplastics with a concentration of 0.02 to 0.03 particles/liter. The results of this study show that the average microplastic concentration in the 12 DAMs is 7.1 particles per liter.

Based on the research results, the concentration of microplastics in refill drinking water samples probably comes from raw water sources that have been contaminated with microplastics, microplastics that come from brushing gallons, and microfibers that possibly stick to the surface of the DAM device and gallon and thus enter the drinking water. The process of distributing drinking water from the DAM to consumers may also contribute to the presence of microplastics in the water. This is consistent with research indicating that ultraviolet radiation influences the rate of fragmentation or release of plastic molecules ⁽²⁶⁾.

In addition, the disinfection measures used may be influencing microplastic concentrations. The research results explain that DAM using reverse osmosis disinfection has a lower microplastic concentration compared to disinfection using ultraviolet irradiation or ozone. The research results show that all DAMs use ultraviolet (UV) irradiation disinfection before the process of filling water into gallons to minimize contamination of organic and inorganic substances ⁽²⁷⁾.

Gallon brushing facilities also influence the presence of microplastics in drinking water. Plastic gallons and gallon brushes can release microplastic particles during the brushing process due to friction. Inadequate rinsing can cause microplastic particles to stick to or settle in the gallon. According to interviews and observations, there were four DAMs with gallon brushing facilities.

Consumers of Drinking Water are exposed to microplastics.

Health risks can arise from the accumulation of microplastics in the body. To determine how much microplastic is likely to accumulate in the body, it is necessary to first know the amount of people's daily consumption of drinking water. According to the WHO and the Indonesian Ministry of Health, adults generally need 2 liters of water per day to meet their body's water needs and maximize their metabolism ⁽⁸⁾.

Based on the amount of daily consumption of refillable drinking water, exposure to microplastics ingested by the public can be determined by multiplying the average microplastics per liter of drinking water by the amount of drinking water consumed by consumers per day. According to the research results, people who consume 2 liters of refilled drinking water per day will swallow 14.20 microplastic particles per liter.

The more microplastics consumed through drinking water, the more likely it is that contaminants will accumulate in the kidneys and bladder. This is proven by research results showing that human urine contains microplastics. The presence of microplastics in urine explains the possibility that there are still microplastics that have accumulated or have even entered the bloodstream through the kidneys, although there has been no research on real health problems regarding the accumulation of microplastics ⁽¹⁷⁾.

CONCLUSIONS AND RECOMMENDATIONS

The microplastic concentration in the 12 DAM samples was 7.1 particles per liter. The concentration of microplastics likely originates from sources such as raw water, brushing gallons, and microfibers that adhere to the surface of DAM devices and gallons, ultimately finding their way into drinking water. According to health recommendations, consuming 2 liters of drinking water per day, exposes consumers to an average of 14.20 microplastic particles per liter. More and more

If microplastics are ingested, there is a higher possibility of microplastic accumulation in the kidneys and bladder. DAM handlers can brush gallons in closed spaces to minimize microplastic contamination from the air. Apart from that, health agencies are advised to carry out supervision of DAM sanitation hygiene in accordance with regulations and provide education to DAM handlers regarding the sanitation hygiene of drinking water depots.

REFERENCES

1. Mishra S, Rath C, Das AP. Marine micro fi ber pollution : A review on present status and future challenges. *Mar Pollut Bull.* 2019;140(November 2018):188–97.
2. Muthmainnah, Adris. *Pengelolaan Sampah Di Tempat Pembuangan Akhir (Tpa) Patommo Sidrap (Tinjauan Yuridis Peraturan Daerah No . 7 Tahun 2016 Tentang Pengelolaan Persampahan)*. 2020;4(1).
3. World Bank Group. *Laporan Sintesis Sampah Laut Indonesia*. 2018;(April).
4. Faujiah IN, Wahyuni DR. Kelimpahan dan Karakteristik Mikroplastik pada Air Minum serta Potensi Dampaknya terhadap Kesehatan Manusia. 2022;7:89–95.
5. Sawalman R, Zamani NP, Werorilangi S, Ismet MS. Akumulasi Mikroplastik Pada Spesies Ikan Ekonomis Penting Di Perairan Pulau Barranglompo, Makassar. 2021;13(August):241–59.
6. Anderson A, Andrady AL, Baker JE, Bouwman H. Sources, fate and effects of microplastics in the marine environment: a global assessment. 2015;(April).
7. Rachmat SLJ, Purba NP, Agung MUK, Yuliadi LPS. Karakteristik sampah mikroplastik di Muara Sungai DKI Jakarta Characteristic. *Depik J Ilmu-ilmu Perairan, Pesisir dan Perikan*. 2019;8(1):9–17.
8. Zettler ER, Mincer TJ, Amaral-zettler LA. Life in the “ Plasticsphere ” : Microbial Communities on Plastic Marine Debris.
9. Katyal D, Kong E, Villanueva J. Mikroplastik di lingkungan : dampak pada kesehatan manusia dan strategi mitigasi di masa depan. 2020;63(April):27–31.
10. Supit A, Tompodung L, Kumaat S. Mikroplastik sebagai Kontaminan Anyar dan Efek Toksiknya terhadap Kesehatan. 2022;13:199–208.
11. Muchlissin SI, Widyanto PA, Sabdono A, Kelautan I, Perikanan F, Diponegoro U. Kelimpahan Mikroplastik Pada Sedimen Ekosistem Terumbu di Taman Nasional Laut Karimunjawa. 2021;24(1):1–6.
12. Avio CG, Gorbi S, Regoli F, Avio CG, Gorbi S, Regoli F. Plastics and microplastics in the oceans: From emerging pollutants to emerged threat. *Mar Environ Res.* 2016;2–14.
13. Luqman A, Nugrahapraja H, Wahyuono RA, Islami I, Haekal H, Fardiansyah Y, et al. Microplastic Contamination in Human Stools , Foods , and Drinking Water Associated with Indonesian Coastal Population. 2021;1–9.
14. Amaludin. *Gambaran Frekuensi Pencucian Galon dengan Mesin Sikat terhadap Kandungan Mikroplastik Air Minum Isi Ulang (AMIU) Tahun 2022*. Universitas Hassanuddin; 2022.
15. Iqbal M, Kamaludin A, Gumiyarna H. Analisis Keberadaan Mikrobiologi Air Minum Depot Air Minum. 2022;21(2).
16. Scherer C, Weber A, Stock F, Vurusic S, Egerci H, Kochleus C, et al. Comparative assessment of microplastics in water and sediment of a large European river. *SciTotal*

- Environ. 2020;738:139866.
17. Singh S, Trushna T, Kalyanasundaram M, Tamhankar AJ, Diwan V. Microplastics in drinking water: a macro issue. *Water Supply*. 2022;22(5):5650–74.
 18. Mintenig SM, Löder MGJ, Primpke S, Gerdt G. Low numbers of microplastics detected in drinking water from ground water sources. *Sci Total Environ*. 2019;648:631–5.
 19. Novotna K, Cermakova L, Pivokonska L, Cajthaml T, Pivokonsky M. Microplastics in drinking water treatment – Current knowledge and research needs. *Sci Total Environ*. 2019;667:730–40.
 20. Pivokonsky M, Cermakova L, Novotna K, Peer P, Cajthaml T, Janda V. Occurrence of microplastics in raw and treated drinking water. *Sci Total Environ*. 2018;643:1644–51.
 21. Mason SA, Welch VG, Neratko J. Synthetic Polymer Contamination in Bottled Water. 2018;6(September).
 22. Güven O, Gökdağ K, Jovanović B, Kideys AE. Microplastic litter composition of the Turkish territorial waters of the Mediterranean Sea, and its occurrence in the gastrointestinal tract of fish. *Environ Pollut*. 2017;223:286–94.
 23. Koelmans AA, Mohamed Nor NH, Hermesen E, Kooi M, Mintenig SM, De France J. Microplastics in freshwaters and drinking water: Critical review and assessment of data quality. *Water Res*. 2019;155:410–22.
 24. Schymanski D, Oßmann BE, Benismail N, Boukerma K, Dallmann G, Von E. Analysis of microplastics in drinking water and other clean water samples with micro-Raman and micro-infrared spectroscopy : minimum requirements and best practice guidelines. 2021;5969–94.
 25. Oladoja NA, Unuabonah IE. The pathways of microplastics contamination in raw and drinking water. *J Water Process Eng*. 2021;41(February):102073.
 26. Shen M, Song B, Zhu Y, Zeng G, Zhang Y, Yang Y, et al. Removal of microplastics via drinking water treatment: Current knowledge and future directions. *Chemosphere*. 2020;251:126612.
 27. Fadilah IR. Pencemaran Mikroplastik pada Gurita Octopus spp. di Perairan Pulau Pramuka Kepulauan Seribu. *Univ Islam Negeri Syarif Hidayatullah*. 2021;36.

