International Seminar and Workshop on Public Health Action
https://swopha.dinus.ac.id

Microplastic Contamination in Refillable and Packaged Drinking Water: Sources, Types, and Health Impacts

Abdul Rahman[1]*

[1]Magister Of Public Health,Faculty Of Public Health, Halu Oleo University, Kendari, Indonesia

Article Info
Article History
Submitted: 06/08/2025
Revised: 28/08/2025
Accepted: 22/08/2025
Keywords:
Microplastics; Drinking water; Bottled water

Abstract

Microplastics are plastic particles smaller than 5 millimeters that have been found widely dispersed in various environments, including in bottled drinking water and refillable drinking water. The presence of microplastics in drinking water is very important because water is a basic human need and a major pathway for microplastics to enter the body, which may pose health risks. Using the literature review study method, through Google Scholar, PubMed, Scopus, and following the guidelines established by PRISMA. As a result, microplastics are found in drinking water due to packaging and processing factors influenced by packaging, distribution, and inadequate processing standards. These particles vary in shape, color, size, and types of polymers such as PET, PE, and PP. Their main sources come from plastic degradation, abrasion of gallon containers, and poor washing and storage processes. The presence of accumulated microplastics in the human body has the potential to cause health issues such as inflammation, oxidative stress, as well as metabolic and digestive disorders. Microplastics have been found in bottled and packaged drinking water, with varying shapes and sizes. This contamination comes from plastic packaging, distribution processes, and depot equipment that do not meet standards. The presence of microplastics can pose health risks.

Correspondence Address:
Jl. H Banawula Sinapoy, Anggoeya, Kencari City, Southeast Sulawesi, Indonesia
E-mail: manlerahman@mail.com

eISSN 3063-2439

Introduction

Microplastics are plastic particles smaller than 5 millimeters that have been widely found dispersed in various environments, including in bottled drinking water and refill drinking water. Research by Syarif et al. (2021) showed that all samples of refill drinking water tested in Tamangapa, Makassar, contained microplastics in the form of fibers and fragments with sizes ranging from 0.088 to 3.411 millimeters. The presence of microplastics in drinking water is very important because water is a basic human need and serves as the main pathway for microplastics to enter the body, which can potentially pose serious health risks (Mason et al., 2018; WHO, 2019).

Sources of microplastics in drinking water can originate from processing, distribution systems, and packaging. The processing and distribution of both tap water and packaged water can lead to the release of microplastic particles that persist until they reach consumers (Syarif et al., 2021). Additionally, exposure to sunlight and high temperatures on plastic packaging bottles can accelerate plastic degradation, thereby increasing microplastic contamination in drinking water (Elkhatib & Oyanedel-Craver, 2020). The diverse forms of microplastics, such as fibers, fragments, and pellets, reflect various pollution sources that need to be identified for effective management (Shadrina, 2024).

Exposure to microplastics through drinking water has the potential to cause negative health impacts. Microplastic particles can accumulate and penetrate biological systems in the body, carrying harmful chemical compounds such as heavy metals and endocrine disruptors that can cause inflammation, organ function disorders, and metabolic disruption (Rai et al., 2024). The very small size of microplastics

allows absorption by body organs and triggers serious systemic toxic effects, making in-depth research on this risk very necessary (Mason et al., 2018).

The water treatment technology currently in use, including dual media rapid sand filter systems, is not fully effective in removing very small microplastics from drinking water (Elkhatib & Oyanedel-Craver, 2020). This limitation indicates the need for the development of more advanced purification technologies and microplastic detection methods to ensure the quality of drinking water. Furthermore, regulations and drinking water quality standards need to be strengthened and integrated with good plastic waste management to reduce the sources of microplastic pollution in the aquatic environment (Mustikasari, 2021).

In addition to technical aspects, the role of education and community awareness is crucial in efforts to reduce microplastic pollution, especially through sustainable plastic waste management and active community engagement (Qodry, 2025). Therefore, a comprehensive literature review study is necessary to integrate various scientific research findings and formulate effective multisectoral strategies for mitigating microplastic pollution in drinking water.

Methods

This research utilizes a Systematic Literature Review (SLR) approach with a descriptive design to collect 50 articles and analyze articles available on the internet. Searching for scientific publications by identifying articles published between 2020-2024 using keywords: microplastics, drinking water, and packaged water, from Indonesian electronic databases such as *Google Scholar*, *PubMed* and *Scoopus.* Data analysis using PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis). The analysis focuses on the presence and identification of microplastic content in drinking water consumed in Indonesia by identifying articles published between 2020 and 2024, using keywords such as microplastics and drinking water.

Results

Table 1. Systematic Review

No.	Autor / Year	Title	Methods	Results
1	Machrany Syarif, Anwar Daud, Muh. Fajaruddin Natsir/2021	Identification of the Existence and Forms of Microplastics in Refill Drinking Water in Tamangapa Village, Makassar City	Observational quantitative with a descriptive approach, using laboratory tests.	A total of 9 samples of refillable drinking water tested were found to have all samples positive (100%) for microplastics.
2	Nur Rachmi, Abd. Gafur, Hidayat/2024	Identification of the Existence and Form of Microplastics in Refillable Drinking Water Depots in Pampang Village, Makassar City	Purposive sampling method	The results of the microplastic examination show that all positive samples contain microplastics. The microplastics that were most commonly found are in the form of lines and films with sizes ranging from 0.322 to 8.155 mm.
3	Rahajeng Tri Wahyuni, Globila Nurika/2024	Study Of Microplastic Concentrations At The Drinking Water Depot In Sumbersari Village, Jember Regency	Observational study uses descriptive methods	The research showed that microplastics had contaminated 12 DAM with an average microplastic concentration of 7.1 particles/liter.
4	Atyaf Umi Faizah, Sugeng Abdullah, Budi Triyantoro, Febri Apwanti Kusumaningtyas/2020	A Comparative Study About The Amount Of Microplastic In Polyethylene Terephtalate (Pet) Drinking Water That Was Exposed And Not Exposed By Sun At Environmental Health Laboratory Of	This type of research is pre-experimental using the static group comparison design	The results showed that there were microplastics in PET bottled water exposed and not exposed to sunlight. Samples of bottled PET which exposed to sunlight have microplastic's number of 175 particles/ liter. Whereas bottled water

No.	Autor / Year	Title	Methods	Results
		Poltekkes Kemenkes Semarang At The Year 2020		that was not exposed to sunlight has microplastic's number of 132,25 particles/ liter.
5	Tasya Aulia Putri Siregar, Devi Nuraini Santi/2023	Analysis of Physical Quality and the Presence of Microplastics in Refillable Drinking Water in Medan Selayang District	This was a descriptive study with observational and interview methods	The processing and cleaning in the drinking water depots have all met the health standards (100%). All samples from drinking water depots contained microplastics in the form of fibers and fragments per liter.
6	Udrika Lailatul Qodri /2025	Introduction to Microplastics and How to Reduce Exposure in Drinking Water and Packaged Food in Perante Village	Using a participatory approach method	This socialization program is designed to educate the Perante Village community about the impact of microplastic exposure on food security.
7	Muhammad Ikhram, Wathri Fitrada, Vina Lestari Riyandini/2024	Microplastic Analysis in Bottled Drinking Water in Padang City	Quantitative observational with a descriptive approach	The microplastic particles found are dominated by fragment particles, followed by fibers and pellets.
8	Edy Supriyo, Siti Nurlaela Noviana/2023	Microplastic Content in Packaged Drinking Water (AMDK) Circulating in Semarang, Central Java	Testing the microplastic content in bottled PET drinking water that was exposed and not exposed to sunlight using microplastic particle analysis.	All samples contained microplastics in the form of fragments and fibers measuring 1.91-44.85 µm and 2.94-130.02 µm respectively.
9	Isma Nur Faujiah, Ira Ryski Wahyuni/2021	Abundance and Characteristics of Microplastics in Drinking Water and Their Potential Impact on Human Health	Literature review method with descriptive qualitative data analysis.	In packaged drinking water, fragments of microplastics in the form of polypropylene (PP) were found at a concentration of 10.4 particles/L with a size of >100 µm, and 335 particles/L with a size of 6.5-100 µm. In refill drinking water, fiber-shaped microplastics of High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), and Polyethylene (PE) were found at quantities of 159, 130, 67, and 35 particles, respectively, with colors blue, red, clear, and yellow.
10	Rahmi Amir/2022	Factors influencing microplastic	Systematic literature review	This systematic literature review found that bottled

No.	Autor / Year	Title	Methods	Results
		contamination in bottled drinking water in Indonesia		drinking water in Indonesia contains 7,043 - 8,339 microplastic particles/L, primarily composed of PP, PE, and PET polymers. Factors influencing contamination include untreated waste disposal, high pollution levels, production processes, sunlight exposure, and repeated bottle use.

Discussion

The coastal areas of Indonesia still face sanitation problems, such as limited access to clean water, low quality of waste management, and minimal ownership of sanitary latrines. This situation increases the risk of environmental pollution, including the accumulation of plastic waste that can degrade into microplastics in coastal waters. The limited capacity of communities to manage household waste and poor sanitation conditions are one of the pathways for microplastics to enter the water consumed by coastal communities (Rahman & Isnaeni, 2025).

Water pollution in coastal areas originates from domestic waste, agriculture, industry, and plastic waste. The impacts include an increase in waterborne diseases, such as diarrhea and skin infections, as well as the accumulation of harmful substances in the body through the consumption of seafood. The presence of abundant microplastics in coastal waters further exacerbates this situation, as they can enter the marine food chain and pose long-term health risks, including disruptions to the digestive, kidney, and nervous systems. When associated with microplastics, the entry of plastic solid waste into river streams has the potential to become an additional source of unidentified pollutants in this study, thereby further decreasing water quality and posing risks to public health. (Nurfadilah et al., 2025)

Microplastics have been detected in refill drinking water and in packaging in various cities in Indonesia (Wahyuni & Nurika, 2024). Research in Medan Selayang shows that all drinking water depots tested contained microplastics even though their physical quality met standards (Siregar & Santi, 2025). In Makassar, all samples from Pampang village were found to positively contain microplastics in the form of fibers and films (Rachmi et al., 2024). Another study mentions that microplastic particles were found in the form of fibers and fragments with sizes ranging from 0.01 to <5 mm (Faujiah & Wahyuni, 2022).

Global research by Mason et al. (2018) states that 93% of bottled water samples from various countries contain microplastics, including Indonesia. Supriyo and Noviana (2023) found that bottled water circulating in Semarang contains microplastic particles measuring up to 130 µm. Ikhram et al. (2024) reported that the microplastic content in Padang reached 11 particles/liter, even without direct exposure to sunlight. Syarif et al. (2021) also detected microplastics in all samples of refill water depots in Tamangapa, Makassar.

Qodri (2025) states that microplastics were found in significant amounts in production water and bottled water in Perante Village, including types PET and PP. Wulandari et al. (2024) reported that microplastics were identified even in water that had been filtered using a dual media sand filter system. Faizah et al. (2020) noted that microplastics also appeared in PET bottled water stored under direct sunlight. Ikhram et al. (2024) added that 100% of bottled water samples in Padang were contaminated with microplastics, both those exposed and not exposed to heat.

Exposure to sunlight on PET packaging has been shown to cause the release of microplastic particles into drinking water (Faizah et al., 2020). Supriyo and Noviana (2023) demonstrated that an increase in temperature up to 40°C led to a spike in microplastic content up to 97 particles/500 mL in bottled plastic water. Ikhram et al. (2024) explained that even if the water is not exposed to heat, contamination still occurs due to micro-degradation from the distribution and packaging process. Mason et al. (2018) noted that microplastic particles were found to originate from bottle caps and the inner walls of water packaging.

In addition to packaging, the condition of refill water depots also significantly contributes to microplastic contamination (Siregar & Santi, 2025). Research conducted by Qodri (2025) observed that the majority of depots still use worn-out and unfit gallons, and some are even patched with glue. Wahyuni and Nurika (2024) added that microplastic contamination can occur from the processing system, such as

the use of plastic pipes or tanks. Syarif et al. (2021) suspect that imperfect filtration and poor sanitation of the depots worsen the condition of refill water.

Faujiah and Wahyuni (2022) explain that abrasion caused by repeated washing of gallon containers can produce microplastic particles measuring 1–1.5 mm. Wulandari et al. (2024) found that the effectiveness of filtration media in filtering microplastic particles highly depends on the size of the sand and microplastics. Rachmi et al. (2024) highlight the weak government oversight on the quality of depot water as a cause for uncontrolled microplastics. Ikhram et al. (2024) state that irregularities in quality supervision of depots create a significant opportunity for microplastic contamination.

The types of microplastics commonly found in drinking water are fibers and fragments ranging from micro to macro sizes (Supriyo & Noviana, 2023). Ikhram et al. (2024) showed that fragments are more dominant than fibers and pellets in bottled mineral water from Padang. Mason et al. (2018) reported that the size of microplastics in bottled drinking water ranges from 6.5 µm to 100 µm. Faujiah and Wahyuni (2022) found variations in the color of microplastics such as blue, red, yellow, and clear in refill water from various depots.

Wahyuni and Nurika (2024) detected that the particles found in refill water in Jember are generally in the form of blue and red fibers. Rachmi et al. (2024) also noted the presence of a film thicker than 5 mm in the Pampang depot samples in Makassar. Syarif et al. (2021) documented microplastics in the form of lines and fragments with a maximum size of 1.6 mm in Tamangapa. Qodri (2025) noted that PET, PE, and PVC are the most commonly found types of polymers in bottled and refill drinking water.

Faizah et al. (2020) showed that the degradation of plastic materials occurs due to exposure to sunlight and high temperatures, accelerating the release of microplastics from the packaging walls. Wulandari et al. (2024) noted that microplastics <400 µm are more difficult to filter compared to larger sizes, making them prone to slip into consumable water. Ikhram et al. (2024) found that brown and clear pellets have also begun to appear in bottled water, albeit in smaller quantities. Siregar and Santi (2025) suggested the need for further identification of the types and sources of polymers to prevent broader impacts.

Wahyuni and Nurika (2024) state that microplastic particles <20 µm can penetrate the intestinal wall and spread to organs such as the liver and kidneys. Syarif et al. (2021) reveal that long-term exposure can cause digestive system disorders and internal inflammation. Faujiah and Wahyuni (2022) add that microplastics carry toxic chemical compounds such as heavy metals and pesticides, which can cause oxidative stress in the body. Qodri (2025) explains that the accumulation of microplastics can also lead to changes in eating patterns and disturbances in gut microbiota.

Faizah et al. (2020) mencatat bahwa senyawa dari lapisan botol plastik dapat bermigrasi ke dalam air dan berpotensi bersifat karsinogenik. Wulandari et al. (2024) memperingatkan bahwa mikroplastik berukuran nano lebih berbahaya karena lebih mudah masuk ke dalam sistem peredaran darah. Rachmi et al. (2024) menyarankan bahwa paparan mikroplastik dapat menimbulkan respons imun tubuh terhadap benda asing, memicu reaksi peradangan kronis. Ikhram et al. (2024) menekankan bahwa belum ada batas aman yang ditetapkan WHO, sehingga pencegahan harus dilakukan secara dini.

Mason et al. (2018) menyebutkan bahwa partikel mikroplastik dalam air minum dapat masuk ke tubuh secara tidak disadari dalam jumlah besar setiap harinya. Supriyo dan Noviana (2023) memperingatkan bahwa partikel berukuran kecil dapat terakumulasi di jaringan dan mengganggu fungsi organ vital. Siregar dan Santi (2025) merekomendasikan perlunya evaluasi rutin terhadap kualitas air depot dan kampanye edukatif kepada masyarakat. Ikhram et al. (2024) menegaskan pentingnya penetapan regulasi nasional mengenai ambang batas mikroplastik dalam air minum.

Conclussion

Microplastics have been consistently found in bottled and refill drinking water, with varying shapes and sizes. This contamination primarily originates from plastic packaging, distribution processes, and depot equipment that do not meet standards. Polymer types such as PET, PE, and PVC are the most dominant. Although the health impacts are still being researched further, the accumulation of microplastics has the potential to cause digestive system disturbances, inflammation, and introduce toxic compounds into the body. Efforts for monitoring, regulation, and public education are urgently needed to prevent further risks to human health.

Author Contributions

The authors have no conflicts of interest to declare.

Acknowledgments

The authors would like to thank the committee of the 5th International Seminar and Workshop on Public Health Action (ISWOPHA 2025) for the opportunity and support in this publication process.

References

Amir, R. (2023). Factors influecing microplastic contamination in botted wrinking water in indonesia: a systematic review. *BKM Public Health & Community Medicine*, *39*(10), 1-9. https://repository.umpar.ac.id/id/eprint/424

Elkhatib, D., & Oyanedel-Craver, V. (2020). A critical review of extraction and identification methods of microplastics in wastewater and drinking water. *Environmental Science & Technology*, *54*(12), 7037-7049. https://doi.org/10.1021/acs.est.9b06672

Faizah, A. U., Abdullah, S., Triyantoro, B., & Kusumaningtyas, F. A. (2020). A Comparative Study About The Amount of Microplastic In Polyethylene Terephtalate (PET) Drinking Water That was Exposed and Not Exposed By Sun At Environmental Health Laboratory Of Poltekkes Kemenkes Semarang At The Year 2020. *Buletin Keslingmas*, *39*(4), 175-180.

Faujiah, I. N., & Wahyuni, I. R. (2022). Kelimpahan Dan Karakteristik Mikroplastik Pada Air Minum Serta Potensi Dampaknya Terhadap Kesehatan Manusia. *Gunung Djati Conference Series*, 7, 89–95. https://conferences.uinsgd.ac.id/index.php/gdcs

Ikhram, M., Fitrada, W., & Riyandini, V. L. Analisis Mikroplastik Pada Air Minum Dalam Kemasan Di Kota Padang. *METANA*, *20*(2), 79-84. DOI: https://doi.org/10.14710/metana.v20i2.62832

Mason, S. A., Welch, V. G., & Neratko, J. (2018). Synthetic Polymer Contamination In Bottled Water. *Frontiers In Chemistry*, 6, 407. https://doi.org/10.3389/fchem.2018.00407

Mustikasari, D. A. (2021). Perlindungan Hukum Bagi Konsumen Produk Air Minum Dalam Kemasan Dari Kandungan Mikroplastik. Universitas Muhammadiyah Jember, 31-1. http://eprints.ums.ac.id/id/eprint/7860

Qodri, U. L. (2025). Penyuluhan Pengenalan Mikroplastik dan Cara Mengurangi Paparannya Pada Air Minum dan Makanan Kemasan di Desa Perante. *Masyarakat Mandiri: Jurnal Pengabdian dan Pembangunan Lokal*, *2*(1), 01-06. DOI: https://doi.org/10.62951/masyarakatmandiri.v2i1.1001

Rachmi, N., & Gafur, A. (2024). Identifikasi Keberadaan Dan Bentuk Mikroplastik Depot Air Minum Isi Ulang Di Kelurahan Pampang Kota Makassar. *Window of Public Health Journal*, *5*(5), 594-601. DOI: https://doi.org/10.33096/woph.v5i5.1864

Rai, I. G. A., Wiadnyana, I. G. A. G., & Dharmadewi, A. A. I. M. (2024). Paparan mikroplastik dan potensi risiko kesehatan pencernaan. *Emasains: Jurnal Edukasi Matematika dan Sains*, *13*(1), 105-112. DOI: https://doi.org/10.59672/emasains.v13i1.3888

Shadrina, A. (2024). *Analisis Kelimpahan Mikroplastik Pada Air Lindi Di Tempat Pemrosesan Akhir (TPA) Gampong Jawa Banda Aceh* (Doctoral dissertation, UIN Ar-Raniry Fakultas Sains dan Teknologi). http://repository.ar-raniry.ac.id/id/eprint/37301

Siregar, T. A. P., & Santi, D. N. (2025). Analisis kualitas fisik dan keberadaan mikroplastik pada air minum isi ulang di Kecamatan Medan Selayang tahun 2023. *Tropical Public Health Journal*, *5*(1), 1-10. DOI: https://doi.org/10.32734/trophico.v5i1.16036

Supriyo, E., & Noviana, S. N. (2023). Kandungan Mikroplastik Pada Air Minum Dalam Kemasan (AMDK) yang Beredar di Semarang, Jawa Tengah. Metana, 19 (2), 69–78. DOI: https://doi.org/10.14710/metana.v19i2.58548

Syarif, M., Daud, A., & Natsir, M. F. (2021). Identifikasi Keberadaan Dan Bentuk Mikroplastik Pada Air Minum Isi Ulang Di Kelurahan Tamangapa Kota Makassar. *Hasanuddin Journal Of Public Health*, 2(3), 346–354. DOI: http://dx.doi.org/10.30597/hjph.v2i3.11971

Wahyuni, R. T., & Nurika, G. (2024). Microplastics Study of Microplastic Concentrations at the Drinking Water Depot in Sumbersari Village, Jember Regency. *JURNAL KESEHATAN LINGKUNGAN: Jurnal dan Aplikasi Teknik Kesehatan Lingkungan*, *21*(1), 125-134. https://doi.org/10.31964/jkl.v21i1.857

Wulandari, M., Marpaung, K., Prasaningtyas, A., Yorika, R., Harfadli, M. M., & Zulfikar, A. (2024). Performance Of Rapid Sand Filter Dual Media For Microplastic Removal In The Water. *Journal Of Community Based Environmental Engineering And Management*, 8(1), 103–110. DOI: https://doi.org/10.23969/jcbeem.v8i1.12502