

This article
contributes to:



6 CLEAN WATER
AND SANITATION



Article Info

Submitted:

2025-09-23

Revised:

2025-11-03

Accepted:

2025-11-05

Published:

2025-11-07



This work is
licensed under a
Creative
Commons
Attribution-
NonCommercial
4.0 International
License

Publisher

Universitas
Panca Marga

Microplastic Contamination in Drinking Water Treatment Systems: A Case Study of Bedadung River Jember

Siti Muyasaroh^{1*}, Adi Mustika¹, Wahyu Nur Achmadin¹

¹ Environmental Engineering, Faculty of Science and Technology, Universitas PGRI Argopuro Jember, 68121, Indonesia

*muyassaroh.siti.sm@gmail.com

Abstract

Microplastic contamination in drinking water systems is an emerging environmental and public health issue. This study investigated the abundance, size distribution, and polymer composition of microplastics across the Bedadung River water treatment chain, from source to consumer taps. Seven sampling points were established, including upstream locations, intake sites, treatment plant reservoirs, and tap water from two water treatment plants (Tegal Gede and Tegal Besar). Microplastic concentrations ranged from 49.33 to 160 particles/L, with particle sizes averaging 0.102–0.233 mm. Contrary to expected treatment outcomes, both plants demonstrated significant increases in microplastic concentrations post-treatment: Tegal Gede saw a 78% increase, while Tegal Besar exhibited a 140% rise. The highest contamination (160 particles/L) was recorded at the Tegal Besar treated water reservoir. These elevated microplastic levels in treated and consumer tap water highlight a critical gap in current water treatment processes, suggesting that material migration from treatment infrastructure, including plastic pipes and filtration components, may contribute to contamination. The predominance of fiber-type microplastics, mainly polyethylene terephthalate (PET), underscores the need for specialized microplastic removal processes and infrastructure upgrades to safeguard public health.

Keywords: Microplastic, Drinking Water Treatment, FTIR Analysis, Polymer, Bedadung River

1. Introduction

Microplastics are plastic particles measuring less than 5 mm [1] and have been detected in various rivers worldwide [2] [3], including in Indonesia [4] [5]. Microplastics originate from various sources, such as plastic waste degradation, industrial waste, and domestic activities. These particles can persist for long periods in the environment and could adsorb chemical pollutants, such as heavy metals and persistent organic compounds, which can increase their toxicity [6]. The presence of microplastics not only threatens aquatic ecosystems [7] but also has the potential to contaminate raw water sources used for drinking water [8].

The Bedadung River is a raw water source for the Tirta Pandalungan Dam, which supplies drinking water to the people of Jember and the surrounding area. However, increasing microplastic pollution in freshwater poses a serious risk to raw water quality and public health. Microplastics originate from the degradation of plastic waste and anthropogenic activities, which can absorb hazardous pollutants and potentially enter the drinking water supply. The Bedadung River is a Class III water category, which still meets the requirements as a raw water source [9] [10]. As the primary source of raw water for the Regional Drinking Water Company (Perumdam) Tirta Pandalungan in Jember Regency, using the Tegal Gede and Tegal Besar Water Treatment Plants (IPA) [11] [12], regular water quality monitoring is necessary for pollutant parameters from domestic and agricultural activities, one of which is microplastics. Based on the CCME-WQI water quality index range, the Bedadung River was categorized as fair to marginal from 2016 to 2019 [12], while the NSF-WQI method categorized the Bedadung River as moderate [10].

The threat of microplastic pollution in the Bedadung River has become a serious environmental issue in recent years [13], as only around 20% of Jember Regency's total daily waste is properly managed, while the remainder is dumped and enters the river [14]. Perumdam Tirta Pandalungan in Jember also has an obligation to preserve the environment. Several nature conservation activities have been implemented to protect all water source areas [15]. Therefore, understanding the level of microplastic contamination in the Bedadung River can provide input for Perumdam Tirta Pandalungan in monitoring and evaluating the institution's performance.

Several studies on microplastics in the Bedadung River, Jember, includes analysis of microplastic abundance in water and gastropods in the Bedadung River segment, Kaliwates District, Jember Regency [16], and analysis of microplastic content in fish in the Bedadung River, Jember, East Java [17]. Although several studies have identified microplastics in the Bedadung River, previous studies have not comprehensively mapped the distribution of microplastics along the Bedadung

River, particularly regarding its function as a raw water source [18] [19]. Previous studies have shown that microplastics can enter the drinking water supply chain through contaminated raw water sources [20]. Hence, this research is essential for determining the prevalence and characteristics—including average size, microplastic types, and primary polymer constituents—of microplastic pollutants present in the Bedadung River, which serves as the source water for the drinking water treatment plant. Additionally, the study assesses the clean water produced by the plant and the tap water supplied to customers of Perumdam Tirta Pandalungan Jember.

2. Methods

This research uses a quantitative approach with field observation and laboratory analysis. The research design consists of quantification of microplastic abundance and size of particles, and identification of its characteristics including type of microplastic and polymer material. The Grid-Based Sampling method was applied in this study by dividing the Bedadung River into four grids:

- a) The upstream section of the Bedadung River is a region characterized by limited or absent human activity.
- b) The raw water intake area affected by human activity;
- c) The area closest to the distribution point for clean water treated by the drinking water treatment plant; and
- d) Tap water in the service area of Perumdam Tirta Pandalungan.

Water sampling was conducted at seven sampling points representing each grid and was repeated three times using the grab sampling method. The sampling was performed in triplicate to ensure the reliability of the results and to account for potential variability across different sampling occasions. While three repetitions are generally considered adequate for obtaining a reliable estimate of microplastic concentrations, additional sampling could further improve the robustness of the results, particularly in capturing temporal variations or atypical spikes in contamination. The procedure for water sampling in the upstream area of the river complies with SNI 03-7016-2004 concerning Sampling Procedures for Water Quality Monitoring in a River Basin. Sampling procedures for raw water intake, treated water from the treatment plant, and customer tap water are conducted in accordance with SNI 7828:2024 standards regarding Water Test Sampling for Drinking Water Supply Systems.

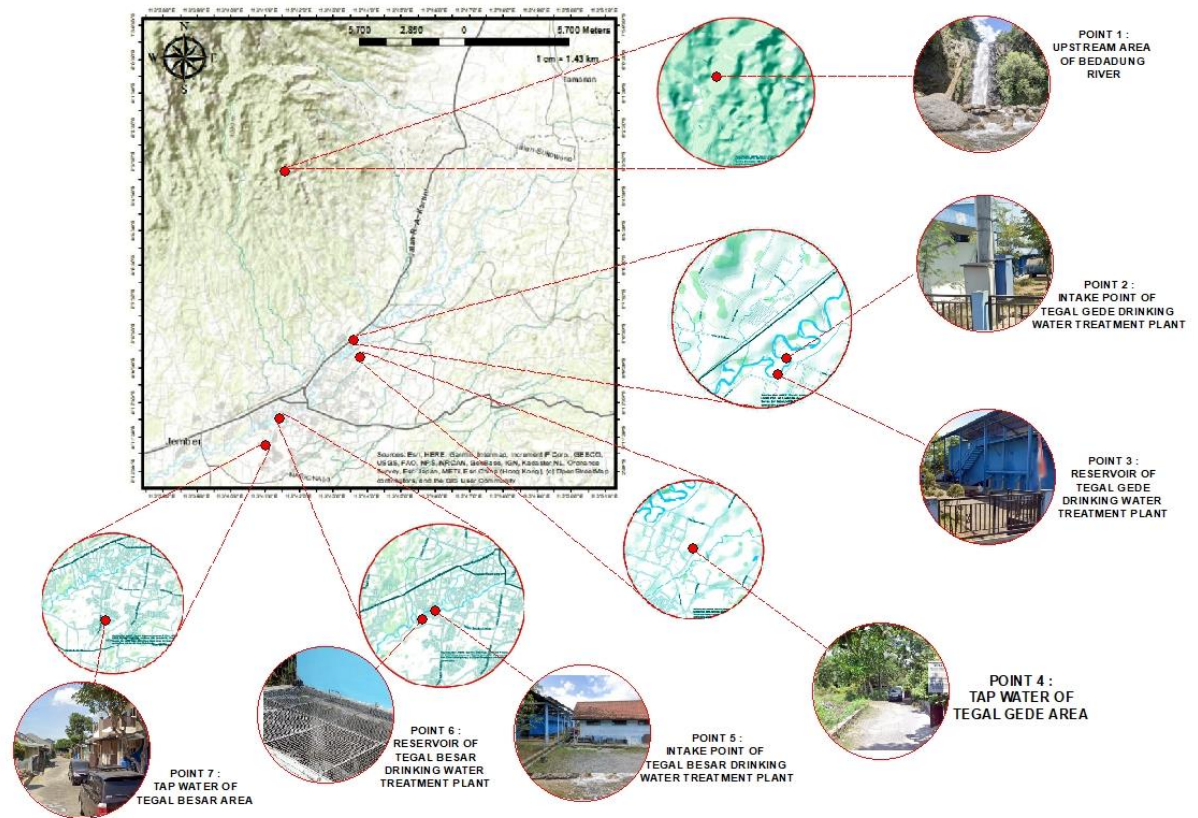


Figure 1. Water Sampling Points

Meanwhile, microplastic collection will be carried out by filtering 100 liters of river water using a plankton net with a mesh size of 330 μm . This mesh size was selected to effectively capture microplastic particles while minimizing the loss of smaller debris, as it strikes a balance between filtration efficiency and clogging. Alternative methods, such as using finer mesh sizes, were considered, but a 330 μm mesh was deemed optimal for ensuring that particles within the microplastic range (larger than 100 μm) were accurately collected without excessive filtering time or material loss. The filtration results will then be poured into sterile glass sample containers and labelled. The water samples will then be analysed using a stereomicroscope to identify the shape of the microplastics, measure the microplastic particles, and calculate the number (abundance) of microplastic particles. Fourier Transform Infra-Red (FTIR) analysis will be used to determine the type of microplastic polymer material in the water samples. Microplastic examination used a method developed by the National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program [28]. Data on the abundance, size of particles, type of microplastic, and polymer material obtained were mapped to visualize the distribution of microplastics in the Bedadung River, thereby providing an overview of the level of microplastic pollution in the area.

3.Results and Discussion

3.1 The Abundance and Average Size of Microplastic

Sampling point 1 is located upstream in the Bedadung River, exhibits minimal human activity relative to the other sampling locations, with tourism being the primary use and experiencing increased visitation on weekends. Microscopic analysis revealed that samples from point 1 contained fiber-type microplastics at a concentration of 73.33 particles/L, averaging 0.199 mm in size.

Sampling point 2 lies at the intake site of the Tegal Gede Water Treatment Plant (IPAM). The area is characterized by dense residential settlements, traditional markets, and several small-scale industries. Here, microplastic abundance measured 49.33 particles/L with an average particle size of 0.104 mm.

Sampling point 3 serves as the reservoir for potable water processed by the Tegal Gede Water Treatment Plant prior to distribution to PDAM Tirta Pandalungan customers. Microplastic concentrations at this location reached 88 particles/L, with an average size of 0.102 mm.

Sampling point 4 represents the nearest residential community to the Tegal Gede Water Treatment Plant. Water samples collected from customer taps indicated a microplastic abundance of 106.67 particles/L and an average particle size of 0.15 mm.

At sampling point 5, the intake for the Tegal Besar Water Treatment Plant (IPAM), residential areas surround the site and possible household waste input into the river has been observed. Microplastic levels were recorded at 66.67 particles/L with an average particle size of 0.152 mm.

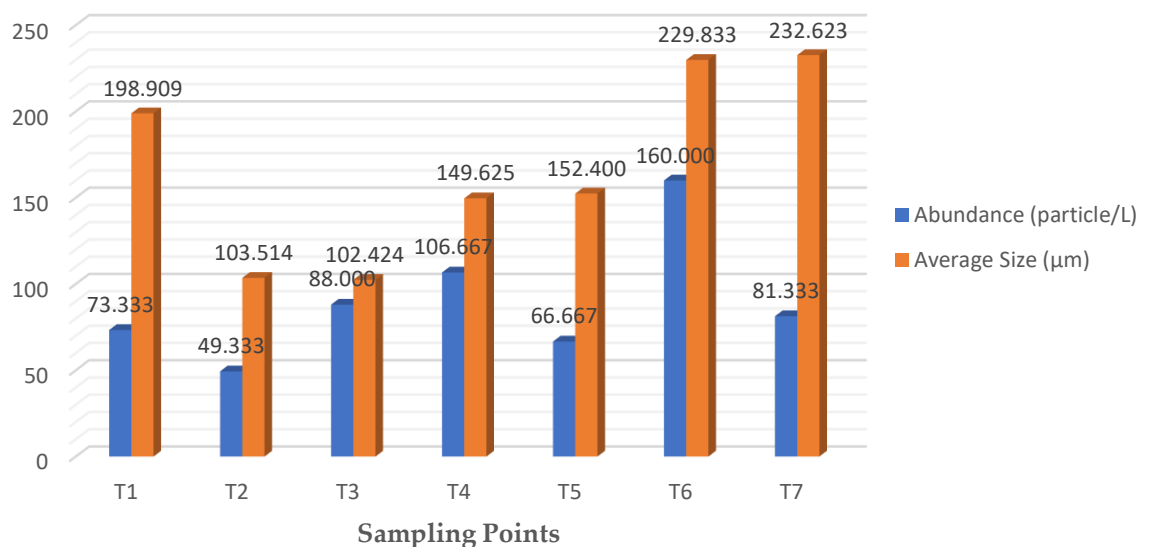


Figure 2. The Abundance and Average Size of Microplastic at Each Sampling Point

Sampling point is the storage facility for treated water from the Tegal Besar Water Treatment Plant, designated for PDAM Tirta Pandalungan distribution. This site exhibited the highest microplastic concentration among the sampling points at 160 particles/L, with an average particle size of 0.23 mm.

Finally, Sampling point 7 refers to the closest residential area to the Tegal Besar Water Treatment Plant, where samples collected from customer taps showed a microplastic abundance of 81.33 particles/L and an average particle size of 0.233 mm.

According to [Figure 2](#), the highest microplastic abundance was observed at point 6, with 160 particles/L, whereas the lowest was at point 2, recording 49.33 particles/L. The largest average microplastic particle size was found at point 7 (0.233 mm or 233 μm), while the smallest was at point 3 (0.102 mm or 102 μm). A comparison of intake and treated water from the IPAMs in Tegal Gede and Tegal Besar revealed a consistent pattern: microplastic concentrations were notably higher in treated water than in intake water. Specifically, Tegal Gede IPAM saw a 78% increase in microplastic abundance following treatment, whereas Tegal Besar IPAM experienced a 140% increase post-treatment.

Variations in microplastic concentrations between source and treated water have been reported across studies. Some investigations attribute local increases to releases from equipment or specific process steps, while many facilities demonstrate an overall reduction after treatment. For example, a supply chain study in Haikou identified elevated microplastic concentrations in treated water compared to raw water, attributing this rise to plastic piping within the distribution network [\[18\]](#). Similarly, assessments at an advanced treatment facility noted relative increases (negative removal efficiency) within certain tanks, leading to particle count rises of 2.8–16.0% at particular process stages [\[19\]](#).

Conversely, analyses of particle migration in drinking water treatment plants (DWTPs) indicated that processes such as sand filtration and ultrafiltration/reverse osmosis generally resulted in substantial concentration reductions. However, material migration assessments highlighted internal equipment as potential sources of microplastic release, possibly increasing outlet concentrations. Such releases can result from abrasion and leaching of plant components—including plastic pipes, fittings, membranes, and filtration materials—especially under conditions of mechanical or chemical stress during DWTP operation [\[20\]](#). Additional sources of microplastic contamination may originate from reservoirs, storage tanks, and the distribution infrastructure, particularly polymer piping, which can act as secondary sources and elevate concentrations at end-use points even when normal plant operations are maintained [\[18\]](#) [\[20\]](#). Supply chain research underscores that plastic pipes and fittings may release polymers (such as PE and PP), resulting in higher concentrations in distributed water relative to intake levels [\[18\]](#).

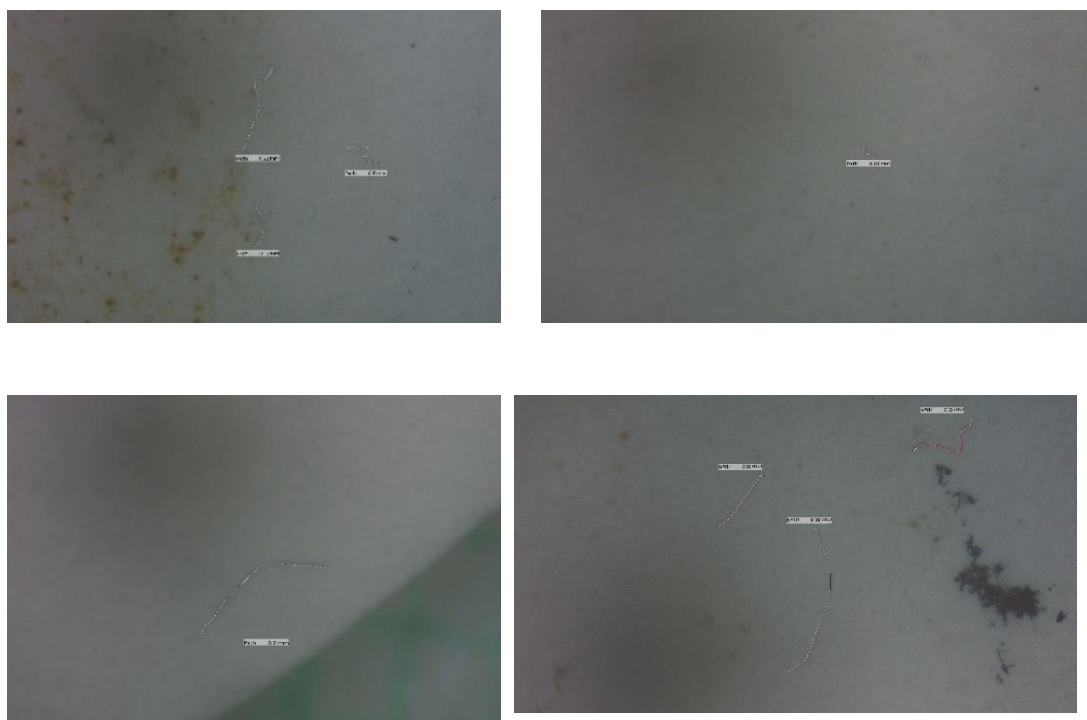


Figure 3. Examination of Microplastic Particles Under Microscope

3.2 The Types of Microplastic and Main Polymer Constituents

FTIR analysis revealed that water sample point 1 contained only one type of microplastic: fiber composed of polyvinyl alcohol (PVA) chemically modified into polyester, or a blend of PVA and polyester (e.g., PET or other aliphatic-ester polymers). At sample point 2, two microplastic types were identified: fiber (91.89%) and fragments (8.11%), with polyester (most likely PET or another aliphatic polyester) as the primary polymer detected. Water sample point 3 yielded three microplastic types—fiber (84.85%), fragments (13.64%), and foam (1.52%)—with PET and polycaprolactone (PCL) as the main polymers.

In water sample point 4, four microplastic forms were observed: fiber (86.25%), fragments (7.5%), filaments (1.25%), and films (5%). FTIR results confirmed the presence of various microplastic polymers in this sample. At point 5, three microplastic types were found—fiber (78%), fragments (18%), and films (4%)—with polyethylene terephthalate (PET) being predominant; there was also minor evidence suggesting polyurethane or isocyanate group modifications. Sample point 6 contained fiber (90.83%), fragments (6.67%), and films (2.5%), with FTIR spectra indicating an aliphatic polymer (PE/PP) containing ester/ether groups, alongside PET. Finally, in water sample point 7, four types were present: fiber (95.08%), fragments (1.64%), and films (3.28%), with PET identified as the most dominant polymer overall.

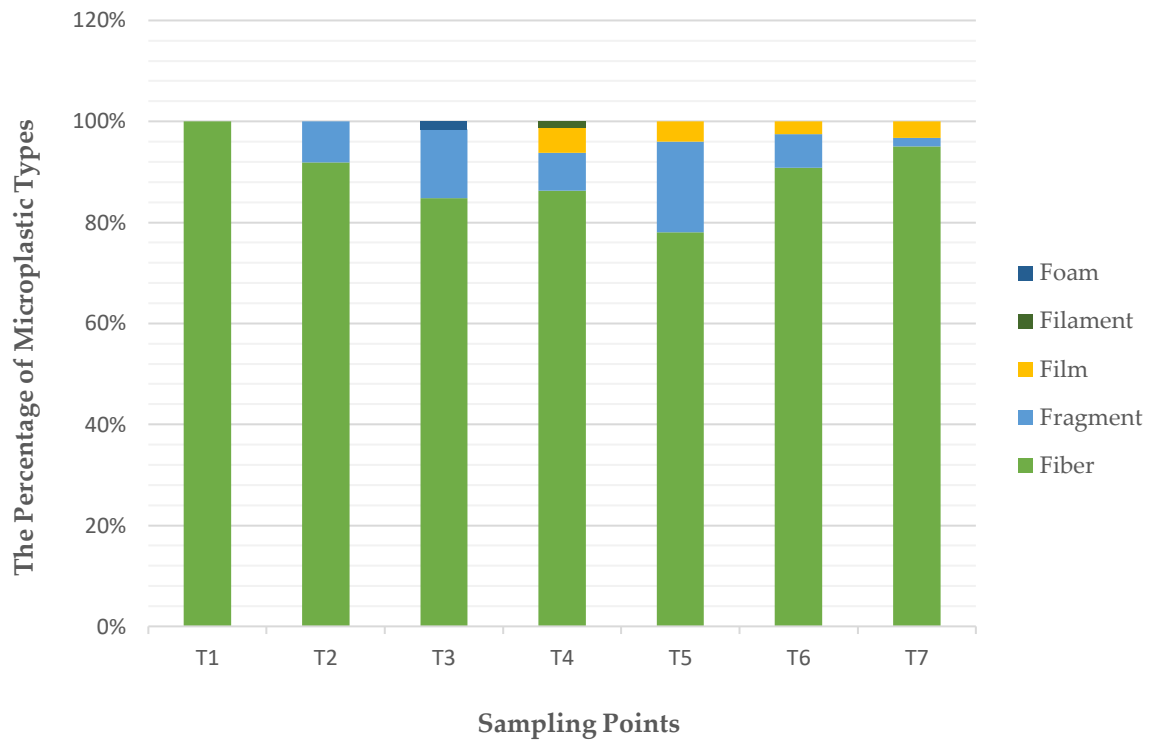


Figure 4. The Percentage of Microplastic Types at Each Sampling Points

Based on the results of FTIR analysis from various sampling points, it can be concluded that fiber is the most abundant type of microplastic across all sampling points. This type of fiber is primarily composed of the polymer polyethylene terephthalate (PET), which was also found as a major component in fragments and films at several locations. This finding aligns with the distribution pattern of microplastics in Indonesian waters, where PET is one of the most frequently encountered polymers due to its widespread sources, such as disposable water bottles and food packaging [21].

In addition to fiber, fragments and films were also identified, although at lower abundances. Other polymers detected included modified polyvinyl alcohol (PVA), polyethylene (PE), polypropylene (PP), polyurethane, and polycaprolactone (PCL). This variety of polymer types reflects the diverse sources of microplastics in the environment, ranging from household waste and plastic packaging to water distribution equipment.

Ineffective plastic waste management in areas around rivers and urban water systems contributes to high levels of microplastics, particularly PET, in raw and treated water [23]. Furthermore, water treatment processes and distribution networks are also potential pathways for microplastic release, particularly in polymer reservoirs and pipes that experience abrasion or material migration [18] [20] [22]. This condition results in a tendency for microplastic content to increase in

treated water and customer tap water compared to intake water, as reflected in findings at the Tegal Gede and Tegal Besar DWTP.

The limitations of conventional technology in removing certain fractions, particularly fiber, and the lack of national standards for monitoring and controlling microplastics present challenges to mitigation efforts. Previous studies of rivers and drinking water depots in Indonesia also underscore the importance of managing the packaging supply chain and routinely monitoring water treatment and distribution equipment to minimize further microplastic contamination [22] [24] [25] [26] [27].

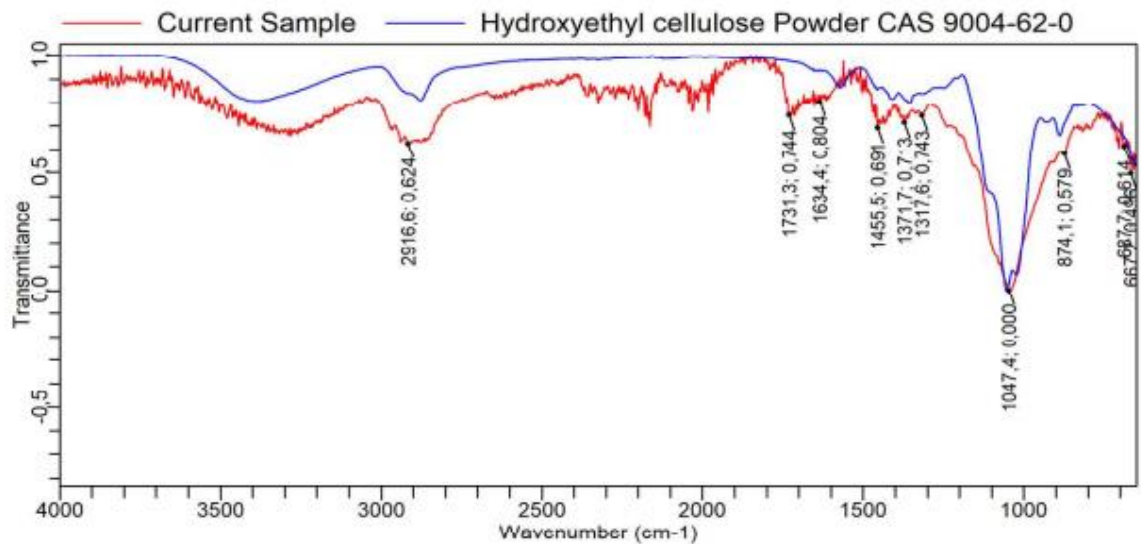


Figure 5. An Example of FTIR Results: Microplastic Polymer Constituent of Fragments

4. Conclusion

This study observed an increase in microplastic concentrations following raw water treatment in the Bedadung River, with levels rising by 78% at Tegal Gede DWTP and 140% at Tegal Besar DWTP. The highest microplastic abundance was recorded at Tegal Besar DWTP, reaching 160 particles/L. Tap water samples also exhibited elevated microplastic content, potentially attributable to distribution piping; specifically, Tegal Gede tap water contained 106.67 particles/L, a 21% increase from its reservoir. Fibers, predominantly composed of PET polymer, were identified as the most prevalent microplastic type across all sampling locations. To address this issue, it is recommended that water treatment infrastructure be upgraded with advanced filtration technologies such as microfiltration or reverse osmosis, which could more effectively capture microplastic particles. Additionally, the use of materials with lower potential for microplastic release, such as alternative piping and filtration components, should be considered. Further research is needed to identify the specific sources of PET contamination throughout the river intake, treatment processes, and distribution systems. By adopting these recommendations,

it may be possible to reduce microplastic levels and improve the safety of drinking water.

Acknowledgement

The authors would like to express their profound gratitude to the Ministry of High Education, Science, and Technology Republic of Indonesia for providing financial support for this study through the Beginner Lecturer Research Grant (Penelitian Dosen Pemula / PDP) 2025. We extend our sincere thanks to the Rector and the Institute for Research and Community Service (LPPM) of Universitas PGRI Argopuro Jember for their invaluable administrative support and for facilitating the research environment. We are also deeply grateful to all staff for their diligent help in the preparation of materials, data collection, and maintenance of the experimental units throughout the research period. Finally, we wish to acknowledge the anonymous reviewers for their constructive comments and insightful suggestions, which have significantly improved the quality of this manuscript.

Authors' Declaration

Authors' contributions and responsibilities - The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation, and discussion of results. The authors read and approved the final manuscript.

Funding - Ministry of High Education, Science, and Technology Republic of Indonesia.

Availability of data and materials - All data is available from the authors.

Competing interests - The authors declare no competing interest.

Additional information - No additional information from the authors.

References

- [1] Romaskila U, Widiastuti EL, Susanto GN, Damai AA, Juliasih NLGR. Karakteristik, Warna, Dan Ukuran Mikroplastik Yang Ditemukan Pada Air Dan Kerang Hijau Di Pulau Pasaran, Lampung. *Journal of Tropical Marine Science* [Internet]. 2023 Oct 11;6(2):147–54. Available from: <https://journal.ubb.ac.id/jtms/article/view/4236>
- [2] Dekiff JH, Remy D, Klasmeier J, Fries E. Occurrence and spatial distribution of microplastics in sediments from Norderney. *Environmental Pollution* [Internet]. 2014 Mar;186:248–56. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0269749113006088>
- [3] Neves D, Sobral P, Ferreira JL, Pereira T. Ingestion of microplastics by commercial fish off the Portuguese coast. *Marine Pollution Bulletin* [Internet]. 2015 Dec;101(1):119–26. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0025326X15301582>

- [4] Al Abid G, Windusari Y. Identifikasi Cemaran Mikroplastik di Perairan Sungai Musi Wilayah Musi Banyuasin (Berdasarkan Konsentrasi Mikroplastik Pada Parameter Biota). PREPOTIF: JURNAL KESEHATAN MASYARAKAT [Internet]. 2024 Sep 29;8(3):4840–5. Available from: <https://journal.universitaspahlawan.ac.id/index.php/prepotif/article/view/33898>
- [5] Ayuningtyas WC. Kelimpahan Mikroplastik Pada Perairan di Banyuwangi, Gresik, Jawa Timur. JFMR-Journal of Fisheries and Marine Research [Internet]. 2019 Apr 22;3(1):41–5. Available from: <https://jfmr.ub.ac.id/index.php/jfmr/article/view/188>
- [6] Rochman CM, Hoh E, Hentschel BT, Kaye S. Long-Term Field Measurement of Sorption of Organic Contaminants to Five Types of Plastic Pellets: Implications for Plastic Marine Debris. Environmental Science & Technology [Internet]. 2013 Jan 9;47(3):130109073312009. Available from: <https://pubs.acs.org/doi/abs/10.1021/es303700s>
- [7] Fachrul MF, Rinanti A. Bioremediasi Pencemar Mikroplastik di Ekosistem Perairan Menggunakan Bakteri Indigenous (Bioremediation of Microplastic Pollutant in Aquatic Ecosystem by Indigenous Bacteria). Seminar Nasional Kota Berkelanjutan [Internet]. 2018 May 26;302–12. Available from: <https://ejournal.trisakti.ac.id/index.php/kotaberkelanjutan/article/view/2910>
- [8] Browne MA, Crump P, Niven SJ, Teuten E, Tonkin A, Galloway T, et al. Accumulation of Microplastic on Shorelines Worldwide: Sources and Sinks. Environmental Science & Technology [Internet]. 2011 Nov 1;45(21):9175–9. Available from: <https://pubs.acs.org/doi/10.1021/es201811s>
- [9] Puspitasari AI, Pradana HA, Novita E, Purnomo BH, Rini TS. Environmental Risk analysis of The Bedadung Watershed By Using DPSIR. IOP Conference Series: Earth and Environmental Science [Internet]. 2020 May 1;485(1):012006. Available from: <https://iopscience.iop.org/article/10.1088/1755-1315/485/1/012006>
- [10] Novita E, Firmansyah JW, Pradana HA. Penentuan Indeks Kualitas Air Sungai Bedadung Kabupaten Jember Menggunakan Metode IP dan NSF-WQI. Jurnal Ilmu Lingkungan [Internet]. 2023 May 21;21(3):495–502. Available from: <https://ejournal.undip.ac.id/index.php/ilmulingkungan/article/view/47731>
- [11] Novita, E., Bisri, M. I. M., & Pradana, H. A. 2023. Analisis Daya Tampung Beban Pencemaran Sungai Bedadung Jember Menggunakan Software WASP. Jurnal Teknosains, 13(1), 75-86.
- [12] Novita E, Pradana HA, Dwija SP. Water quality Assessment at Bedadung River in Jember Regency. J Pengelolaan Sumberd Alam dan Lingkung. 2020;10(4):699–714.
- [13] Solichah Z. Antara News JATIM. 2022 [cited 2025 Mar 24]. p. 1 Ecoton sorot banjirnya sampah plastik di Sungai Bedadung Jember. Available from: <https://www.antaranews.com/berita/2628769/ecoton-soroti-banjirnyasampah-plastik-di-sungai-bedadung-jember>
- [14] Nahwawi I. Surya.co.id. 2022 [cited 2025 Mar 24]. p. 1 Jadi Perhatian Serius

- DLH Jember, Dari 1700 Ton Sampah Per Hari, Baru Mampu Angkut 350 Ton. Available from: https://surabaya.tribunnews.com/index.php2022/12/15/jadiperhatian-serius-dlh-jember-dari-1700-ton-sampah-per-hari-baru-mampuangkut-350-ton?jxrecoid=0bf4e169-3e64-45965dff339c7ea0696~mix_tribunnews?source=widgetArtikelRekomendasi&engine=JXA PDAM. Dinas Komunikasi dan Informatika Kabupaten. 2023 [cited 2025 Jun5]. p. 1 Program Konservasi Unit Produksi Perumdam Tirta Pandalungan Jember. Available from: <https://ppid.jemberkab.go.id/index.php/berita-ppid/detail/program-konservasi-unit-produksi-perumdam-tirta-pandalunganjember>
- [15] Dinas Komunikasi dan Informatika Kabupaten Jember. 2023 [cited 2025 June 07]. p. 1. Program Konservasi Unit Produksi Perumdam Tirta Pandalungan Jember. Available from: <https://ppid.jemberkab.go.id/index.php/berita-ppid/detail/program-konservasi-unit-produksi-perumdam-tirta-pandalungan-jember>
- [16] Ariyunita S, Subchan W, Alfath A, Wardatun Nabilla N, Nafar SA. Analisis Kelimpahan Mikroplastik Pada Air Dan Gastropoda Di Sungai Bedadung Segmen Kecamatan Kaliwates Kabupaten Jember. JURNAL BIOSENSE [Internet]. 2022 Dec 3;5(2):47–51. Available from: <http://ejournal.unibabwi.ac.id/index.php/BIOSENSE/article/view/2267>
- [17] Sholihin T. Analisis kandungan mikroplastik pada ikan di sungai bedadung jember jawa timur. 2023;1(2):818–24.
- [18] X. Li, Y. Yu, M. Yang, S. Wen, and J. Zhang, "Tracking Microplastics Contamination in Drinking Water Supply Chain in Haikou, China: From Source to Household Taps," *Toxics*, vol. 12, no. 11, p. 0793, 2024. doi: 10.3390/toxics12110793
- [19] Z. Wang, T. Lin, and W. Chen, "Occurrence and removal of microplastics in an advanced drinking water treatment plant (ADWTP)," *Science of The Total Environment*, 2020. doi: 10.1016/J.SCITOTENV.2019.134520
- [20] J. Dalmau-Soler, R. Ballesteros-Cano, M. R. Boleda et al., "Microplastics from headwaters to tap water: occurrence and removal in a drinking water treatment plant in Barcelona Metropolitan area (Catalonia, NE Spain)," *Environmental Science and Pollution Research*, 2021. doi: 10.1007/S11356-021-13220-1
- [21] N. Ulhasanah et al., "Characterization of Microplastics in Jakarta's Urban Downstream and Estuary Water Bodies," *Ecological Engineering & Environmental Technology*, 2024. doi: 10.12912/27197050/192678
- [22] R. Amir, "Factors influencing microplastic contamination in bottled drinking water in Indonesia: a systematic review," *Journal Article*, 2023. doi: 10.22146/bkm.v39i10.7980
- [23] F. Warmansyah et al., "Review of Microplastic Pollution in Indonesian Waters," *Science and Environmental Journals for Postgraduate*, vol. 5, 2023. doi: 10.24036/senjop.v5i2.197
- [24] A. D. Radityaningrum, Y. Trihadiningrum, M. Mar'atusholihah, E. S. Soedjono,

- and W. Herumurti, "Microplastic contamination in water supply and the removal efficiencies of the treatment plants: A case of Surabaya City, Indonesia," *Journal of Water Process Engineering*, 2021. doi: 10.1016/j.JWPE.2021.102195
- [25] G. L. Sari et al., "Investigation of Microplastics in Raw and Processed Water for Unbranded Refilled Drinking Water in Karawang, Indonesia," *Journal Article*, 2025. doi: 10.2139/ssrn.5071763
- [26] M. D. Van, T. L. Thanh, and V. D. Ngo, "Distribution and occurrence of microplastics in wastewater treatment plants," *Environmental Technology and Innovation*, 2022. doi: 10.1016/j.eti.2022.102286
- [27] T. Reza et al., "Microplastic Removal in Wastewater Treatment Plants (WWTPs) by Natural Coagulation: A Literature Review," *Toxics*, 2023. doi: 10.3390/toxics12010012
- [28] Masura, J., et al. 2015. Laboratory methods for the analysis of microplastics in the marine environment: recommendations for quantifying synthetic particles in waters and sediments. NOAA Technical Memorandum NOS-OR&R-48.