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Community Perception of Waste Management and Microplastic Content in the Benanga Lempake Dam

Running title: Waste Management Perception and Microplastics in Benanga Dam

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Abstract

Background: The increase in plastic production and waste accumulation in Samarinda City has caused a microplastic pollution problem in the Benanga Dam. Objective: This study aimed to assess community perception of waste management and to identify the presence, type, and size of microplastics at the study site. Methods: A quantitative descriptive design was used. A survey was administered to 65 respondents living around the dam, while water samples were collected from three points for laboratory analysis. Results: Most respondents held a positive perception: 95.4% agreed with waste-sorting activities, 98.5% agreed with disposing of waste on schedule, but only 56.9% weighed their waste. Laboratory testing detected microplastics at all sampling points in the form of fibers, fragments, films, and granules, with average particle sizes ranging from 20.94 µm to 410.48 µm. Conclusion: Community perception of waste management is generally good, yet microplastics were still found at every point, indicating a gap between perception and behavior and the presence of other pollutant sources from household and small-industry waste. This study recommends increased public education on the dangers of microplastics, provision of adequate waste-management facilities, and stricter oversight of waste disposal around the Benanga Dam.

Keywords: community perception; household waste; microplastics

Research Highlights

- Most respondents (87.7%) demonstrated a high level of perception toward household waste management around the Benanga Dam.
- Laboratory analysis confirmed microplastics (fiber, fragment, film, and granule) at every sampling point, ranging from 20.94 µm to 410.48 µm.
- A gap exists between positive community perception and actual waste-handling behavior, pointing to the need for targeted education and stricter oversight.

Introduction

Plastic waste, in particular, has become an extremely serious global environmental issue. According to data from the United Nations Environment Programme (UNEP), more than 300 million tons of plastic are produced worldwide every year, and most of it ends up in the environment without adequate recycling. Plastic waste that is not properly managed can degrade into microplastics — small particles less than 5 mm in size that are very difficult to break down and can contaminate the food chain, water, and air.

Indonesia faces major challenges in waste management, with a waste stock reaching 27.74 million tons in 2024, dominated by household waste at 54.44%; East Kalimantan, particularly the city of Samarinda, is among the largest contributors, while plastic waste accounts for 19.78% of the total. Plastic particles smaller than 5 millimeters are known as microplastics, which can endanger human health and pollute the environment; microplastics can enter the human body through the respiratory tract, through food and beverages, and through the skin because of the chemicals they contain (Fensynthia, 2024). Microplastics have the potential to cause a range of adverse health effects, including oxidative stress, inflammation, metabolic disturbance, neurotoxicity, reproductive disorders, cancer risk, and disorders of the liver, kidneys, and immune system (Aulia et al., 2023).

The increase in plastic production and waste accumulation in the city of Samarinda has caused a serious microplastic pollution problem in aquatic environments, including the Benanga Dam. Microplastics, owing to their very small size, can enter the human food chain and pose various health risks, such as metabolic disturbance, inflammation, and cancer risk. Poorly managed plastic waste also threatens aquatic ecosystems and environmental quality.

Although most community members hold a positive perception of waste management, actual behavior in sorting and weighing waste remains low. This points to a gap between knowledge and action and to the need for more effective interventions. In addition, data on the presence, type, and size of microplastics in the Benanga Dam remain very limited, even though the dam is an important water source for the surrounding community. Community behavior in generating and disposing of waste strongly influences how that waste is managed; if handling begins early, by raising awareness to reduce waste production and prevent indiscriminate disposal, the waste problem can be minimized (Sriwahyuni et al., 2022). Research by Nanda and Halimatus (2024) identified three factors that influence a person's behavior in waste management: knowledge, attitude, and education. Building on this background, the present study aims to assess community perception of waste management and to identify the presence, type, and size of microplastics at the Benanga Dam.

Materials and Methods

Study design and setting

This study used a quantitative descriptive design. It was conducted at the Benanga Dam, Lempake Village, North Samarinda Subdistrict, Samarinda City, in May 2025, with laboratory analysis carried out at the Water Quality Laboratory, Faculty of Fisheries and Marine Science, Universitas Mulawarman.

Population, sampling, and sample size

The study population comprised all heads of household living around the Benanga Dam (77 households). The sample size was determined using the Slovin formula with a 5% margin of error, yielding 65 respondents selected by simple random sampling. Water samples were collected at three observation points (upstream, midstream, and downstream), 100 liters at each point, then filtered and placed into 120 mL sample bottles for further laboratory analysis. Data sources comprised primary data (questionnaires, observation, and laboratory analysis) and secondary data (literature and relevant institutional documents).

Variables and measurements

The research instrument consisted of a closed-ended questionnaire that had been tested for validity and reliability to measure the community-perception variable, together with a stereo microscope and ScopeImage software for microplastic identification. The tools and materials used included a plankton net, 120 mL sample bottles, stainless-steel basins, a vacuum pump, a drying oven, filter paper, Erlenmeyer beaker glasses, and 0.05 M $FeSO_4$ and 30% H_2O_2 solutions.

Community perception was analyzed using frequency distribution and then categorized as low, moderate, or high based on questionnaire scores. Microplastics were analyzed through biological digestion with $FeSO_4$ and H_2O_2, filtration using a vacuum pump, drying in an oven at 80°C, and morphological identification using a stereo microscope. Microplastic types were classified as fiber, fragment, film, or granule, and size was measured in micrometers (µm).

Statistical analysis

Data were summarized using descriptive statistics, primarily frequency distribution and percentages, to characterize respondent profiles, community-perception scores (categorized as low, moderate, or high), and the type and size of microplastics identified at each sampling point.

Ethical considerations

Permission to conduct the research was obtained from the Lurah (village head) of Lempake Jaya and from the management of the Benanga Dam, and verbal informed consent was obtained from all respondents prior to data collection.

Results

Findings are presented in sequence, beginning with the sampling location and respondent characteristics, followed by community perception of waste management and the laboratory findings on microplastic presence, type, and size.

Overview of the Sampling Location

The study location, around the Benanga Dam in Lempake Village, North Samarinda Subdistrict, Samarinda City, in 2025, is shown in Figure 1.



Figure 1. Map of the Sampling Location

Respondent Characteristics

Respondent characteristics from the study conducted in the Benanga Dam area in 2025 are presented in Table 1.

Table 1. Characteristics of Respondents in the Benanga Lempake Dam Area, 2025

Characteristic	Frequency	Percent
Sex		
Male	32	49.2%

Characteristic	Frequency	Percent
Female	33	50.8%
Age		
10–19 years	10	15%
20–29 years	19	29%
30–39 years	9	13%
40–49 years	19	29%
50–59 years	5	7%
60–69 years	2	3%
≥ 70 years	1	1%
Highest education		
Elementary school	13	20.0%
Junior high school	9	13.8%
Senior high school	41	63.1%
Diploma/Bachelor's degree	2	3.1%

Table 1 shows that the majority of respondents were of productive age (20–29 years and 40–49 years, each 29%). The respondent composition consisted of 49.2% male and 50.8% female. Most respondents had completed senior high school (63.1%), followed by elementary school (20%), junior high school (13.8%), and diploma/bachelor's degree (3.1%). These data indicate a predominance of economically active respondents with secondary education, which may influence their awareness of waste management and microplastic issues.

Perception of Waste Management

Based on interviews on community perception of household-waste management around the Benanga Dam in 2025, results are shown in Table 2.

Table 2. Frequency Distribution of Respondents' Answers

No.	Variable	Category	n	%
1	Waste sorting	Agree	62	95.4%
		Disagree	3	4.6%
2	Waste weighing	Agree	37	56.9%
		Disagree	28	43.1%
3	Providing a closed, easy-to-clean waste bin	Agree	51	78.5%
		Disagree	14	21.5%
4	Waste disposal scheduled at 06:00–18:00	Agree	64	98.5%
		Disagree	1	1.5%
5	Household cosmetic waste disposed into the dam causes microplastics	Agree	46	70.8%
		Disagree	19	29.2%
6	Not disposing of plastic bottles and styrofoam into the dam because they can produce microplastics	Agree	46	70.8%

No.	Variable	Category	n	%
		Disagree	19	29.2%
7	Being more careful in using products to avoid adding to microplastic problems in the environment	Agree	55	15.4%
		Disagree	10	84.6%
8	Reusing plastic containers	Agree	54	83.1%
		Disagree	11	16.9%
9	Using refillable bottles	Agree	54	83.1%
		Disagree	11	—
10	Using shopping bags	Agree	65	65%
		Disagree	—	—
11	Participating in river clean-up activities	Agree	61	93.8%
		Disagree	4	6.2%
12	Disposing of waste properly along the dam's edge	Agree	61	93.8%
		Disagree	4	6.2%
13	Collecting waste at the dam as a form of environmental concern	Agree	60	92.3%
		Disagree	5	7.7%
14	Reducing plastic waste in daily life	Agree	64	98.5%
		Disagree	1	1.5%
15	Good waste management depends on cooperation with the government	Agree	63	96.9%
		Disagree	2	29.2%
Total			65	100%

Table 3. Categorization of Community Perception in the Benanga Lempake Dam Area, 2025

Interval	Category	Frequency	Percentage
0–5	Low	0	0%
6–10	Moderate	8	12.3%
11–15	High	57	87.7%
Total		65	100%

Table 3 shows that the majority of respondents had a high perception score — 57 people (87.7%). Eight respondents (12.3%) fell into the moderate-perception category, and no respondents (0%) had a low perception. More than half of the community demonstrated good understanding of, and a positive attitude toward, waste management.

Presence of Microplastics

Laboratory results from the Benanga Lempake Dam, Lempake Village, North Samarinda, on the presence and type of microplastics found are presented in Table 4.

Table 4. Presence of Microplastics in the Benanga Lempake Dam, 2025

Sampling Point	Presence	Remarks
Upstream	Positive	Detected

Sampling Point	Presence	Remarks
Midstream	Positive	Detected
Downstream	Positive	Detected

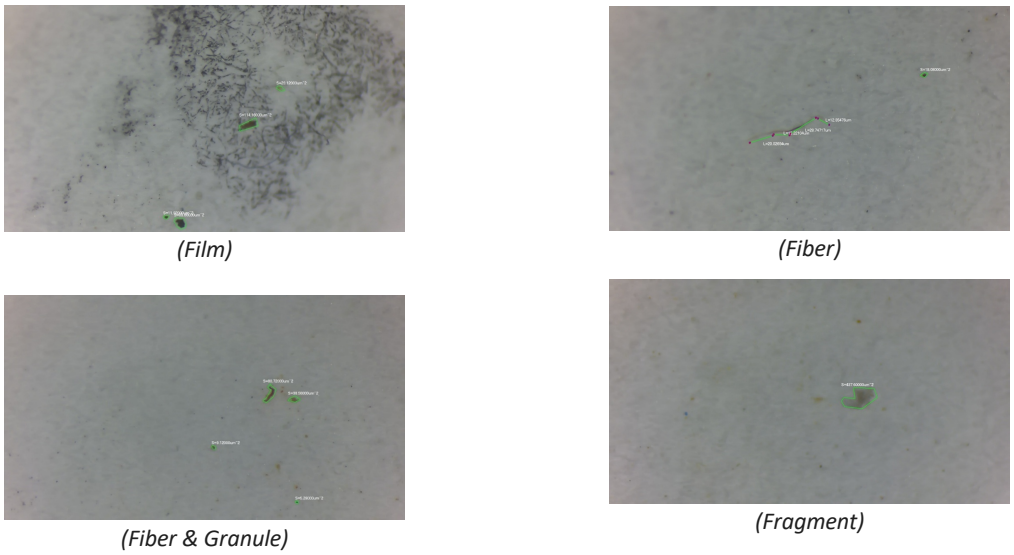


Figure 2. Types and Sizes of Microplastics Found in the Benanga Lempake Dam, 2025

Table 5. Average Microplastic Size in the Benanga Lempake Dam, 2025

Sampling Point	Type	Average size (µm)
Upstream	Fragment	50.31
	Film	410.48
	Fiber	20.97
	Granule	48.00
Midstream	Fragment	155.46
	Film	107.51
	Fiber	30.35
	Granule	21.18
Downstream	Fiber	112.53
	Film	153.47
	Granule	36.79

Table 5 shows that the average size of microplastics found in the Benanga Dam varied across sampling points.

Community Perception of Waste Management by Demographic Group



Figure 3. Perception of Waste Management by Sex, 2025

Based on Figure 3, among male respondents 29 had a high perception and 3 had a moderate perception; among female respondents, 28 had a high perception and 5 had a moderate perception. No male or female respondents fell into the low-perception category.

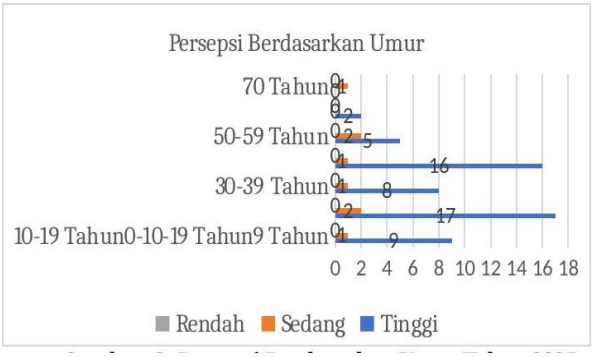


Figure 4. Perception of Waste Management by Age Group, 2025

Based on Figure 4, high perception was most common in the 20–29 and 40–49-year age groups. The moderate category appeared across nearly all age groups but in relatively small numbers, and no respondents in any age group had a low perception.

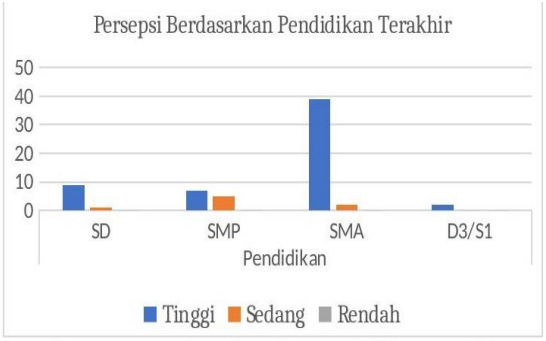


Figure 5. Perception of Waste Management by Highest Education Level, 2025

Based on Figure 5, high perception of waste management was most common among respondents whose highest education was senior high school, far exceeding the other education groups. Among respondents with elementary or junior-high education, some had a high perception while others fell into the moderate category. Respondents with a diploma/bachelor's degree were relatively few but tended to show high perception. No respondents at any education level fell into the low-perception category.

Discussion

Respondent Characteristics

Communities living around the Benanga Dam generally possess characteristics conducive to a positive perception — being of productive age, having secondary-level education, and balanced representation of both sexes —

indicating that this positive perception has not yet been fully reflected in actual waste-management practice. This finding is consistent with Premarathna et al. (2023), who reported that even when communities understand the risks of microplastics, they may still contribute to pollution if this understanding is not accompanied by practical knowledge of the sources and prevention of microplastics. Similarly, Galdies et al. (2020) emphasized that environmental awareness does not necessarily translate into behavioral change, particularly when individuals are not accustomed to adopting environmentally friendly lifestyles. Thus, although age and education create opportunities for good understanding, without concrete action — such as sorting waste, reducing single-use plastics, and recognizing hidden sources of microplastics (for example, cosmetic waste or synthetic clothing) — environmental pollution is likely to continue.

a) Perception of Waste Management by Sex

Both male and female respondents showed a high perception of waste management, and most understood the importance of maintaining environmental cleanliness. Nevertheless, microplastics were still found at every sampling point, indicating that action has not kept pace with awareness: sorting and reducing plastic use remain inconsistent, and education has not yet translated into everyday habits. Galdies et al. (2020) noted that a high perception of environmental issues does not always result in action, a pattern also observed among both male and female respondents here; awareness alone is not sufficient without supporting habits and facilities.

b) Perception of Waste Management by Age

Respondents aged 20–29 and 40–49 years dominated the high-perception category, yet microplastics were still identified at every location. Household behavior does not yet reflect this awareness, as liquid waste continues to be discharged directly and plastic use has not been reduced. Premarathna et al. (2023) similarly noted that being of productive age does not necessarily equate to understanding the technical practices needed to prevent microplastic pollution.

c) Perception of Waste Management by Educational Level

The majority of respondents with a senior-high-school education showed a high perception, yet microplastics were still found at every point. Secondary education appears to provide a basic level of understanding, but this knowledge has not yet extended to microplastic sources arising from domestic waste, and corresponding behavior has not yet formed. Ilmiawati et al. (2022) similarly observed that education has often not addressed the micro-level aspects that contribute to pollution.

Analysis of Community Perception of Waste Management

Most respondents around the Benanga Dam held a positive perception of waste management, yet microplastics were still found in every sample — indicating a gap between understanding and behavior (Heryeni et al., 2024). Disagreement was highest for technical aspects such as waste weighing (28 respondents), reuse of materials (11 respondents), and the importance of closed waste bins (14 respondents). Nineteen respondents were unaware that cosmetic waste and single-use plastics are sources of microplastics, indicating low awareness regarding household waste (Dewi, 2022). Limited facilities, information, and community participation are thought to be major barriers to the formation of more sustainable waste-related behavior (Windiari & Salsabiela, 2022).

Presence and Size of Microplastics in the Benanga Lempake Dam

Laboratory results from the Faculty of Fisheries and Marine Science, Universitas Mulawarman (Tables 4 and 5) show that all samples from the upstream, midstream, and downstream points contained microplastics ranging in size from 20.94 µm to 410.48 µm. The size distribution was relatively even: 33.3% were smaller than 50 µm, 33.3% were between 50–150 µm, and 33.3% were larger than 150 µm. Interviews and observation indicated that some community members still dispose of household waste directly into the dam and use dam water for daily needs; liquid waste from small industries, such as tofu and tempeh producers, further worsens the pollution. This is consistent with Arifah et al. (2024), who reported that microplastics in waterways originate from

community behavior in disposing of household and small-industry waste, with fiber and fragment as the dominant forms. Jaelani et al. (2024) similarly found high microplastic concentrations in coastal sediments linked to anthropogenic activity and land-based waste, and Dewi (2022) noted that domestic waste such as textiles, cosmetics, and plastic bags are major sources of microplastics entering waterways through household drainage.

At the upstream point, microplastics were found as fragments, films, fibers, and granules, ranging from 20.97 µm to 410.48 µm; the largest particles (film) were found upstream, reflecting the diversity of pollution sources such as household waste and single-use plastics. At the midstream point, particle sizes ranged from 21.18–155.46 µm, indicating ongoing fragmentation from water flow and human activity. The downstream point showed more homogeneous sizes (maximum 153.47 µm; average range 29–153 µm), consistent with particle transport from upstream. Small fibers and granules were more widely dispersed and carry greater potential to enter the human body. Compared with a study by Pradiptaadi and Fallahian (2022) in the Brantas watershed, microplastics in the Benanga Dam tended to be smaller, particularly fibers, likely originating from domestic sources such as cosmetics and synthetic plastics.

Potential Impact of Microplastics in the Benanga Lempake Dam

The presence of microplastics in the Benanga Lempake Dam indicates serious pollution: all three sampling points (upstream, midstream, and downstream) were positive for microplastics, with particle types including fiber, fragment, film, granule, and pellet, and average sizes ranging from under 30 µm to over 400 µm. This small particle size allows microplastics to enter the food chain through aquatic organisms such as fish and plankton, which are widely used by the surrounding community, creating potential for bioaccumulation in the human body — particularly since dam water is also used for daily activities such as washing and cooking. Beyond health impacts such as inflammation, hormonal disruption, and cancer risk (Aulia et al., 2023), microplastic pollution also threatens the sustainability of the aquatic ecosystem and local biodiversity. These findings reinforce the importance of more targeted waste management to prevent the accumulation of microplastics from both domestic and small-industry sources around the dam.

Conclusion

Communities around the Benanga Dam generally hold a positive perception of waste management, although this has not been fully reflected in actual practice, particularly regarding technical aspects such as weighing, sorting, and reusing waste. Of the 65 respondents, 29.2% were unaware that household liquid waste such as cosmetics and soap can generate microplastics, while 70.8% agreed that it can. Laboratory analysis detected microplastics at every water-sampling point, with sizes ranging from 20.97 µm to 410.48 µm and fiber and film as the dominant types — indicating that pollution is largely driven by poorly managed domestic activity.

Declarations

Ethics approval and consent to participate

Permission to conduct this research was obtained from the Lurah (village head) of Lempake Jaya and the management of the Benanga Dam, and verbal informed consent was obtained from all respondents prior to data collection.

Consent for publication

Not applicable.

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Competing interests

The authors declare no competing interests.

Author contributions (CRediT)

Conceptualization, R.N.F. and D.K.; methodology, R.N.F. and D.K.; investigation, R.N.F. and O.P.S.; formal analysis, R.N.F.; writing — original draft, R.N.F.; writing — review and editing, all authors; supervision, D.K.

Data availability

Data are available from the corresponding author upon reasonable request.

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Generative AI statement

The authors did not use generative AI in the preparation of this manuscript.

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