Unveiling Microplastics in Tilapia (Oreochromis Niloticus) from Lake Lanao and Assessing Community Awareness: Basis for IEC and I'm Development

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ABSTRACT

This study explores the growing concern of microplastic pollution in Lake Lanao by analyzing its presence in *Oreochromis niloticus* (tilapia) and assessing community awareness and attitudes in three lakeside municipalities: Marawi City, Mulondo, and Tamparan. Using a mixed-methods design, eighteen tilapia samples (six per site) were dissected, and their gastrointestinal tracts and gills were analyzed using 10% potassium hydroxide (KOH) digestion, filtration, and stereomicroscopy. A total of 21 microplastic particles were extracted and categorized by morphology, with films most prevalent in Marawi and fibers dominating in Mulondo and Tamparan. FTIR analysis identified common polymers such as Polyethylene (PE), Polypropylene (PP), Polyester (PET), and Polyamide (Nylon). Complementing the lab analysis, survey data from 989 residents revealed consistently low awareness of microplastic pollution but high willingness to engage in environmental action. Spearman's correlation showed a moderate positive relationship between knowledge and attitude ($\rho = 0.422$), highlighting the influence of education. Focus Group Discussions (FGDs) further illustrated firsthand observations of declining fish quality and increased plastic waste. These findings led to the development and expert validation of two educational outputs: a localized Grade 8 instructional module and a tri-fold IEC brochure promoting microplastic awareness in schools and communities.

Keywords: Microplastics, Lake Lanao, Tilapia, Awareness, FTIR, Instructional Module, IEC, Mixed Methods

INTRODUCTION

Aquatic ecosystems are essential for sustaining biodiversity and supporting human well-being through services such as food provision, water regulation, and cultural identity (Global Goals, n.d.; European Environment Agency, 2023; Poff & Day, 2002). However, these ecosystems are increasingly threatened by human activities, prompting urgent calls for conservation (Leverage Edu, 2022). The United Nations Sustainable Development Goals (SDGs)—particularly SDG 14: Life Below Water—underscore the need to safeguard marine and freshwater environments (United Nations, 2018; United Nations General Assembly, 2015).

One such ecosystem of concern is Lake Lanao, one of the world's few ancient lakes, which holds immense ecological, economic, and cultural value (Bulaon-Ducusin, 2021; Tuddao, n.d.). Historically teeming with endemic fish species (Herre, 1933; Myers, 1960), the lake has suffered declines in biodiversity due to overfishing, invasive species, and improper waste disposal (Rosaragon, 2021; Ismael et al., 2014; Mayuga, 2019). Among emerging threats is microplastic pollution, which adds a complex dimension to ongoing environmental degradation.

Microplastics—plastic particles smaller than 5 mm (Nafea et al., 2024)—originate from sources such as packaging, laundry wastewater, and degraded fishing gear (Duis & Coors, 2016). These persistent particles accumulate in aquatic environments, where they are ingested by fish and other organisms (Rossatto et al., 2023; GESAMP, 2015; Gregory, 1996; Mato et al., 2001). Their impacts range from physical and chemical toxicity in marine life (UNEP, 2021b; McCauley & Bjorndal, 1999) to potential risks to humans, including oxidative stress, DNA damage, and metabolic disorders (Blackburn & Green, 2022; Li et al., 2023; Prata et al., 2020).

Despite global concern (Ghosh et al., 2023), microplastic research in Philippine freshwater systems remains limited (Arcadio et al., 2023; Navarro et al., 2022; Gabriel et al., 2023). Few studies have examined their presence in fish species consumed by local populations or assessed public awareness of the issue (Onda et al., 2020; Parungao, 2024). Likewise, studies have reported limited environmental literacy among students and communities (Anggraini et al., 2018; Nunez & Clores, 2017; Coracero et al., 2022; Punzalan, 2020).

To address these gaps, this study investigates the presence of microplastics in Oreochromis niloticus (tilapia), a culturally and nutritionally significant species in the Lake Lanao region (Pimping, 2023), and assesses the awareness and attitudes of residents in Marawi City, Mulondo, and Tamparan. In doing so, it contributes to the growing body of literature on freshwater plastic pollution and lays the foundation for developing localized Instructional Materials (IMs) and Information, Education, and Communication (IEC) tools aimed at promoting environmental literacy.

Beyond its scientific contribution, the study supports several SDGs. It advances SDG 14 (Life Below Water) by contributing to the understanding of pollution impacts on aquatic ecosystems. It supports SDG 6 (Clean Water and Sanitation) by drawing attention to water quality issues in freshwater environments. Through the creation of educational tools, it promotes SDG 4 (Quality Education). Finally, by highlighting microplastics' potential health risks, it aligns with SDG 3 (Good Health and Well-being) (UNESCO, 2020; UNEP, 2021).

Objective

This study aimed to investigate the presence of microplastics in *Oreochromis niloticus* (tilapia) from Lake Lanao and explore its broader implications for ecological sustainability and public awareness. Specifically, the research focused on identifying and quantifying the microplastics found in the gastrointestinal tract and gills of tilapia collected from three lakeside municipalities: Marawi City, Mulondo, and Tamparan. It also sought to assess the levels of awareness and attitudes among local residents regarding microplastic pollution using a structured survey instrument.

Furthermore, the study analyzed the statistical relationship between awareness and attitude through Spearman's rho correlation to determine whether knowledge about microplastics influences behavioral intentions toward environmental action. Drawing from both laboratory and survey findings, the study culminated in the development and expert validation of contextualized educational outputs—a Grade 8 instructional module and a tri-fold Information, Education, and Communication (IEC) brochure—intended to promote microplastic literacy among students and community stakeholders in the Lake Lanao region.

METHODOLOGY

Study Area and Sampling Sites

The study was conducted in three (3) lakeside municipalities surrounding Lake Lanao: Marawi City, Mulondo, and Tamparan. These areas were selected based on their direct access to the lake, high fish consumption, and local dependence on tilapia *(Oreochromis niloticus)* as a food source (Pimping, 2023). Fish samples were collected directly from local fishermen along the lake shore to ensure the authenticity of origin. The geographical sampling points were documented and plotted on a map of Lake Lanao.

Fig. 1. Map of Lake Lanao showing the three tilapia sampling sites: Marawi City, Mulondo, and Tamparan.

Fish Collection and Dissection

A total of eighteen (18) tilapia with an average weight of 298 grams and an average length of 18.71 centimeters were collected—six (6) from each sampling site. The fish were immediately transported on ice to the laboratory for processing. Upon arrival, the total length and weight of each specimen were measured and recorded. The gastrointestinal tracts and gills were then carefully dissected using sterilized instruments to prevent contamination.

Microplastics Extraction and Analysis

The extraction and analysis of microplastics from fish tissues followed standardized methodologies adapted from Pan et al. (2021), Koongolla et al. (2020), Baalkhuyur et al. (2020), and Similatan et al. (2023). After dissection, the gastrointestinal tracts and gills of each tilapia sample were subjected to a digestion process using a 10% potassium hydroxide (KOH) solution. The samples were incubated at 60°C for 48 hours to ensure complete breakdown of organic matter, leaving behind non-digestible particles such as microplastics. The digested solutions were then subjected to vacuum filtration using Whatman GF/C glass microfiber filters with a pore size of 1.2 µm. To prevent cross-contamination, all glassware, filtration units, and tweezers were rinsed thoroughly with distilled water before and after each use.

The retained residues on the filter papers were examined under a stereomicroscope to identify suspected microplastic particles. Identification was based on observable morphological features such as fiber, film, or fragment. Only particles consistent with common plastic characteristics—non-cellular structure, lack of organic texture, and resistance to fracturing—were classified as microplastics. Suspected particles were carefully isolated using fine-tipped tweezers and transferred to glass plates for FTIR analysis.

Survey Design, Validation, and Focus Group Discussions

A structured survey questionnaire was designed to assess the awareness and attitudes of local residents toward microplastic pollution. The questionnaire contained four (4) main thematic sections: general awareness, health-related awareness, ecological awareness, and attitude toward mitigation. Each item was rated on a 4-point Likert scale. The instrument underwent expert validation by three (3) professionals in environmental science and education, and was revised based on their feedback. A total of nine hundred eighty-nine (989) respondents participated in the survey, with the sample size determined using Slovin's Formula at a 5% margin of error. Respondents were selected through cluster sampling from barangays located near the lakeshore in the three sampling sites.

To complement the quantitative data, Focus Group Discussions (FGDs) were conducted with fishers from each municipality. The FGDs provided qualitative insights into the lived experiences, perceived threats, and behavioral practices related to plastic waste and fishing activities.

Statistical Analysis

Descriptive statistics were used to summarize the responses in each survey category. To determine the association between awareness and attitude, Spearman's rho correlation was applied due to the ordinal nature of the Likert scale data. A p-value of less than 0.05 was considered statistically significant.

Development and Validation of Educational Materials

The findings from the laboratory analysis, survey responses, and FGDs served as the basis for the creation of two (2) educational outputs: a contextualized instructional module for Grade 8 Science and a tri-fold Information, Education, and Communication (IEC) brochure. The module included three (3) structured lessons aligned with the MELCs of the Department of Education in the Philippines. The IEC brochure was culturally tailored and produced in both English and Maranao. Both materials were validated by expert reviewers to ensure pedagogical effectiveness, cultural sensitivity, and scientific accuracy.

RESULTS AND DISCUSSION

Microplastic Counts and Morphology

A total of twenty-one (21) microplastic particles were recovered from the gastrointestinal tracts and gills of eighteen (18) tilapia samples collected from the three sampling sites. Marawi City recorded the highest count with nine (9) microplastics, followed by Mulondo with eight (8), and Tamparan with four (4). Morphologically, fiber-type microplastics were the most prevalent overall, particularly in Mulondo and Tamparan. This finding aligns with global trends observed in freshwater and marine ecosystems, where fiber-type microplastics frequently dominate due to their widespread release from synthetic textiles, fishing gear, and domestic effluents (Prinz & Korez, 2023; Hossain et al., 2024). Fragments were the least frequently observed. These patterns are visually represented in Figure 2 and summarized in Table 1.

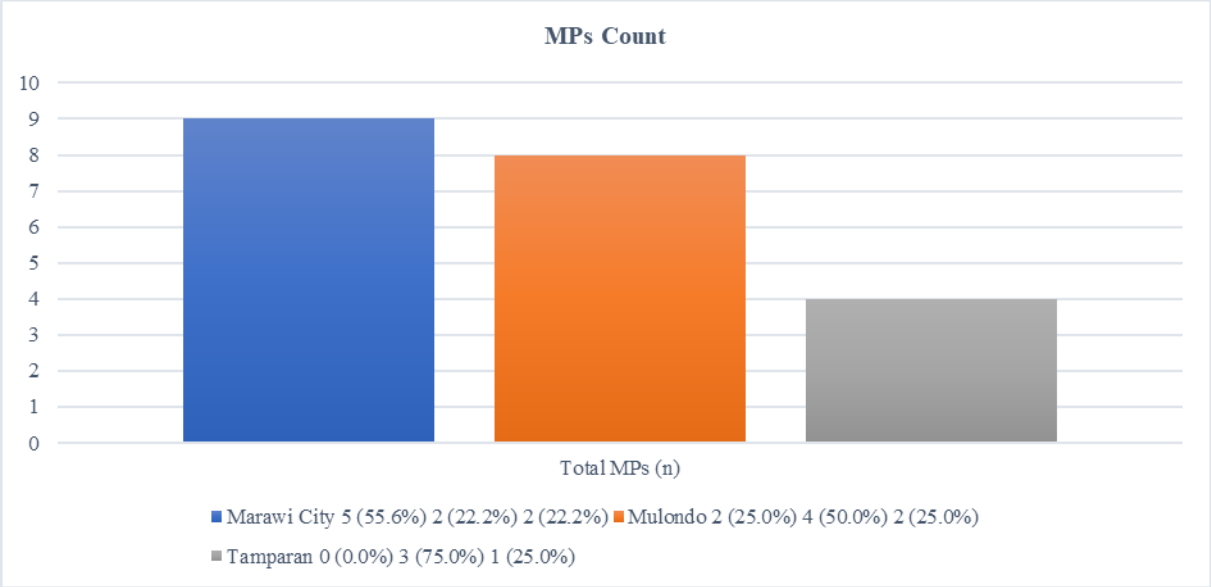

Fig. 2. Total number of microplastic particles extracted from tilapia samples across the three sampling sites in Lake Lanao.

Table 1. Morphological Classification and Count of Microplastics Found in Tilapia Per Site

Sampling Site	Film (n)	Fiber (n)	Fragment (n)	Total MPs (n)
Marawi City	5 (55.6%)	2 (22.2%)	2 (22.2%)	9
Mulondo	2 (25.0%)	4 (50.0%)	2 (25.0%)	8
Tamparan	0 (0.0%)	3 (75.0%)	1 (25.0%)	4
Total	7	9	5	21

Polymer Types Identified via FTIR

Polymer identification of selected microplastic particles was conducted using Fourier Transform Infrared Spectroscopy (FTIR). One (1) microplastic particle was analyzed per replicate, resulting in nine (9) particles being tested for polymer composition. Although there are 21 MPs in total extracted, only nine (9) were subjected to polymer identification due to instrument limitations. The analysis revealed four (4) distinct polymer types: The FTIR analysis identified four distinct polymer types: Polyethylene (PE), Polypropylene (PP), Polyester (PET), and Polyamide (Nylon). Polyethylene and polypropylene were the most prevalent, which aligns closely with previous studies in freshwater fish, reflecting the dominance of these polymers in consumer products, packaging, and fishing materials (Hossain et al., 2024; Pirsaheb et al., 2023). Similarly, the presence of polyester (PET) and polyamide (nylon) has been reported, often attributed to synthetic textile fibers and fishing nets (Pirsaheb et al., 2023). Table 2 presents the polymer types identified in each sampling site. Figure 3 presents

stereomicroscope images of the microplastic particles that were subjected to FTIR, providing visual context of their physical forms prior to spectral analysis.

Table 2. Identified Polymer Types in Microplastic Samples from Each Sampling Site

Sampling Site	Sample Code	Polymer Type
Marawi City	MC-MP1	Polyethylene (PE)
Marawi City	MC-MP2	Polyethylene (PE)
Marawi City	MC-MP3	Polypropylene (PP)
Mulondo	MU-MP1	Polyester (PET)
Mulondo	MU-MP2	Polypropylene (PP)
Mulondo	MU-MP3	Polyester (PET)
Tamparan	TA-MP1	Polyethylene (PE)
Tamparan	TA-MP2	Polyamide (PA or Nylon)
Tamparan	TA-MP3	Polyamide (PA or Nylon)

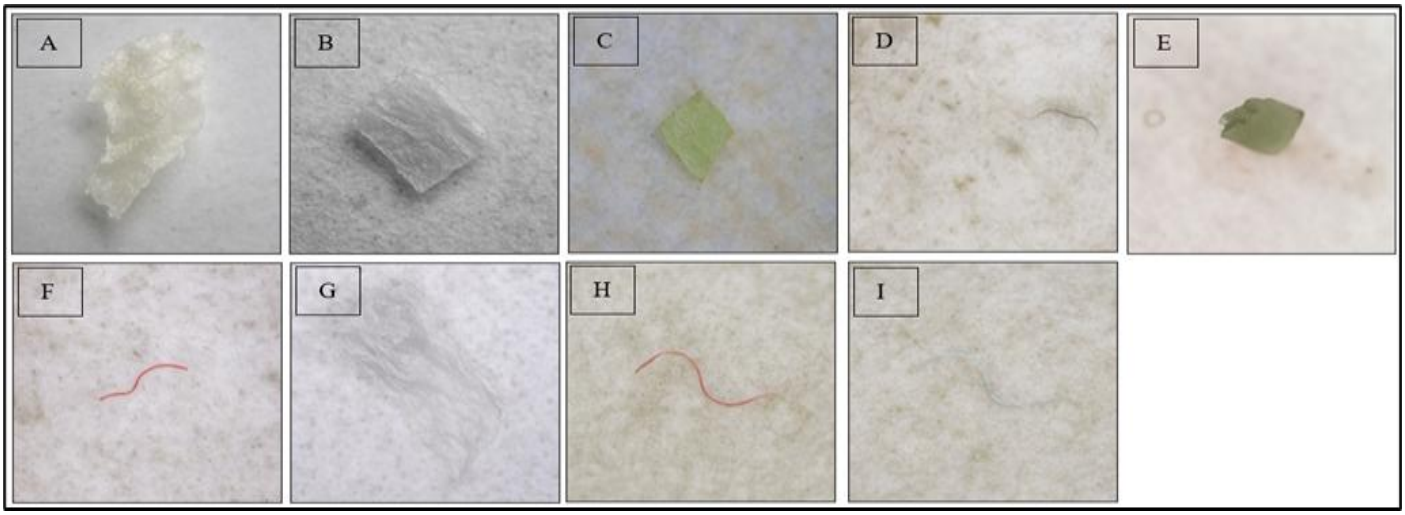

Fig. 3. Microplastics isolated from tilapia samples in Marawi City (MC), Mulondo (MU), and Tamparan (TA) and subjected to FTIR analysis. Images are arranged from top left to bottom right: MC-MP1 to TA-MP3.

Demographic Profile of Respondents

A total of 989 respondents participated in the study. Across all municipalities, the 26–30 age group was the most represented. Females comprised the majority in each locale, with Tamparan reporting the highest percentage. Most respondents completed only elementary education and were predominantly self-employed. Table 3 below summarizes key demographic data across the three municipalities.

Table 3 Demographic Profile of Respondents

Demographic Variable	Marawi City	Mulondo	Tamparan
Most Common Age Bracket	26–30 (32.62%)	26–30 (36.45%)	26–30 (36.94%)
Female %	63.08%	61.45%	70.57%
Male %	36.92%	38.55%	29.43%

Highest Education	Elementary (42.77%)	Elementary (46.99%)	Elementary (47.15%)
Most Common Occupation	Self-employed (50.46%)	Self-employed (53.61%)	Self-employed (53.45%)
>10 Years Residency	54.77%	49.10%	54.35%

Awareness and Attitudes Toward Microplastics

Awareness was measured across three dimensions: general knowledge (Q1), perceived health effects (Q2), and ecological impacts (Q3), while attitudes toward microplastic mitigation were assessed independently (Q4). The results revealed consistently low levels of awareness across all dimensions (general knowledge, health effects, ecological impacts), yet notably high positive attitudes among respondents. These findings parallel previous studies indicating limited public awareness of microplastic pollution, despite a strong communal willingness to participate in mitigation efforts (Omoyajowo et al., 2022; Premarathna et al., 2023). Such patterns suggest the significant potential for educational interventions to harness existing positive attitudes towards enhanced environmental stewardship.

Table 4 Awareness and Attitudes Toward Microplastics

Municipality	Q1 (Knowledge)	Q2 (Health)	Q3 (Aquatic)	Q4 (Attitude)
Marawi City	2.081 (Low)	1.727 (Low)	1.620 (Low)	3.747 (Very High)
Mulondo	2.000 (Low)	1.717 (Low)	1.595 (Low)	3.690 (Very High)
Tamparan	2.004 (Low)	1.728 (Low)	1.666 (Low)	3.694 (Very High)

Despite the limited awareness, the attitude scores suggest a strong predisposition among residents to participate in microplastic mitigation efforts. This provides a vital opportunity to strengthen knowledge through education.

Correlation Between Awareness and Attitude

To examine how awareness relates to attitude, Spearman's rho correlation was calculated. General knowledge had a moderate correlation with attitude ($\rho = 0.422$), while ecological awareness showed a weak yet significant link ($\rho = 0.101$). Health-related awareness had no notable impact on attitude. Overall awareness (Q1–Q3) moderately correlated with attitude ($\rho = 0.383$). This finding aligns with previous research indicating that increased awareness is associated with more proactive environmental attitudes (Righi, et al., 2021)

Table5 between awareness and attitude

Variables Compared	Spearman's rho	p-value
Q1 (Knowledge) vs Q4 (Attitude)	0.422	< 0.001
Q2 (Health Effects) vs Q4	0.027	0.3897
Q3 (Aquatic Effects) vs Q4	0.101	0.0015
Q1+Q2+Q3 vs Q4	0.383	< 0.001

These results support the need for improving general and ecological awareness through educational interventions. Residents already possess strong attitudes that can be leveraged for greater behavioral change when paired with appropriate knowledge.

IEC and IM Development

To address the observed knowledge gaps and favorable attitudinal trends toward environmental protection, two educational outputs were developed and validated: a contextualized instructional module for Grade 8 Science and a tri-fold Information, Education, and Communication (IEC) brochure for the broader community.

The instructional module, titled "Tiny Plastics, Big Problem: Understanding Microplastics in Lake Lanao," aligns with the Most Essential Learning Competencies (MELCs) of the K–12 Science curriculum. It contains three structured lessons: (1) an introduction to microplastics and their classification; (2) sources and environmental impacts, including effects on aquatic life and human health; and (3) presentation and interpretation of the localized research findings. Each lesson includes activities such as data analysis, collaborative discussion, and reflective writing to encourage critical thinking and student engagement. Designed for classroom integration, the module empowers learners to connect science concepts with real-world environmental issues affecting their own communities.

The IEC brochure was developed to complement the instructional module by targeting a broader, non-academic audience—particularly residents of lakeside barangays. The brochure is presented in a tri-fold layout and written in both English and Maranao to ensure accessibility and cultural resonance. Designed for informal learning settings such as barangay halls, sari-sari stores, waiting sheds, and school bulletin boards, the brochure offers concise and visually engaging information.

It opens with a brief history of Lake Lanao's cultural and ecological importance, establishing emotional and geographic relevance for the reader. It then transitions to the threat of microplastic pollution, drawing directly from findings in this study (e.g., the presence of microplastics in fish consumed by the community). Infographics illustrate sources of microplastics—such as laundry water, discarded plastics, and fishing gear—and their path into the food chain. The brochure closes with practical calls to action, such as minimizing plastic use, participating in local cleanups, and practicing proper waste segregation. Throughout the material, culturally embedded values like kapamagogopa (mutual help) are subtly invoked to encourage collective action and responsibility.

Both educational tools were validated by experts for clarity, content accuracy, and local appropriateness. Together, the module and brochure serve as foundational resources for improving microplastic literacy and fostering environmentally conscious behaviors within and beyond the classroom.

Qualitative Insights and Policy Implications

Focus group discussions (FGDs) conducted across the three study sites—Marawi City, Mulondo, and Tamparan—offered rich qualitative insights into the community's perceptions, practices, and lived experiences related to plastic waste and environmental conditions surrounding Lake Lanao. Participants from Marawi City expressed growing concern over the noticeable accumulation of plastic waste near fishing zones. Several individuals observed that discarded wrappers, plastic bottles, and household waste were increasingly visible along lake shores and shallow waters, especially in densely populated areas. This observation aligns with the site's more urbanized setting and higher population density.

In Mulondo and Tamparan, participants voiced apprehension regarding changes in fish quality, noting that fish appeared less vibrant and, in some instances, were accompanied by an unpleasant odor. While not conclusively attributed to plastic pollution, these experiential accounts reflect a growing community suspicion that the lake's deteriorating water quality is affecting both aquatic life and human consumption safety. Despite these concerns, there was a prevailing lack of awareness about existing barangay or municipal ordinances related to waste disposal and lake protection. Some participants openly admitted that they were unaware of any formal policies regulating plastic usage, dumping, or penalties for littering.

Furthermore, traditional waste disposal practices such as open dumping, burning of plastic materials along the shoreline, and the absence of regulated waste segregation were reported to be common and unmonitored. These highlight a significant implementation gap between local environmental policies and actual community

practices, pointing to weak enforcement mechanisms and limited grassroots education campaigns. Gaps between policy and practice have similarly been reported in low-income lakeside communities in Southeast Asia, where weak enforcement and limited grassroots education undermine plastic waste reduction efforts (UNEP, 2021; Edwin, 2023).

Notably, across all FGDs, the cultural value of *kapamagogopa*—a Maranao principle centered on mutual assistance and collective responsibility—emerged as a recurring theme. Participants acknowledged that if environmental campaigns were framed within this cultural lens and mobilized through community elders or religious leaders, greater participation and behavioral change could be fostered. This implies the need to design future IEC programs and policy rollouts that not only convey scientific knowledge but also resonate with local cultural identity and values.

In light of these insights, it is recommended that local government units (LGUs) and environmental agencies strengthen both community-level education and policy enforcement, while collaborating with schools, mosques, and traditional leaders to embed environmental consciousness into daily practices. Such culturally embedded, multisectoral approaches may improve compliance and nurture long-term environmental stewardship among Lake Lanao's lakeside communities.

CONCLUSION

The findings of this study confirm the presence of microplastics in tilapia (*Oreochromis niloticus*) collected from Lake Lanao, raising important ecological and public health concerns. Microplastics were extracted from all three sampling sites—Marawi City, Mulondo, and Tamparan—with varying morphological types and polymer compositions identified. Fiber-type microplastics were the most prevalent overall, while FTIR analysis confirmed the presence of Polyethylene (PE), Polypropylene (PP), Polyester (PET), and Polyamide (Nylon).

In parallel, the community survey revealed generally low awareness levels about microplastics, particularly in relation to their health risks. Despite this, respondents across all sites demonstrated a strong willingness to engage in environmental protection activities, suggesting a high level of attitudinal receptiveness to future educational initiatives. The moderate correlation between awareness and attitude further highlights the pivotal role of knowledge dissemination in influencing behavior.

Based on these insights, the study developed and validated two educational outputs: a contextualized instructional module for Grade 8 students and an IEC brochure for the wider community. These materials are designed to bridge the knowledge gap, promote informed action, and support the broader goals of sustainable freshwater resource management. The integration of local cultural values and the involvement of key community members are recommended for the effective implementation of these materials.

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