Original Article

Environmental distribution and polymer characterization of microplastics in the Miagao Estuary, Iloilo, Philippines

Rea Grace P. Galit[1], Edcyl Lee O. Salac[1], Gabrielle Troy A. Cuevas[2]*, Lency S. Rosana[1], Shairra Joy G. Bacuta[1], Maridel S. Somejo[1], Jay O. Martizano[1], Sherwin L. Escayo[1,3], and Elmer-Rico E. Mojica[4,5]

[1]Department of Chemistry, University of the Philippines Visayas, Miagao, Iloilo, Philippines, 5023;
[2]Department of Chemistry and Biochemistry, Ohio University, Athens Ohio 45701, USA;
[3]School of Materials Science and Engineering, Nanyang Technological University, Singapore, 639798 Singapore;
[4]Department of Chemistry and Physical Sciences Dyson College of Arts and Sciences, Pace University, W340 One Pace Plaza, New York, NY 10038;
[5]Institute of Chemistry, University of the Philippines Los Baños, Los Baños, Laguna, Philippines, 4030

**Corresponding author: gacuevas@up.edu.ph; gc181925@ohio.edu*

Received: 02 Oct. 2025 || Revised: 05 May 2026 || Accepted: 18 Aug. 2026 || Available Online: 16 Sep. 2026

How to cite:
Galit RGP, Salac ELO, Cuevas GTA, Rosana LS, Bacuta SJG, Somejo MS, Martizano JO, Escayo SL, Mojica ERE. 2026. Environmental distribution and polymer characterization of microplastics in the Miagao Estuary, Iloilo, Philippines. The Palawan Scientist. 18(2):in press. https://doi.org/10.69721/TPS.J.2026.18.2.05

ABSTRACT

The Philippines contributes significantly to marine plastic pollution, yet little is known about microplastics (MPs) in its many estuaries. This study was the first to examine how many MPs are present, where they are located, and what types are present in Brgy. Baybay Sur, Miagao, Iloilo. Surface water samples were collected from three sampling sites: sample site 1 (SP1), sample site 2 (SP2), and sample site 3 (SP3) along the estuary, then separated, and MPs were isolated. Visualization of MPs was performed using a microscope and Nile Red Dye, which makes the MPs glow under UV light. The number of MPs ranged from 11 ± 6.02 to 20 ± 13.8 particles per liter. Water movement allows MP deposition near the mouth of the estuary. The morphology of MPs was dominated by fibers (72–85%), suggesting sources such as wastewater and fishing gear. Fragments (15–28%) were also found in the area. The Nile red test showed that the majority of the plastics present were polyester (blue) and polyethylene (yellow). Results showed that the method works well for most plastics (recovering 90.9–100%), but the dye did not work equally for all kinds. These results show that this estuary acts as a collection point for MPs from both land and sea activities. This study sets a starting point for future research and shows that Nile Red can be used to monitor MPs, but it also highlights the need for further testing to accurately identify plastic types in tropical estuaries.

Keywords: estuary, fibers, fluorescence, microplastics, Nile Red, pollution sources

INTRODUCTION

Plastic pollution has become a major worldwide environmental problem that exists today. The environment continues to face major effects of plastic pollution, which will persist for many years to come. The threat exists as a worldwide permanent danger that threatens all marine ecosystems throughout the entire planet (Barnes et al. 2009; Borrelle et al. 2020). The Philippines is recognized as the third-largest contributor to ocean plastic waste. The marine ecosystem faces annual contamination from 0.75 million metric tons of plastic waste because of insufficient waste management practices (Meijer et al. 2021). The archipelago serves as the main location for an ongoing severe environmental crisis. Plastic waste exists in large amounts, which threatens both marine species and the health of coastal populations and ecosystem operations. The manufacturing and usage of plastics have led to an unsustainable buildup of waste. Most of the plastic waste receives insufficient treatment before it enters water bodies through various routes, which include stormwater drainage, wastewater discharge, and ocean fishing operations (Jambeck et al. 2015; Lebreton et al. 2017). The plastic waste contains plastic items that transform into microplastics through decomposition until they reach sizes of less than 5 mm. The environment breaks down plastic materials through three main processes, which include UV radiation exposure, wave-induced mechanical damage, and biological decomposition (Andrady 2011; Cole et al. 2011). Microplastics have dangerous substances such as persistent organic pollutants and heavy metals that bind to their surfaces because of their small dimensions and extensive surface area (Rochman et al. 2013; Caruso 2019). Marine organisms such as zooplankton and fish consume these particles, which lead to physical damage, stress, and toxic substance accumulation through the food chain that threatens human health through the consumption of seafood (Wright et al. 2013; Barboza et al. 2018).

Microplastic pollution creates significant threats to estuaries because these areas are highly susceptible to its impacts. Estuaries serve as a vital boundary between freshwater and saltwater from the sea. The circulation of water in estuaries is vital for transporting nutrients, oxygen, and sediments in the area. Tidal currents push saltwater inward, and river currents push freshwater outward, which creates mixing and differences in salinity. This circulation entraps particles, resulting in the accumulation of buoyant MPs (Browne et al. 2010; Rodrigues et al. 2018). Studies show that estuaries are essential for the accumulation of MPs in water bodies, which in turn contributes to the increase in the concentration of MPs in the ocean (Nel et al. 2018). Research conducted in several estuaries around the world shows that MP contamination is high. This seems to be connected to both the population density of nearby human settlements and agricultural activities (Yonkos et al. 2014; Gray et al. 2018). Despite the global urgency, there is a notable lack of data on MP pollution in Philippine estuaries. The current lack of knowledge prevents the creation of suitable local solutions and policies needed to solve this problem (Bucol et al. 2020).

Miagao, in the province of Iloilo, is a coastal town with fishing as one of the sources of livelihood. This contributes to the accumulation of MPs in the area due to the use of fishing nets that contain nylon (polyamide), polyethylene (PE), and polypropylene (PP). The communities maintain their survival through their practice of subsistence activities and their small fishing operations, which supply them with food and economic resources. The estuary in Barangay Baybay Sur serves as a vital resource for the community because it supports fish habitats and fish reproduction areas. The area faces threats from residential pollution and fishing activities, and local trade operations. The rising number of MPs leads to environmental damage to marine habitats, which threatens both marine wildlife and local economic sustainability (Smith et al. 2018).

Research about MPs in bodies of water in the Philippines continues to grow, but most studies concentrate on specific areas such as Manila Bay (Silva et al. 2024) and Laguna de Bay (Arcadio et al. 2023) or specific organisms like oysters (Carballeira Braña et al. 2021) and fish (Bucol et al. 2020; Cabansag et al. 2021a). Most Panay Island research focuses on river systems, including the Iloilo River (Hansen et al. 2023), and coastal sediments in Anilao, Iloilo (Ray et al. 2022). There is a critical lack of data on the baseline status of MPs in the estuarine waters of Miagao, even though the area is economically and ecologically significant and exposed to potential pollution.

To fill this gap, the current study assessed the prevalence of MPs in the estuarine waters of Brgy. Baybay Sur, Miagao, Iloilo, for the first time. The research had three main objectives, which included determining the quantity and distribution pattern of MPs from freshwater to marine environments, identifying the dominant forms of MPs to trace pollution origins, and assessing Nile Red fluorescence staining with density separation for affordable MPs monitoring in resource-constrained areas. The fluorescence microscopy detection of MPs becomes more efficient through Nile Red staining, but this method faces challenges because it does not equally stain all types of plastic materials (Maes et al. 2017a; Prata et al. 2020). The main goal of this research was to create a foundational dataset on MPs pollution in this under-researched estuary. The gathered information will enable local authorities to create management strategies and will serve as evidence for future scientific investigations about MPs behavior in tropical estuaries.

METHODS

Sampling Region

Surface water samples were collected from the estuary in Brgy. Baybay Sur, Miagao, Iloilo (10°38'N, 122°14'E) on 25 February 2025. This estuary connects freshwater sources to the Sulu Sea. It features fishing operations, housing communities, and nearby small businesses. Three sampling locations were set up along a 120-m transect: SP1 (riverine zone, furthest from the sea), SP2 (mid-estuary), and SP3 (marine zone, closest to the sea) (Figure 1).

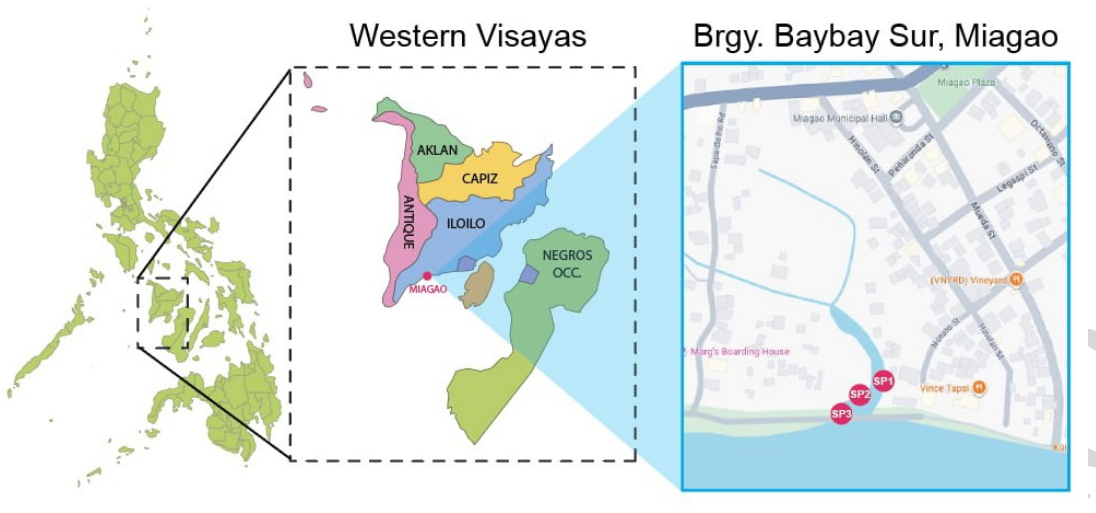


Figure 1. Geographical location of the estuary in Brgy. Baybay Sur, Miagao, Iloilo, Philippines, along with the sampling points in the area.

Chemical Solutions and Solvents

Nile Red dye (analytical grade) was sourced from Sigma-Aldrich (N3013) and dissolved in acetone to create a 1 mg mL^{-1} stock solution. Zinc chloride ($ZnCl_2$, technical grade) was utilized to prepare a density separation solution (1.5 g cm^{-3}). Ferrous sulphate heptahydrate ($FeSO_4 \cdot 7H_2O$) and hydrogen peroxide (30% H_2O_2) were utilized for oxidative digestion via Fenton's method. All solvents and reagents used were of laboratory quality or higher.

Sample Collection

Surface water samples were obtained through the grab sampling technique described in the "Toolkit for Quantifying Microplastics in the Marine Environment: Sampling Methods" created by the Microbial Oceanography Laboratory at the University of the Philippines Diliman. One-liter glass bottles that were pre-rinsed were utilized, and air contamination controls were positioned near the sampling locations. After the collection of water samples, aluminum foil and aluminum caps were used to cover the water containers. Water samples were collected approximately 20 cm below the water surface. The global positioning system was used to record the coordinates of the sampling area. To tackle the variability in MPs levels, estuarine water samples were gathered in triplicate. From this total, 1 L from each location was reserved for Fourier transform infrared (FTIR) spectroscopy analysis to verify the existence of MPs. All samples were delivered to the laboratory in conditions that reduced contamination for the following detection and characterization of MPs.

Sample Processing: Density Separation and Digestion

One liter (1 L) of the sample was collected and filtered. Procedural blanks were created by filtering 1 L of tap water using glass filtration. Spiked samples were prepared by cutting plastic pieces (>5 mm) and blending them with filtered water collected from the sampling locations. Every sample, along with blanks and spiked controls, was passed

through clean membrane filters with a pore size of 0.45 μm. To remove organic matter, oxidative digestion using Fenton's reagent (30% H_2O_2 and 0.05 M Fe (II) solution, analytical reagent grade from the UPV Chemistry Laboratory) was conducted at approximately 60°C until boiling commenced. The processed samples underwent two density separation rounds using zinc chloride solution (technical grade, density 1.5 g/cm^3, Dalkem Corporation) for at least 4 hours, enabling MPs to float and eliminating denser inorganic materials. The MPs that were recovered underwent vacuum filtration. The membranes were subsequently meticulously dried in an oven and readied for microscopy, stained with Nile Red, and visually counted to verify the presence and amount of MPs in the samples.

Nile Red Staining and MPs Characterization

The filter papers, which had been vacuum-dried with the gathered samples, were stored in Petri dishes before analysis. The detection and quantification of MPs employed fluorescent tagging with Nile Red (analytical grade, 98% purity), applied at a working concentration of 10 μg/mL to enhance visibility, reduce background interference, and ensure effective staining (Maes et al. 2017a). A stock solution was created by dissolving the dye in acetone to reach a final volume of 100 mL. A working solution was then prepared by diluting the stock in methanol to obtain the target concentration of 10 μg/mL (Rumin et al. 2015; Erni-Cassola et al. 2017). The filter papers containing MPs were examined using a stereomicroscope and categorized based on their fluorescence response under UV light at 365 nm. Observations were conducted in a dimly lit setting to ensure clear visibility. Images of each filter paper were taken to aid in measuring the MPs, using an iPad (9th generation) equipped with an 8-megapixel camera.

Recovery Rate Testing and Sample Size Considerations

Recovery methods were assessed via spike recovery experiments involving seven typical plastic polymer types. Plastic materials were mechanically mixed and screened to achieve microplastic-sized particles (<5 mm) before spiking. Every type of polymer was individually added to pre-cleaned samples at specified particle counts, and recovery trials were performed in triplicate to evaluate method precision. After processing the samples, the retrieved particles were visually recognized and tallied, and recovery rates were determined by evaluating the number of particles recovered against the number initially introduced. This process enabled the evaluation of method effectiveness among various polymer types. Field sampling took place at three geographically separate sites, with one composite sample gathered from each location (n = 3), mirroring logistical limitations and the study's exploratory nature. Though this sampling approach aligns with initial microplastic assessments focused on detecting spatial trends, it restricts statistical strength. Thus, the limited sample size is recognized as a constraint, and subsequent research should include larger sample sizes.

Data Analysis

Data on MPs concentration were summarized through descriptive statistics, with means and standard deviations computed from three separate samples (n = 3) gathered at each sampling location. Before conducting statistical comparisons, data were evaluated for normality to identify the suitable inferential test. Variations between sampling locations were assessed using one-way analysis of variance (ANOVA) for normally distributed data or the non-parametric Kruskal–Wallis test when normality assumptions were violated. Statistical significance was established at $P < 0.05$. The observed negative spatial gradient was founded on a steady decline in average microplastic levels across sampling sites and was reinforced by the outcomes of the statistical analyses. All statistical analyses were conducted using conventional statistical software. Despite the sample size being small (n = 3 per site), this design aligns with exploratory or initial MPs research, reflecting logistical limitations; nonetheless, the restricted replication is recognized as a drawback, and future research should utilize larger sample sizes to enhance statistical power and reliability.

Quality Control

Quality control protocols were performed after every phase of sample collection and analysis. To minimize contamination by plastic, cotton apparel, cotton lab coats, and gloves were used. A sample blank was also used to minimize errors in each analysis. All equipment for holding samples was rinsed with distilled water prior to use, as per the protocol of Egessa et al. (2020). Air contamination was minimized by placing dried samples in a Petri dish and wrapping it with aluminum foil. Procedural blanks and air contamination measures were incorporated at every phase to evaluate baseline contamination from both field and laboratory sources, encompassing air, sampling instruments, and containers. These controls remained exposed to the air throughout the sampling and analysis processes to guarantee accurate tracking of possible contamination.

RESULTS

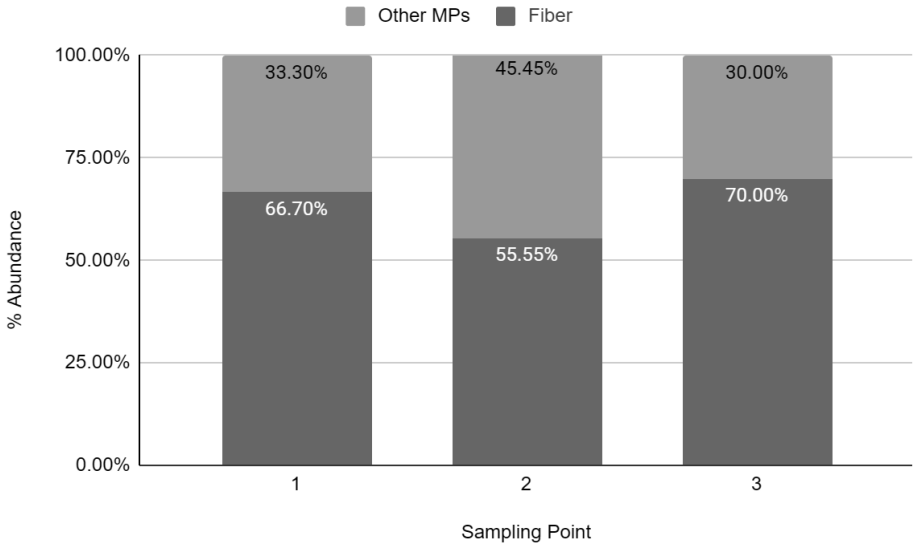
Microplastic Quality and Distribution

About 11 ± 6.02 to 20 ± 13.8 particles per liter (par/L) of MPs were detected in the surface waters of the Miagao estuary. Procedural blanks were used to correct the data collected from the samples. Among the sampling sites, SP3, which was nearest the sea, had the highest concentration of MPs. On the other hand, SP2, which was in the middle of the estuary, had the lowest concentration of MPs (Table 1). A significant inverse correlation was found between MPs abundance and distance from the sea ($R^2 = 0.89$). Fibers were the most common type of MPs across all sites, making up 55.6%-70% of the total, followed by fragments (Figure 2).

198 **Table 1.** Microplastic abundance and morphological distribution at each sampling point.

Sampling Point	Location	Fiber Count (par/L)	Fragment Count (par/L)	Total MP (par/L)	Standard Deviation
SP1	Riverine Zone	8	4	12	2.0
SP2	Mid-Estuary	6	5	11	6.02
SP3	Marine Zone	14	6	20	13.8

199



200

201 **Figure 2.** Relative proportion of fibers and fragments of microplastics detected at each sampling point.

202 **Types of microplastics detected from surface water samples.** A stereomicroscope examination of unstained
203 samples revealed the existence of MPs exhibiting diverse physical properties. These included clear, red, black, and
204 white fibers, as well as red, white, and yellow fragments (Figure 3).

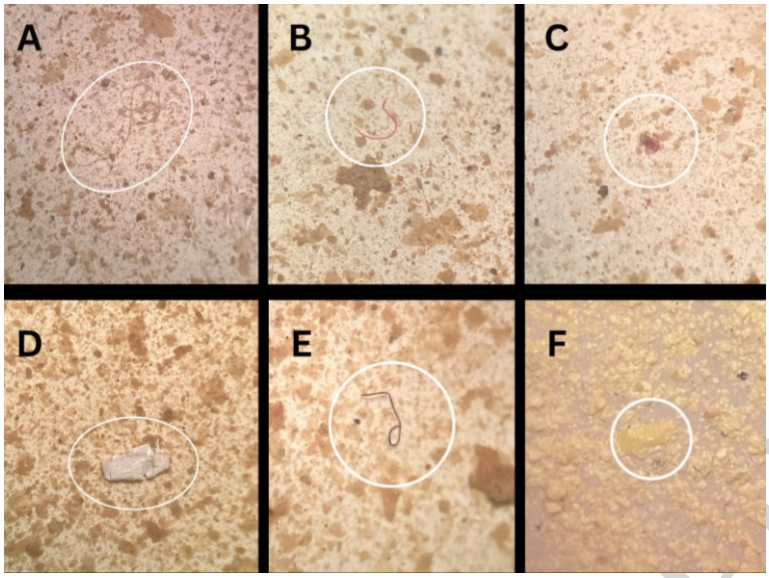


Figure 3. Representative micrographs of unstained microplastics under stereomicroscopy: (A) clear fiber, (B) red fiber, (C) red fragment, (D) white fragment, (E) black fiber, and (F) yellow fragment. Scale bar: 500 μm.

After Nile Red staining, particles showed fluorescence under 365-nm UV light. Most fluorescent particles appeared as fiber-like structures with pinkish to orange fluorescence (Figure 4A-C). Smaller, fragment-like particles displayed yellow to yellow-green fluorescence (Figure 4D and 4E). Under confocal microscopy (excitation at 531 nm, emission at 593 nm), stained fibers showed a bright orange fluorescence, providing high-resolution details of their shape (Figure 5).

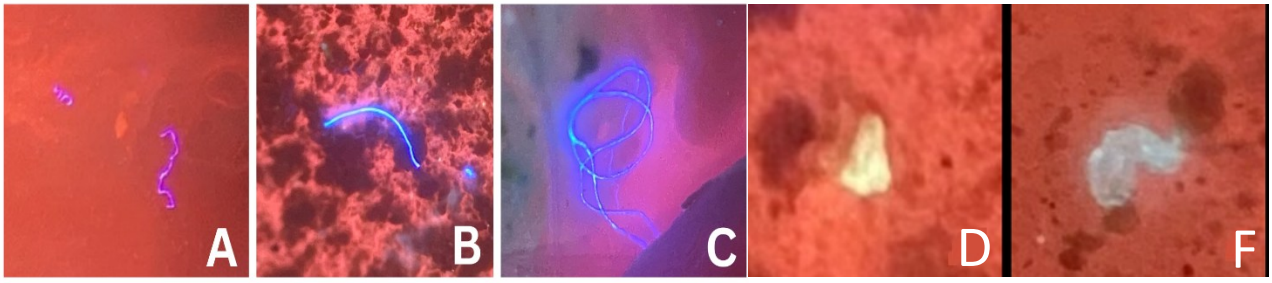


Figure 4. Fluorescence of Nile Red-stained microplastics under UV light (365 nm): (A-C) Fibers showing pinkish to intense blue fluorescence; (D-E) fragments showing yellow and yellow-green fluorescence.

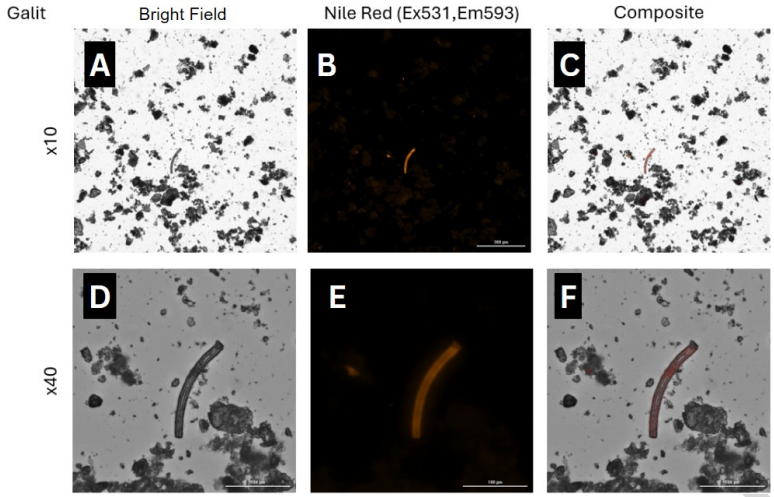


Figure 5. Confocal microscopy images of Nile Red-stained microplastic fibers at (A-C) 10x and (D-F) 40x magnification. Left panels show bright-field images; right panels show fluorescence (neon-orange).

Assessing Nile red fluorescence staining with density separation for MPs monitoring. The effectiveness of the density separation and digestion method was validated through spike recovery tests. Recovery rates for a mix of seven common plastics, including polyethylene terephthalate (PET), polypropylene (PP), low-density polyethylene (LDPE), high-density polyethylene (HDPE), polyvinyl chloride (PVC), polystyrene (PS), and nylon fibers, ranged from 90.9% to 100%. This was within accepted quality control limits (85-115%) (Table 2). The incomplete recovery in one replicate (SP2) was due to two LDPE particles not being recovered. When spiked samples were stained with Nile Red and viewed under UV light, fluorescence varied by polymer type. Under the staining conditions used (10 μg/mL Nile Red), PET fragments and synthetic fibers showed clear fluorescence (blue and pink/violet, respectively) (Figure 6). Other plastic types, including PP, LDPE, HDPE, PVC, and PS, did not fluoresce.

Table 2. Percentage recovery of spiked plastic particles from water samples.

Spiked Sample	Initial Total Amount	Total MP Recovered	% Recovery
1	22	22	100%
2	22	20	90.91%
3	22	22	100%

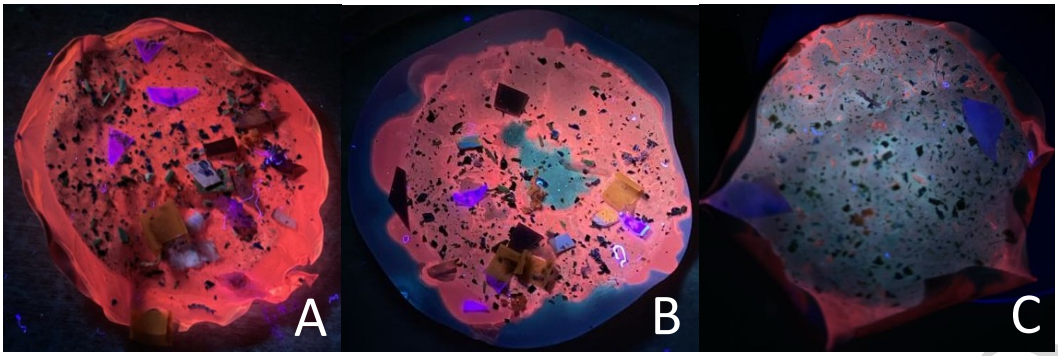


Figure 6. Fluorescence of stained spiked samples under UV light (365 nm) (A-C). The blue, fluorescent film is a PET fragment, and the pink-violet film is a nylon fiber.

DISCUSSION

Microplastic Quality and Distribution in Miagao Estuary

This study presents the initial quantitative proof that the Miagao estuary serves as a significant sink for MPs pollution, with concentrations varying from 11 to 33.8 particles L^{-1}. The notable negative correlation between MPs abundance and distance from the ocean ($R^2 = 0.89$) indicates a distinct accumulation pattern. The greatest concentration was found at the site influenced by the marine environment (SP3). This pattern is characteristic of estuarine environments, where unique hydrodynamics, such as tidal pumping and density differences, capture suspended particles, which results in the accumulation of MPs (Browne et al. 2010; Nel et al. 2018; Rodrigues et al. 2018). The elevated levels at SP3 were probably a result of hydrodynamic trapping and surrounding human activities. Construction activities near SP3 during the sampling period may have contributed to plastic waste. The distribution of MPs in the surface waters of the Miagao estuary was at a lower concentration in comparison to other bodies of water in the Philippines. In the study of Gabriel et al. (2023), they reported ~300 items/m^3 (up to ~600 items/m^3 near the mouth) in the river estuary in Cagayan de Oro. Osorio et al. (2021) also reported high concentrations of MPs (1,580 – 57,665 particles/m^3) at the Manila Bay river mouths in Pasig, Meycauayan, Parañaque, Tullahan, and Cañas.

Types of MPs detected from surface water samples. A major finding in this research was the substantial occurrence of fibrous MPs, constituting 72%-85% of all gathered particles. This corresponds with increasing studies that recognize fibers as the predominant form of MPs in water habitats globally, including the Philippines (Browne et al. 2010; Suaria et al. 2020). The presence of fibers in the area indicates pollution sources from the equipment of local fishing and industry. The frequent use of fishing nets, which degrade over time, eventually leads to the distribution of fibers in the estuary. Local waste products and the washing of clothes with microfibers also contribute to the increase in MPs distribution in the Miagao estuary (Naji et al. 2018). Moreover, the sampling location's proximity to residential

zones in Brgy. Baybay Sur indicates that laundry wastewater and inadequate waste management substantially contribute, since synthetic fabrics are a primary source of microfibers (Sudheshna et al. 2022; Santonicola et al. 2023).

A proxy based on morphology for size distribution indicated that fibers constituted approximately 65.1% of the microplastic community, while fragments represented 34.9%. At all collection sites, fibers were consistently more prevalent, ranging from 54.5% to 70.0%. This indicates that smaller, thread-like particles predominate and possess a significant potential for transport within the estuarine ecosystem. In contrast, fragments, which tend to be larger and more irregularly shaped, were less frequently observed. Although this provides indirect insight into the characteristics of particle sizes, a formal analysis of size distribution could not be conducted due to the absence of quantitative measurements of particle sizes, which poses a limitation to the study.

Several studies in Philippine waters also support this trend of fiber prevalence. For instance, Cabansag et al. (2021b) discovered that semi-synthetic microfibers, primarily rayon, predominate in subtidal sediments and the rabbitfish *Siganus fuscescens* (Houttuyn, 1782) in Negros Oriental (WoRMS Editorial Board 2026). Carballeira Braña et al. (2021) also found that most MPs in commercial oysters *Crassostrea iredalei* (Faustino, 1932) (Froese and Pauly 2025) obtained from markets in Capiz were fibers. This may be caused by the use of ropes and fishing nets that disintegrate into microfibers as they age. Ray et al. (2022) noted fibers and fragments as the primary elements in the coastal sediments of Anilao, Iloilo. The regular identification of fibers in these studies underscores a local pollution pattern associated with wastewater and maritime operations. The reduced quantity of fragments in our samples might result from larger macroplastic materials in the estuary, which require more time to break down into MPs.

Nile Red Staining Efficiency and Limitations in Microplastic Detection

The Nile Red staining was beneficial in the visualization and detection of MPs from the samples. The detected fluorescence patterns, particularly blue fluorescence for fiber-like particles and yellow/yellow-green fluorescence for fragments, enable certain deductions regarding polymer types. The blue fluorescence is characteristic of polymers such as polyester (PET), which is frequently utilized in textiles and fishing equipment (Santonicola et al. 2024). The fluorescence ranging from yellow to yellow-green is frequently associated with polyethylene (PE), with UV light-induced degradation potentially leading to yellowing via the creation of nano-sized supramolecular structures (Elmer-Dixon et al. 2022).

Results from the spiked sample experiment, however, revealed a notable limitation of the Nile Red method: its staining efficiency varied based on polymer type. Under our staining conditions (10 μg/mL Nile Red), only PET and nylon fibers exhibited distinct fluorescence, whereas other prevalent plastics such as PP, HDPE, LDPE, PVC, and PS did not exhibit any fluorescence. Sargadillos et al. (2025) observed fluorescence solely in PET and PS at this level, while Maslov and Dulin (2020) identified unique fluorescence in PET, PP, and HDPE, but not in other materials. This

variation is related to the solvatochromic properties of Nile Red. The fluorescence emission is affected by the polarity of the polymer environment (Maes et al. 2017b). Polycarbonate, PVC, polyurethane, and PET showed reduced or no fluorescence due to their lower hydrophobicity. The lower hydrophobicity of these materials reduces the fluorophore's mobility. The decrease in movement results in fewer interactions with solvent molecules and potential quenchers, such as oxygen, which ultimately facilitates non-radiative decay (Erni-Cassola et al. 2017; Tirkey and Upadhyay 2021). Elements such as dye-to-surfactant ratios, duration of staining, and temperature can also affect the effectiveness of staining (Park et al. 2022). Fluorescence quenching may diminish the observed intensity, which could explain why fragments appeared less fluorescent than fibers in this study.

Nile Red staining serves as an efficient and cost-effective method for rapid evaluation and quantification, particularly useful in resource-limited environments, although it does not provide a definitive approach for polymer identification. The insights made here about polymer classifications based on the color of fluorescence remain speculative. The lower recovery rate for nylon (73.3%) indicates a limitation of the staining methods for certain polymers. These findings underline the importance of using spectroscopic techniques, such as FTIR spectroscopy, for accurate identification of polymers and to avoid misclassification or the underestimation of non-fluorescent polymers (Song et al. 2015). The considerable error margins linked to visual identification alone (20-70%, particularly for particles smaller than 1 mm) underscore the need for additional analytical techniques (Löder and Gerdts 2015).

This study provides the initial evaluation of MP contamination in the estuarine waters of Brgy. Baybay Sur, Miagao, Iloilo. It shows major contamination levels, with as much as 33.8 particles L^{-1}. The prevalence of fibrous MPs underscores an immediate necessity to tackle sources from municipal wastewater and the breakdown of fishing equipment in coastal management plans. While the Nile Red staining technique was successful for rapid quantification and morphological evaluation, its shortcomings in polymer identification highlight the need for spectroscopic methods for precise risk assessment. This research offers a core dataset for upcoming studies and policy initiatives focused on decreasing plastic pollution in tropical estuarine settings. For future studies, it is recommended to increase the sampling area for a better correlational analysis. The larger sampling area will improve representativeness, reduce sampling error, and increase the statistical accuracy of the results. Seasonal sampling is also recommended to determine the effects of weather on the microplastics distribution. Analysis of the samples using FTIR or Raman spectroscopy is also recommended to further characterize the microplastic samples. A thorough size distribution analysis should also be added to support the data for further studies.

FUNDING

The authors did not receive support from any organization for the submitted work.

GENERATIVE AI STATEMENT

Grammarly was used to check the grammar of the manuscript.

ETHICAL CONSIDERATIONS

The necessary permits addressed to the Local Government Unit of Miagao, Iloilo, Philippines, were secured by the authors.

DECLARATION OF COMPETING INTEREST

No potential conflict of interest was reported by the authors.

ACKNOWLEDGMENTS

The authors acknowledge the Department of Chemistry, University of the Philippines Visayas, for providing the chemicals used in the experiments. Appreciation is also extended to the College of Fisheries and Ocean Sciences, University of the Philippines Visayas, and the Local Government Unit (LGU) of Miagao for granting permission to collect sediment samples from Miagao Beach. The authors further acknowledge the Department of Science and Technology–Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD), through the Balik Scientist Program, for its invaluable support to Elmer-Rico E. Mojica. The authors would also like to acknowledge the editors who helped improve the manuscript.

REFERENCES

Andrady AL. 2011. Microplastics in the marine environment. Marine Pollution Bulletin. 62(8):1596–1605. https://doi.org/10.1016/j.marpolbul.2011.05.030

Arcadio CGLA, Navarro CKP, Similatan KM, Inocente SAT, Ancla SMB, Banda MHT, Capangpangan RY, Torres AG, Bacosa HP. 2023. Microplastics in surface water of Laguna de Bay: First documented evidence on the largest lake in the Philippines. Environmental Science and Pollution Research. 30(11):29824–29833. https://doi.org/10.1007/s11356-022-24261-5

Barboza LGA, Dick Vethaak A, Lavorante BRBO, Lundebye A-K, Guilhermino L. 2018. Marine microplastic debris: An emerging issue for food security, food safety and human health. Marine Pollution Bulletin. 133:336–348. https://doi.org/10.1016/j.marpolbul.2018.05.047

Barnes DKA, Galgani F, Thompson RC, Barlaz M. 2009. Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences. 364(1526):1985–1998 https://doi.org/10.1098/rstb.2008.0205

Borrelle SB, Ringma J, Law KL, Monnahan CC, Lebreton L, McGivern A, Murphy E, Jambeck J, Leonard GH, Hilleary MA. 2020. Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution. Science. 369(6510):1515-1518. https://doi.org/10.1126/science.aba3656

Browne MA, Galloway TS, Thompson RC. 2010. Spatial patterns of plastic debris along estuarine shorelines. Environmental Science and Technology. 44(9):3404–3409. https://doi.org/10.1021/es903784e

Bucol LA, Romano EF, Cabcaban SM, Siplon LMD, Madrid GC, Bucol AA, Polidoro B. 2020. Microplastics in marine sediments and rabbitfish (*Siganus fuscescens*) from selected coastal areas of Negros Oriental, Philippines. Marine Pollution Bulletin. 150:110685. https://doi.org/10.1016/j.marpolbul.2019.110685

Cabansag JBP, Olimberio RB, Villanobos ZMT. 2021a. Microplastics in some fish species and their environs in Eastern Visayas, Philippines. Marine Pollution Bulletin. 167:112312. https://doi.org/10.1016/j.marpolbul.2021.112312

Cabansag JBP, Olimberio RB, Villanobos ZMT. 2021b. Microplastics in some fish species and their environs in Eastern Visayas, Philippines. Marine Pollution Bulletin. 167:112312. https://doi.org/10.1016/j.marpolbul.2021.112312

Carballeira Braña CB, Cerbule K, Senff P, Stolz IK. 2021. Towards environmental sustainability in marine finfish aquaculture. Frontiers in Marine Science. 8: 666662. https://doi.org/10.3389/fmars.2021.666662

Caruso G. 2019. Microplastics as vectors of contaminants. Marine Pollution Bulletin. 146(2):921–924. https://doi.org/10.1016/j.marpolbul.2019.07.052

Cole M, Lindeque P, Halsband C, Galloway TS. 2011. Microplastics as contaminants in the marine environment: A review. Marine Pollution Bulletin. 62(12):2588–2597. https://doi.org/10.1016/j.marpolbul.2011.09.025

Egessa R, Nankabirwa A, Ocaya H, Pabire WG. 2020. Microplastic pollution in surface water of Lake Victoria. Science of the Total Environment. 741:140201. https://doi.org/10.1016/j.scitotenv.2020.140201

Elmer-Dixon M, Fawcett L, Hinderliter B, Maurer-Jones M. 2022. Could superficial chiral nanostructures be the reason polyethylene yellows as it ages? ACS Applied Polymer Materials Journal. 4(9):6458–6465. https://doi.org/10.1021/acsapm.2c00877

Erni-Cassola G, Gibson MI, Thompson RC, Christie-Oleza JA. 2017. Lost, but found with Nile Red: A novel method for detecting and quantifying small microplastics (1 mm to 20 µm) in environmental samples. Environmental Science and Technology. 51(23):13641–13648. https://doi.org/10.1021/acs.est.7b04512

Froese R, Pauly D. 2025. FishBase. *Siganus fuscescens* (Houttuyn, 1782). World Register of Marine Species. [accessed 2025 Nov 07]. https://www.marinespecies.org/aphia.php?p=taxdetails&id=273912.

Gabriel AD, Amparado Jr. RF, Lubguban AA, Bacosa HP. 2023. Riverine microplastic pollution: Insights from Cagayan de Oro River, Philippines. International Journal of Environmental Research and Public Health. 20(12):6132. https://doi.org/10.3390/ijerph20126132

Gray AD, Wertz H, Leads RR, Weinstein JE. 2018. Microplastic in two South Carolina Estuaries: Occurrence, distribution, and composition. Marine Pollution Bulletin. 128:223–233. https://doi.org/10.1016/j.marpolbul.2018.01.030

Hansen J, Hildebrandt L, Zimmermann T, El Gareb F, Fischer EK, Pröfrock D. 2023. Quantification and characterization of microplastics in surface water samples from the Northeast Atlantic Ocean using laser direct infrared imaging. Marine Pollution Bulletin. 190:114880. https://doi.org/10.1016/j.marpolbul.2023.114880

Jambeck JR, Geyer R, Wilcox C, Siegler TR, Perryman M, Andrady A, Narayan R, Law KL. 2015. Marine pollution. Plastic waste inputs from land into the ocean. Science. 347(6223):768–771. https://doi.org/10.1126/science.1260352

Lebreton LCM, van der Zwet J, Damsteeg J-W, Slat B, Andrady A, Reisser J. 2017. River plastic emissions to the world's oceans. Nature Communications. 8:15611. https://doi.org/10.1038/ncomms15611

Löder MGJ, Gerdts G. 2015. Methodology used for the detection and identification of microplastics—A Critical Appraisal. In: Bergmann M, Gutow L, Klages M, editors. Marine Anthropogenic Litter. Cham: Springer International Publishing. p. 201–227. https://doi.org/10.1007/978-3-319-16510-3_8

Maes T, Jessop R, Wellner N, Haupt K, Mayes AG. 2017a. A rapid-screening approach to detect and quantify microplastics based on fluorescent tagging with Nile Red. Scientific Reports. 7:44501. https://doi.org/10.1038/srep44501

Maes T, Van der Meulen MD, Devriese LI, Leslie HA, Huvet A, Frère L, Robbens J, Vethaak AD. 2017b. Microplastics baseline surveys at the water surface and in sediments of the North-East Atlantic. Frontiers in Marine Science. 4:135. https://doi.org/10.3389/fmars.2017.00135

Maslov N, Dulin V. 2020. Investigation of fluorescence spectra of various types of plastics for the purpose of sorting and further processing. Journal of Physics: Conference Series. 1677:012186. https://doi.org/10.1088/1742-6596/1677/1/012186

Meijer L, van Emmerik T, Ent R, Schmidt C, Lebreton L. 2021. More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. Science Advances. 7(18):eaaz5803. https://doi.org/10.1126/sciadv.aaz5803

Naji A, Nuri M, Vethaak AD. 2018. Microplastics contamination in molluscs from the northern part of the Persian Gulf. Environmental Pollution. 235:113–120. https://doi.org/10.1016/j.envpol.2017.12.046

Nel HA, Dalu T, Wasserman RJ. 2018. Sinks and sources: Assessing microplastic abundance in river sediment and deposit feeders in an Austral temperate urban river system. Science of Total Environment. 612:950–956. https://doi.org/10.1016/j.scitotenv.2017.08.298

Osorio ED, Tanchuling MAN, Diola MDLD. 2021. Microplastics occurrence in surface waters and sediments in five river mouths of Manila Bay. Frontiers in Environmental Science. Toxicology, Pollution and the Environment. 9. https://doi.org/10.3389/fenvs.2021.719274

Park DH, Oh SB, Hong SC. 2022. In situ fluorescent illumination of microplastics in water utilizing a combination of dye/surfactant and quenching techniques. Polymers. 14(15):3084. https://doi.org/10.3390/polym14153084

Prata JC, da Costa JP, Lopes I, Duarte AC, Rocha-Santos T. 2020. Environmental exposure to microplastics: An overview on possible human health effects. Science of Total Environment. 702:134455. https://doi.org/10.1016/j.scitotenv.2019.134455

Ray SS, Lee HK, Huyen DTT, Chen S-S, Kwon Y-N. 2022. Microplastics waste in environment: A perspective on recycling issues from PPE kits and face masks during the COVID-19 pandemic. Environmental Technology and Innovation. 26:102290. https://doi.org/10.1016/j.eti.2022.102290

Rochman CM, Hoh E, Kurobe T, Teh SJ. 2013. Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. Scientific Reports. 3:3263. https://doi.org/10.1038/srep03263

Rodrigues MO, Abrantes N, Gonçalves FJM, Nogueira H, Marques JC, Gonçalves AMM. 2018. Spatial and temporal distribution of microplastics in water and sediments of a freshwater system (Antuã River, Portugal). Science of Total Environment. 633:1549–1559. https://doi.org/10.1016/j.scitotenv.2018.03.233

Rumin J, Bonnefond H, Saint-Jean B, Rouxel C, Sciandra A, Bernard O, Cadoret J-P, Bougaran G. 2015. The use of fluorescent Nile red and BODIPY for lipid measurement in microalgae. Biotechnology for Biofuels and Bioproducts. 8:42. https://doi.org/10.1186/s13068-015-0220-4

Santonicola S, Volgare M, Pace E, Mercogliano R, Cocca M, Colavita G. 2023. Research and characterization of fibrous microplastics and natural microfibers in pelagic and benthic fish species of commercial interest. Italian Journal of Food Science. 12(1). https://doi.org/10.4081/ijfs.2023.11032

Santonicola S, Volgare M, Rossi F, Castaldo R, Cocca M, Colavita G. 2024. Detection of fibrous microplastics and natural microfibers in fish species (*Engraulis encrasicolus, Mullus barbatus* and *Merluccius merluccius*) for human consumption from the Tyrrhenian Sea. Chemosphere. 363:142778. https://doi.org/10.1016/j.chemosphere.2024.142778

Sargadillos R, Endoma Jr L, Nillos MG, Yap EE. 2025. Nile red staining technique for microplastics detection in sardines (*Sardinella lemuru*) using fluorescence stereomicroscopy. Philippine Journal of Science. 154:475–488.

Silva DM, Almeida CMR, Guardiola FA, Pereira R, Rodrigues SM, Ramos S. 2024. Uncovering microplastics contamination in canned seafood. Food Chemistry. 448:139049. https://doi.org/10.1016/j.foodchem.2024.139049

Smith M, Love DC, Rochman CM, Neff RA. 2018. Microplastics in seafood and the implications for human health. Current Environmental Health Reports. 5(3):375–386. https://doi.org/10.1007/s40572-018-0206-z

Song YK, Hong SH, Jang M, Han GM, Rani M, Lee J, Shim WJ. 2015. A comparison of microscopic and spectroscopic identification methods for analysis of microplastics in environmental samples. Marine Pollution Bulletin. 93(1-2):202–209. https://doi.org/10.1016/j.marpolbul.2015.01.015

Suaria G, Perold V, Lee JR, Lebouard F, Aliani S, Ryan PG. 2020. Floating macro- and microplastics around the Southern Ocean: Results from the Antarctic Circumnavigation Expedition. Environment International. 136:105494. https://doi.org/10.1016/j.envint.2020.105494

Sudheshna AA, Srivastava M, Prakash C. 2022. Characterization of microfibers emission from textile washing from a domestic environment. Science of Total Environment. 852:158511. https://doi.org/10.1016/j.scitotenv.2022.158511

Tirkey A, Upadhyay LSB. 2021. Microplastics: An overview on separation, identification and characterization of microplastics. Marine Pollution Bulletin. 170:112604. https://doi.org/10.1016/j.marpolbul.2021.112604

WoRMS Editorial Board. 2026. World Register of Marine Species. [accesed 2025 Nov 27]. https://doi.org/10.14284/170

Wright SL, Thompson RC, Galloway TS. 2013. The physical impacts of microplastics on marine organisms: A review. Environmental Pollution. 178:483–492. https://doi.org/10.1016/j.envpol.2013.02.031

Yonkos LT, Friedel EA, Perez-Reyes AC, Ghosal S, Arthur CD. 2014. Microplastics in four estuarine rivers in the Chesapeake Bay, U.S.A. Environmental Science and Technology. 48(24):14195–14202. https://doi.org/10.1021/es5036317

ROLE OF AUTHORS: **RG** - conceptualization, methodology, validation, formal analysis, investigation, data curation, and writing - original draft; **ELS** - resources, supervision, and project administration; **GTC** - resources, data curation, writing -review and editing, visualization, supervision, and project administration; **LSR** - conceptualization, formal analysis, and writing - original draft; **SJB** - conceptualization, formal analysis, and writing - original draft; **MSS** - resources, supervision, and project administration; **JOM** - resources, supervision, and project administration; **SLE** - formal analysis, and investigation; **ERM** - writing - review and editing, and visualization

Responsible Editor: Dr. Ajeet Singh Chauhan