INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN APPLIED SCIENCE (IJRIAS)
ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue XIII January 2026
Special Issue on Innovations in Environmental Science and Sustainable Engineering

Occurrence of Microplastics in Hijo River Sediments, Davao Region, Philippines

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DOI: https://doi.org/10.51584/IJRIAS.2026.11013SP0006

Received: 08 January 2026; Accepted: 14 January 2026; Published: 12 February 2026

ABSTRACT

Microplastic (MP) pollution is an emerging environmental concern in river systems as it can be deposited in sediments. This study assessed the occurrence, characteristics, and polymer composition of MP in the sediments of Hijo River, Davao Region, Philippines during the wet season. Sediment samples were collected from five barangays, Pandapan, Magdum, Magugpo East, Apokon, and Bucana, using random sampling along river transects. MP was extracted through wet peroxide oxidation and density separation, visually identified MP under a stereomicroscope, and characterized using ATR-FTIR spectroscopy. MP were detected in all sampling sites, with transparent particles domination in Magugpo Easr (50%), Apokon (47.27%), and Pandapan (33.33%), indicating extensive degradation of plastic films. Blue microplastics were most abundant in Magdum (32.22%) and Apokon (47.27%) due to its proximity to banana plantation, while black particles were notable in Bucana (17.89%), reflecting downstream accumulation. Film and fragment shapes were dominant across all sampling stations, followed by fibers and foam. ATR-FTIR confirmed the polymers polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polystyrene polymers (PS). The results demonstrate the strong influence of rainfall and runoff on microplastic transport and deposition, highlighting the need for localized waste management interventions.

Keywords: microplastics, Hijo River sediment, FTIR

INTRODUCTION

Plastics have gained traction in manufacturing, industry, and agriculture due to its affordability, durability, and lightness [1] However, a notable increase in plastic pollution in bodies of water was observed which eventually lead to negative consequences [2].

Recently, scientists have pinpointed microplastics as a new pollutant and have categorized them into two types: primary and secondary. Microplastic is any solid particle that measures less than 5 mm in diameter [3], derived from various sources, and subsequently classified as primary and secondary types [4].

Philippines stands out as a major source of mismanaged plastic, ranking first for river-borne plastic waste and third for land-based sources [5; 6]. With global plastic waste production continuing to rise, it poses a serious risks to both the environment and human health. The growing concern for microplastic pollution demands mitigation tailored to local communities [7].

In 2013, DENR-RCBO reported that Hijo River in Davao del Norte has a drainage of 700 km^2 with annual runoff of 1,400 million cubic meters annually [3]. It is classified as Class C making it suitable for fishing, recreation, some industrial and domestic activities. However, [6] found out that the Hijo River ranked 47^{th} highest plastic emitting worldwide, with an average plastic discharge of 2,700 metric tons annually (87 grams per second), posing a serious risk to marine life. Thus, this research aims to characterize the MPs in the sediment of the Hijo River sediment.

METHODOLOGY

Sediment samples were collected using random sampling method from five strategically selected sites along Hijo River during the wet season. Each sampling location has two transects laid out along the water's edge, and the GPS coordinates of each side was documented. The upper 5 cm of each sampling unit was removed by a metal shovel and placed in glass bottles. The sample was air dried and covered with aluminum foil [8]. To prevent the material from sticking together, it was gently pounded and then sieved through a 5 mm screen. There was a total of 30 samples collected, with 15 samples per season.

A 50 g homogenized sample of sediment was taken and mixed with 50 mL of 30% hydrogen peroxide. The WPO process was repeated several times until no bubbles are seen, which means that the organic impurities have been removed. Then the sample was filtered on a Cytiva Whatman Grade GF/C glass filter and subjected to the density separation method.

For the purpose of extraction of microplastics, firstly 100 mL of saturated NaCl solution and 50 g of sediment will be mixed and stirred for 1 minute, followed by 5 hours of standing. After that, the supernatant was filtered in order to recover microplastics. The filter papers were dried and then their examination was done under a stereo microscope at 40x magnification to see microplastics' visual characteristics like color and shape present in each sample. Clean forceps were applied to carefully separate and move the microplastics onto the glass slides [9]. The number of microplastics found was given in terms of microplastics per kilogram (MP/kg) of dry sediment. Moreover, once the microplastics were gotten, they were put under further examination and polymer identification through Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) spectroscopy. With respect to ATR-FTIR analysis, the infrared spectrum of the microplastic was taken and then it was compared with the known spectra of different polymers to determine the exact type of plastic. Four different types of microplastics were identified by Four-Attenuated Total Reflectance-Fourier Transform Infrared Spectroscopy (ATR-FTIR) through the set spectral range of 400-4000 cm-1, and thirty-two scans were carried out [10]. The recorded FTIR spectrum of the microplastic was then compared with a reference spectrum of known polymers to categorize the microplastic. Also, the existence of the polymer was validated by the absorption peaks in the spectrum as a result of several functional groups being present at specific wavelengths that give rise to corresponding distinct peaks for a specific polymer.

To avoid any possible contaminations, the researchers followed the method in the literature [11] by cleaning all glassware and containers and then rinse them with distilled water. Moreover, they completely refrained from using plastics in any form so as not to increase contamination [12].

RESULTS AND DISCUSSION

Across all barangays, transparent microplastics were more abundant, particularly in Brgy. Magugpo East (50%), Brgy. Apokon (38.18%), and Brgy. Pandapan (33.33%). Blue microplastics dominated Brgy. Magdum (32.22%) and Brgy. Apokon (47.27%), while black microplastics were again notable in Brgy. Bucana (17.89%). Microplastics occurrence during the the wet season can be attributed to the influence of rainfall and runoff, which enhance the fragmentation and movement of lighter and more weathered plastics [13]. Rain and wind are known pathways that mobilize microplastics from surrounding land areas into aquatic systems [14;15]. Because transparent particles typically originate from degraded packaging films and smaller fragments, their elevated presence reflects enhanced transport during high precipitation [13].

MP Color

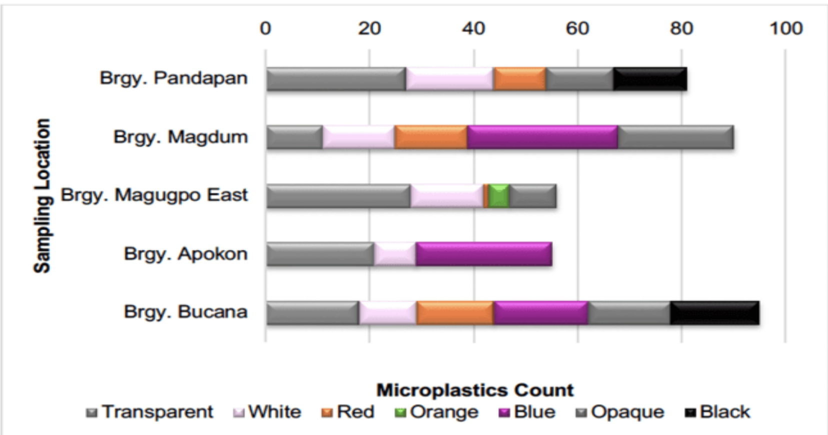

Figure 1. Frequency of the microplastics present in each barangay per color.

Figure 1 represents the microplastics from each sampling location. Blue microplastics in Apokon and Magdum can be linked to colored packaging, clothing fibers, and household plastics. Synthetic textiles and consumer goods contribute significantly to microplastic release, and these particles frequently enter river systems through domestic wastewater and surface runoff [16;17]. The heavy rainfall during the wet season intensifies this transport, increasing the deposition of colored plastics in nearby waterways [18].

Black microplastics commonly derived from rubber, burnt plastics, and industrial materials remained prominent in Bucana, consistent with its downstream location where denser and darker particles tend to settle [19]. Polymers with higher densities, such as PVC and PET, are more likely to accumulate in sediments under strong water flow conditions [20;21].

The color of MP particles can influence its ingestion by aquatic fauna, as most species rely on visual cues to identify food [22]. Under various light conditions, fish exhibited preferences for red, yellow, and green MP over blue or gray ones [23]. The same study suggested that the color-based preferences that brightly colored plastics may mimic natural prey which affects feeding habits. The selective ingestion of certain colors has important ecotoxicological consequences, since these particles may contain colorants, additives, or adsorbed pollutants that differentially affect species [24].

MP Shape

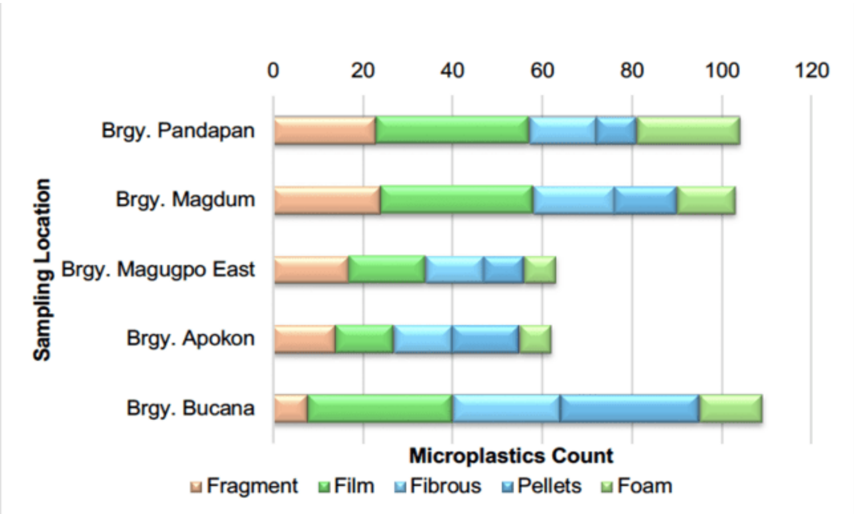

Figure 2. Frequency of the microplastics present in each barangay per shape.

The microplastic shapes found in each sampling location is represented by Figure 2. The consistent dominance of film and fragment microplastics reflects ongoing degradation of common plastic products such as packaging, shopping bags, and other disposable items [9]. These shapes are widely recognized as typical outcomes of secondary microplastic formation, which results from the fragmentation of larger plastic debris through sunlight exposure, mechanical abrasion, and chemical weathering [17]. Polymers such as polyethylene (PE) and polypropylene (PP), which are heavily used in household and commercial packaging, frequently degrade into films and irregular fragments [25]. Their persistence across seasons suggests a continuous and widespread input of plastic waste into the river [26].

The presence of fibers in all sampling locations indicates the influence of domestic wastewater and textile-related activities [16]. Synthetic fibers shed from clothing during laundry are known to pass through wastewater systems and accumulate in river sediments [27]. The observed fiber distribution during the wet season can be further intensified by runoff, which mobilizes fibers from households and urban drainage systems [28].

Foam particles found during the wet season suggests the introduction of polystyrene-based materials through stormwater [29]. Foam microplastics commonly originate from packaging materials, disposable food containers, and insulation products [30]. Their transport is often enhanced by rainfall, which washes loose or degraded foam residues into waterways. The higher concentration of foam in Pandapan and Apokon points to rainfall-driven mobilization of debris from residential or commercial areas [31].

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Overall, the distribution of microplastic shapes during the wet season illustrates the strong role of environmental factors, particularly rainfall and surface runoff, in transporting, redistributing, and depositing microplastics within the river system[32]. Films, fragments, and fibers remain the most persistent shapes, while the increased presence of foam and pellets highlights additional pathways of microplastic entry during periods of intense rainfall [33].

FTIR analysis confirmed the microplastics type collected from the sediments of Hijo River. The presence of aromatic and ester functional groups indicates occurence of PET (polyethylene terephthalate) and PS (polystyrene), both of which contain carbonyl and aromatic moieties [34]. Stronger carbonyl and hydroxyl peaks also reflect polymer oxidation and hydrolysis, degradation processes accelerated by moisture, UV exposure, and mechanical abrasion [35]. Downstream barangays such as Apokon and Bucana exhibited the highest chemical diversity, consistent with their role as microplastic deposition zones. Tropical rivers have been documented as both transport pathways and sinks for plastic debris, with hydrology strongly influencing the accumulation of diverse polymer types [36]. The abundance of oxygenated functional groups supports the presence of secondary microplastics, formed through continuous degradation of PE, PP, and other consumer plastics [37].

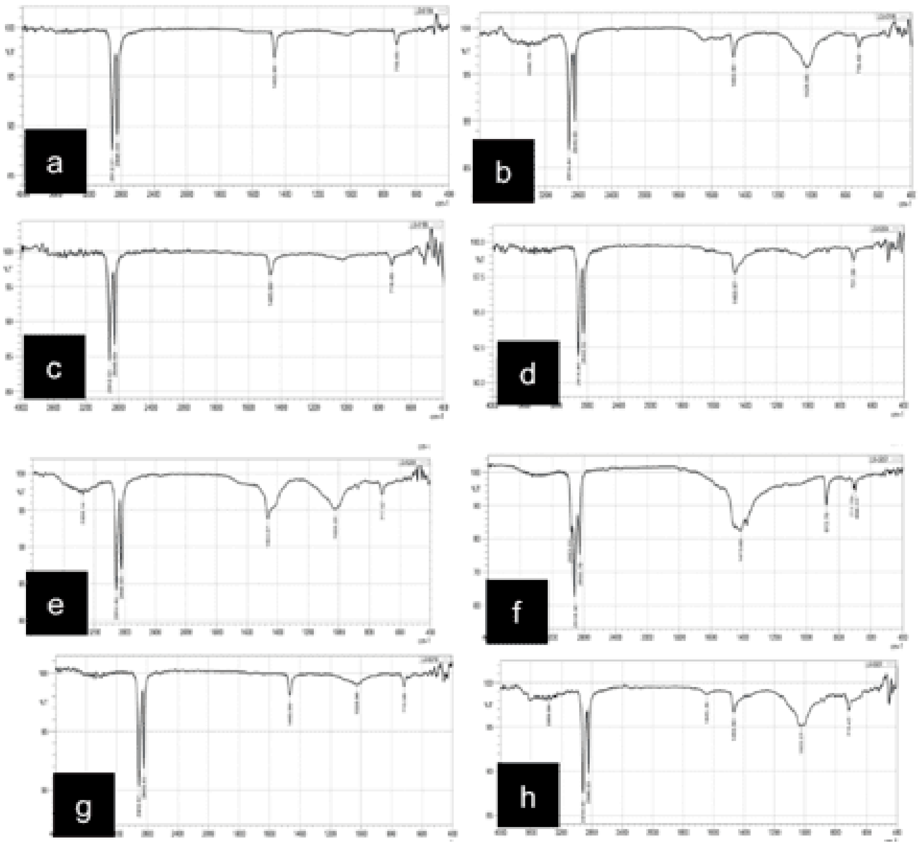

Figure 3. FTIR scans indicating HDPE of MP samples across sampling locations (S1-a, S2-b, S3-c, S4-d, S5- e-h).

As shown in Figure 3, several of the FTIR scans closely resemble the characteristic peaks and spectral features of HDPE. The findings are consistent with the identical peaks of HDPE FTIR [38].Specifically, the characteristic absorption bands corresponding to CH_2 rocking vibrations (717±10 cm^{-1}, 730±10 cm^{-1}), CH_2 bending (1462±10 cm^{-1}, 1472±10 cm^{-1}), and C-H stretching (2915±10 cm^{-1}, 2845±10 cm^{-1}) are consistently present across all seven samples. The strong agreement between these spectral features and the reference HDPE data suggests that the samples of unknown plastic material is high-density polyethylene [39]. Therefore, based on the FTIR spectral analysis, it can be inferred that the unidentified samples are composed primarily of HDPE.

CONCLUSION

The study confirms the widespread presence of microplastics in the sediments of the Hijo River during wet season, indicating microplastic contamination across sampled barangays. The prevalence of transparent, blue,

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and black MP, along with the dominance of film and fragment shapes, suggest secondary microplastics derived from degraded packaging materials, and consumer plastics are the primary contributors of contamination. Polymer identification through ATR-FTIR revealed polyethylene, polypropylene, polyethylene terephthalate, and polystyrene as the most common plastic types, reflecting their extensive use in domestic, agricultural, and commercial activities within the river basin. The higher abundance and varied distribution of microplastics during the wet season highlight the critical role of rainfall and surface runoff in mobilizing and redistributing plastic debris from surrounding land-based sources into the river system, with downstream areas showing evidence of particle accumulation. These findings underscore the need for strengthened local waste management strategies, improved control of plastic inputs from urban and agricultural sources, and continued monitoring of riverine microplastic pollution to mitigate potential ecological and human health risks.

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Ethical Consideration

This study was conducted in accordance with accepted ethical research standards. Ethical approval was obtained from the appropriate institutional authority prior to data collection. Participation was voluntary, and informed consent was secured from all respondents. Confidentiality and anonymity of participants were maintained throughout the study. The researchers declare no conflict of interest.

Data Availability

The data supporting the findings of this study are not publicly available due to ethical and confidentiality considerations but may be made available from the corresponding author upon reasonable request.