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Analysis of Microplastic Abundance in Sediments of Lake Limboto

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ABSTRACT

Microplastics accumulate in aquatic sediments, but information from Lake Limboto remains limited. This exploratory descriptive study quantified visually identified microplastic-like particles in sediment from four contrasting lakeshore locations: an area far from settlements, West Pentadio Village, an area near settlements, and an area near a waste-disposal site. One sediment grab was obtained at each location approximately 5 m from the shoreline and 50 cm deep; therefore, the locations were not replicated. The exact sampling date and coordinates were not retained in the available field record. Sediments were oven-dried at 110°C for 24 h, milled, sieved through a 250-mesh sieve, and subsampled at 15 g dry mass. Each subsample was mixed with 50 mL saturated NaCl for 24 h, vacuum-filtered through Whatman No. 42 paper, and examined microscopically. Counts were converted as abundance (particles kg^{-1} dry sediment) = observed particles × (1000/15). The observed counts were 3, 1, 4, and 5 particles, equivalent to 200.00, 66.67, 266.67, and 333.33 particles kg^{-1}, respectively. The highest descriptive value occurred near the waste-disposal site, whereas the lowest occurred in West Pentadio Village. These unreplicated observations indicate possible spatial variation but do not establish a causal relationship with human activity. Because no procedural blanks, polymer confirmation, or recovery tests were conducted, the results should be interpreted as preliminary visual counts and may underestimate dense polymers not efficiently recovered by NaCl.

Keywords: abundance; Lake Limboto; microplastics; sediment; visual microscopy

INTRODUCTION

Lake Limboto is an ecologically and socioeconomically important freshwater body in Gorontalo Province, including as habitat and a fishing area. The lake has also experienced sedimentation and pressure from waste entering or accumulating along the shoreline. Because lake sediments can retain plastic debris and integrate contamination over time, sediment examination provides useful baseline evidence for environmental monitoring.

Microplastics are generally defined as plastic particles smaller than 5 mm, while the operational lower-size limit varies with sampling, filtration, and identification procedures. Recent syntheses show that differences in sampling design, extraction, and analytical confirmation strongly affect reported abundance and cross-study comparability (Dusaucy et al., 2021; Sajad et al., 2023; Bhardwaj et al., 2024). In this study, the upper boundary follows the conventional 5 mm definition, whereas the effective lower boundary is constrained by the 250-mesh sieve and visual microscopy.

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Sediment comprises mineral and organic particles transported and deposited by water, wind, gravity, or biological processes. Grain size, organic-matter content, density, shoreline setting, and hydrodynamic energy can influence the capture, burial, redistribution, and analytical recovery of microplastics (Belontz et al., 2022; Huang et al., 2022; Maisto et al., 2022; Range et al., 2023). These controls mean that sediment abundance can vary over short distances and should be interpreted in relation to both depositional conditions and the sampling design.

Aquatic sediments can act as temporary or long-term sinks for microplastics. Studies in freshwater lakes have documented accumulation in surface and deeper sediment layers, spatial contrasts associated with wastewater influence, and variation among lake settings (Ajay et al., 2021; Neelavannan et al., 2022; Viitala et al., 2022; Ephsy & Raja, 2023). Deposition is also influenced by polymer density, particle size and shape, biofouling, aggregation with mineral or organic matter, resuspension, and burial.

Potential freshwater inputs include fragmented household plastics, synthetic fibres transported in wastewater, fishing materials, runoff, and debris carried from other parts of a catchment. Indonesian investigations and reviews report microplastics in river biota and coastal or mangrove sediments, indicating multiple land-based and aquatic pathways (Cordova et al., 2021; Buwono et al., 2022; Akbar et al., 2023). Comparable sediment observations from other freshwater systems also demonstrate the importance of catchment activities and local hydrodynamics (Saad et al., 2022). Against this background, the present study provides an exploratory description of visually identified microplastic-like particles in Lake Limboto sediment and explicitly limits inference to the analysed subsamples.

RESEARCH METHODS

This exploratory descriptive study used one sediment grab from each of four lakeshore locations: Location 1 (far from settlements), Location 2 (West Pentadio Village), Location 3 (near settlements), and Location 4 (near a waste-disposal site). Each grab was collected approximately 5 m from the shoreline and at a reported depth of 50 cm using a 75-cm shovel, then stored in a zip-seal bag. The four locations represented four observations rather than four replicated treatment groups. The available field record did not retain the sampling date, geographic coordinates, grain-size composition, organic-matter content, or other sediment characteristics; these omissions limit exact replication and environmental interpretation.

Sediments were oven-dried (Irmeco) at 110°C for 24 h, milled (Herzog) for 20 s, and sieved through a 250-mesh sieve. A 15 g dry subsample from each location was mixed with 50 mL saturated NaCl and allowed to settle for 24 h. Density separation with salt solutions is widely used, but recovery depends on solution density, sediment texture, particle density, and separation-device design (Cutroneo et al., 2021; Jarosz et al., 2022; Maisto et al., 2022; Crutchett & Bornt, 2024; Gran et al., 2025). The supernatant was filtered, and retained particles were examined visually under a binocular microscope. Candidate particles were classified by visible characteristics; no hot-needle test, FTIR, or Raman confirmation was performed.

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Consequently, the observations are reported as visually identified microplastic-like particles, and natural or non-plastic material may have been misclassified. More rigorous workflows combine matrix treatment, contamination control, and spectroscopic verification (Monteiro et al., 2022; Sajad et al., 2023). Abundance was calculated as $C = n/m$, where n is the observed particle count and m is sediment dry mass in kilograms.

RESULTS AND DISCUSSION

Visual examination found microplastic-like particles at all four locations. Because each location was represented by only one 15 g subsample, the results describe the analysed samples and do not estimate within-location variability or support inferential comparisons among location types. Table 1 therefore reports both the raw count and its mass-normalised value.

Table 1. Microplastic abundance in sediments of Lake Limboto.

No.	Location	Observed particles in 15 g	Abundance (particles kg−1 dry sediment)
1	Far from settlements	3	200.00
2	West Pentadio Village	1	66.67
3	Near settlements	4	266.67
4	Near waste-disposal site	5	333.33

The raw counts were 3, 1, 4, and 5 particles in 15 g dry sediment at Locations 1-4, respectively. Multiplication by 1000/15 yielded 200.00, 66.67, 266.67, and 333.33 particles kg−1. Location 4 had the highest observed value and Location 2 the lowest. This ordering is compatible with, but does not prove, an association between nearby waste accumulation and sediment microplastics.

The values should not be interpreted as location means because no field or laboratory replicates were available. A difference of one observed particle changes the mass-normalised estimate by 66.67 particles kg−1; therefore, the apparent spatial contrasts are highly sensitive to small counting differences. Reporting additional decimal precision would imply a level of certainty unsupported by the sample mass and count data.

The presence of three particles in the sample collected far from settlements shows that local proximity to housing is not a necessary condition for occurrence. Microplastics may be transported by inflowing water, wind, shoreline movement, and resuspension before deposition. Hydro-geomorphic controls and nearshore processes can redistribute particles independently of the nearest visible source (Belontz et al., 2022; Range et al., 2023), while sediment records can also integrate contamination over time (Viitala et al., 2022; Huang et al., 2022).

The samples near settlements and the waste-disposal site contained four and five particles, respectively. Domestic wastewater, fragmented litter, runoff, and fishing materials are plausible inputs, and comparable Indonesian research identifies diverse land-based and

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aquatic pathways (Cordova et al., 2021; Buwono et al., 2022; Akbar et al., 2023). However, the present design did not measure source tracers, hydrodynamics, or polymer composition, so these explanations remain hypotheses rather than demonstrated causes. The observed range is broadly consistent with evidence that freshwater sediment contamination is spatially heterogeneous across catchments and lake settings (Dusaucy et al., 2021; Saad et al., 2022; Ephsy & Raja, 2023). Future work should use replicated sampling across seasons, procedural blanks, recovery tests, finer size fractions, and FTIR or Raman confirmation.

CONCLUSION

Visually identified microplastic-like particles occurred in all four 15 g sediment subsamples from Lake Limboto. Raw counts of 1-5 particles corresponded to 66.67-333.33 particles kg−1 dry sediment, with the highest descriptive value near the waste-disposal site. This pattern indicates a possible association with local human activities but does not demonstrate causation or statistically generalisable spatial differences. Interpretation is constrained by one sample per location, missing sampling coordinates and sediment characteristics, lack of blanks and recovery tests, visual identification without polymer confirmation, and the limited recovery of high-density polymers by saturated NaCl. Replicated sampling and spectroscopic confirmation are required before robust source attribution or lake-wide inference can be made.

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