Spatial Heterogeneity and Pollution Risk of Microplastics in Tropical Mangrove Sediments: A Case Study from the Panadura Estuary, Sri Lanka

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Mangrove ecosystems function as critical depositional sinks for microplastic (MP) pollution, yet quantitative data from tropical South Asian estuaries remain limited. This study assessed MP abundance, morphology, colour, and pollution risk in mangrove sediments of the Panadura estuary, Sri Lanka. Duplicate 1 kg surface sediment samples (top 5 cm) were collected from eight locations (PE1–PE8). 250 g subsample from each was processed via density separation using saturated NaCl. The supernatant was sieved at 300 µm, and extracted particles were filtered, stained with Nile Red, and visualized under blue light for categorization by morphology. Abundance varied widely among locations, ranging from 267.5±40.3 particles/kg at PE2 to 3442.5 ± 597.3 particles/kg at PE8, indicating substantial spatial heterogeneity across the estuary. By morphology, irregular-shaped particles were the most abundant shape (52.5%), closely followed by filament-shaped particles (46.9%), while round particles (foam and pellets) contributed only 0.6%. By particle type, fibres were the most abundant morphotype (46.9% of total), followed by fragments (40.6%), films (11.9%), foams (0.5%), and pellets (0.07%), together indicating a strong dominance of fibrous and fragment-type particles over other morphologies. Colour distribution showed white particles to be dominant (43.8%), followed by red (20.2%), transparent (12.5%), blue (9.8%), yellow (6.4%), black (5.3%), and green (1.9%). White particles were predominantly associated with fragment-type particles, while red particles were more commonly recorded as fibres. Despite considerable differences in total abundance between sites, there were no significant differences among the locations. Risk assessment classified six sites as moderately contaminated (CF=1.0–2.3), PE1 as considerably contaminated (CF=4.8), and PE8 as very highly contaminated (CF=12.9), yielding a zone-wide PLI of 2.26 (polluted). These findings demonstrate that irregular and filament-type microplastics are the principal contaminant forms in the study area, with site-specific inputs driving substantial variation in total particle load. The results underscore the need for source-tracking at high-abundance sites to inform targeted mitigation strategies.

Keywords: *Contamination factor, Mangrove sediment, Microplastics, Panadura estuary, Pollution load index*