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Macro and Micro-Litter Pollution at Crow Island Beach: Abundance and Composition

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Abstract

Marine litter pollution has become an increasing environmental concern worldwide. The coastal regions near major river mouths are highly vulnerable to accumulation of litter. Crow Island Beach is located at the mouth of the Kelani River, Sri Lanka, one of the major rivers in Sri Lanka, which is the source of water for the capital, however, has no comprehensive scientific data on source identification, litter abundance, composition, and pollution status. This study was conducted in January, February, and May 2026 across 10 sampling locations along the beach to assess the pollution level at the beach. 2.5 m² quadrat was used to collect macro-litter samples, and FTIR spectroscopy was used to perform polymer identification. To evaluate the overall pollution status of the beach, the Clean Coast Index (CCI) and Pollution Load Index (PLI) were calculated. Results indicated that domestic and household waste was the dominant source of macro-litter, and the most abundant identified polymer types were HDPE and PP. The 0.5-5 cm range plastic debris category represented the largest proportion of collected litter, suggesting extensive fragmentation of macro-litter due to prolonged weathering. Spatial analysis was used to identify persistent litter accumulation hotspots, particularly near major accumulation areas influenced by riverine inflows. The calculated CCI value of 180.8 and PLI value of 2.2 indicated a highly polluted coastal environment. Field observations identified clinically related waste, including syringes and blood collection tubes. Increased litter accumulation during periods of rainfall and high-water levels suggest that riverine transport may contribute to litter accumulation. This study contributes quantitative baseline data on macro-litter abundance, polymer composition, and pollution indices for the coastal region of Colombo.

Keywords: *Accumulation; FTIR spectroscopy; PLI; CCI; Coastal pollution; HDPE; PP*

I. Introduction

Marine litter is a persistent environmental problem in coastal ecosystems. Land-based waste can reach the ocean through surface runoff and anthropogenic activities, making rivers an important pathway for plastic transport [1]. In Sri Lanka, inadequate solid waste management and the widespread use of single-use plastics contribute to coastal pollution. Previous studies have investigated marine debris along the western coast of Sri Lanka [2] and buried microplastics at Sarakkuwa beach following the MV X-Press Pearl disaster [3]. Riverine plastics transport has also been examined through modelling approaches [4], while studies in Lombok, Indonesia, have assessed microplastic abundance and distribution in coastal sediments [5]. These studies highlight the importance

of investigating litter abundance, composition, and distribution in coastal environments. Crow Island Beach is a highly vulnerable site situated near the mouth of the Kelani River in Colombo that receives substantial litter transported from densely polluted urban and industrial catchments upstream. Riverine plastic inputs, systematic source identification, polymer characterization, detailed quantification of macro- and micro-litter abundance, and pollution indices remain limited. This knowledge gap supports the development of targeted, evidence-based coastal management interventions for this section of Colombo's coastline. Therefore, this study aimed to generate comprehensive baseline knowledge on the abundance, composition, pollution status, and spatial distribution of macro- and micro-litter at Crow Island Beach. The findings provide baseline information to support coastal litter monitoring and management.

II. Materials and Methodology

The investigation was carried out near the mouth of the Kelani River at Crow Island Beach in Mattakkuliya, Colombo. To capture spatial and temporal variation in trash buildup, including seasonal effects of monsoonal rainfall, a systematic sampling design was implemented at two transects spaced 50m apart to cover a wider area. Along each transect, five sampling points were selected at equal intervals (Figure 1), parallel to the shoreline. Monthly field surveys were carried out from January to May 2026. Following established beach-litter survey techniques, 2.5 m^2 quadrats were used at each sampling location to gather macro-litter samples [4]. The collected material was sorted, washed, cleaned, and air-dried in the sun before being categorized by size class, colour, and source category. A commonly used technique for characterizing polymers is FTIR spectroscopy (PerkinElmer, Model L1600400, UK) [5], [6]. To characterize smaller and fragmented debris, micro-litter samples were collected from the same 10 sampling locations used for macro-litter collection. The top 5 cm layer of beach sand samples were collected using clean glass bottles to minimize plastic contamination. An empty glass bottle was used as a control sample during sampling to monitor potential atmospheric contamination. For laboratory analysis,100g of dried beach sand was initially passed through a 5mm metal sieve to remove larger debris [6]. The retained samples were allowed to undergo a density separation and a 72-hour digestion process. After the filtering process, Nile Red staining was used to count micro-litter particles, and FTIR spectroscopy (PerkinElmer, Model L1600400, UK) was used to confirm polymer type. Two complementary pollution assessment indices were calculated to evaluate the level of beach contamination [7]. The CCI was calculated by multiplying plastic item density by a constant factor of 20. The PLI was calculated using contamination factors, obtained by dividing plastic density at each sampling location by the reference density (3.6 items m^{-2}), followed by calculation of their geometric mean. CCL values were interpreted using established cleanliness categories, while PLI values above 1 indicated increasing plastic contamination [2].

$$CCI = (\text{Number of plastic items per m}^2) \times K \quad \text{(Eq. 1)}$$

$$CF = \frac{\text{Plastic item density at sampling point}}{\text{Reference plastic density}} \quad \text{(Eq. 2)}$$

$$PLI = (CF_1 \times CF_2 \times CF_3 \times \cdots \times CF_n)^{1/n} \quad \text{(Eq. 3)}$$

III. Results and Discussion

Macro- litter was recorded across the 10 fixed sampling locations at Crow Island Beach during the study periods. Source identification revealed that domestic and household waste is the dominant contributor to macro-litter at Crow Island Beach, followed by debris that may be associated with fishing-related activities, mismanaged waste, and recreational beach use. The presence of clinical waste items, including syringes and blood collection tubes (Figure 2), is of particular concern because such items can pose physical and biological hazards to beach users and waste handlers. Similar concerns have been reported for marine litter containing potentially hazardous healthcare-related items, highlighting the need for proper disposal and effective waste management to reduce their accumulation in coastal environments [2]. The relative contribution of these source categories is presented in Figure 3. This pattern is consistent with the study site's proximity to a strongly populated urban river catchment and inadequate upstream litter management as the principal driver of litter accumulation at the locations [5]. Polymer characterization using FTIR spectroscopy identified a total of 226 polymer-identified items. Among the identified polymers, PP was the most abundant (89 items, 39.4%), followed by PS (65 items, 28.8%) and HDPE (43 items, 19%). The dominance of these polymers is consistent with their widespread use in packaging, household products, food containers, and fishing-related materials [1]. Analysis of size-class distribution indicated that small-sized debris (0.5-5 cm) indicated the largest proportion of collected litter, possibly reflecting fragmentation

associated with prolonged exposure to sunlight, long-distance transportation, wave action, and mechanical abrasion [1]. Color analysis showed that white was the most frequently observed color, followed by transparent and blue items. Spatial distribution analysis identified persistent litter accumulation hotspots concentrated near major deposition locations (L5, L6, L7, and L9), consistent with the influence of localized depositional conditions and hydrodynamic conditions along the beach [4]. Similar accumulation patterns have been reported at Crow Island Beach, where high concentrations of bottles, bags, and packaging materials were previously observed [5]. The calculated CCI value of 180.8 indicates a high level of beach litter accumulation according to the classification used in this study. The PLI value of 2.2 shows that plastic litter contributed substantially to the overall pollution status of the beach [4]. Taken together with the source identification, polymer fingerprinting, and spatial patterns suggest that both land-based and local coastal activities may contribute to litter accumulation at Crow Island Beach. The Kelani River may contribute to litter transport, but further studies are needed to confirm its relative contribution to beach pollution.

IV. Conclusions and Recommendations

This study provides scientific data on the index-based evaluation of the macro- and micro-litter pollution at Crow Island Beach, demonstrating the presence of considerable anthropogenic plastic litter within the study area. The findings indicate that household and domestic waste were the major identified source categories, while riverine pathways may also contribute to the accumulation of litter at the beach. The dominant size class was 0.5-5 cm, which indicates fragmented debris, and the predominant polymer types are HDPE and PP. The high CCI and PLI values together highlight the need for focused intervention in this area of Colombo's shoreline. Improved municipal solid waste management, measures to reduce litter entering the Kelani River and its surrounding drainage system, stronger enforcement against improper waste disposal within the catchment, and long-term monitoring are recommended to reduce plastic accumulation and identify changes in pollution patterns over time. To better distinguish riverine inputs from possible transboundary or marine-sourced contributions, future research should expand the monitoring period to capture one-year seasonal variation, examine the ecological effects of microplastic contamination on coastal biota, and use polymer fingerprinting techniques.

V. Acknowledgement

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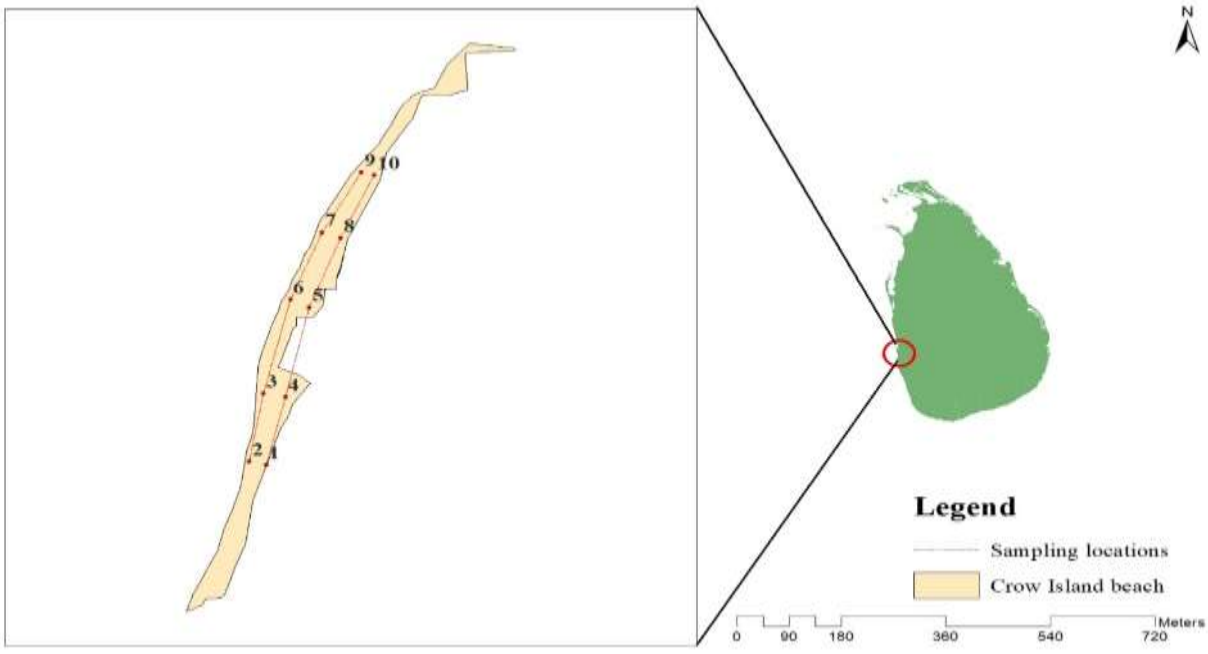


Figure 1. Sample locations along Crow Island Beach, Mattakkuliya, Sri Lanka



Figure 2. Observed clinical waste during the field sampling

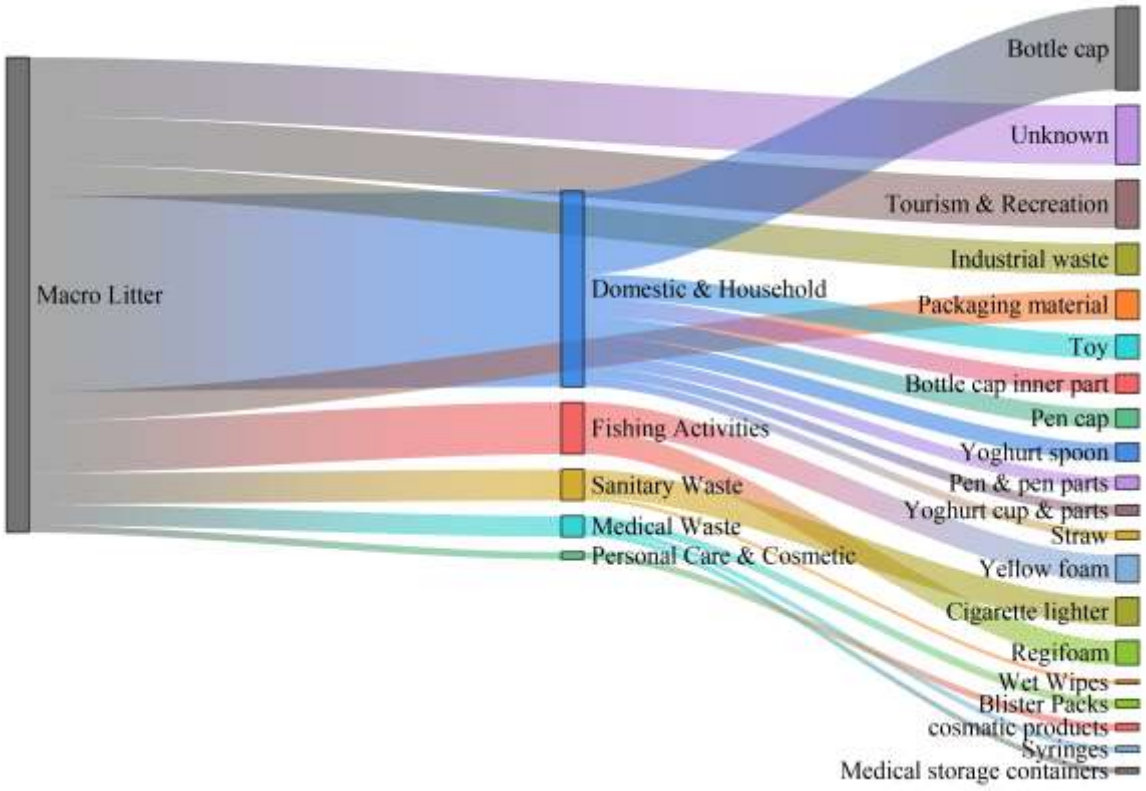


Figure 3. Relative contribution of macro-litter sources identified at Crow Island Beach during the study period

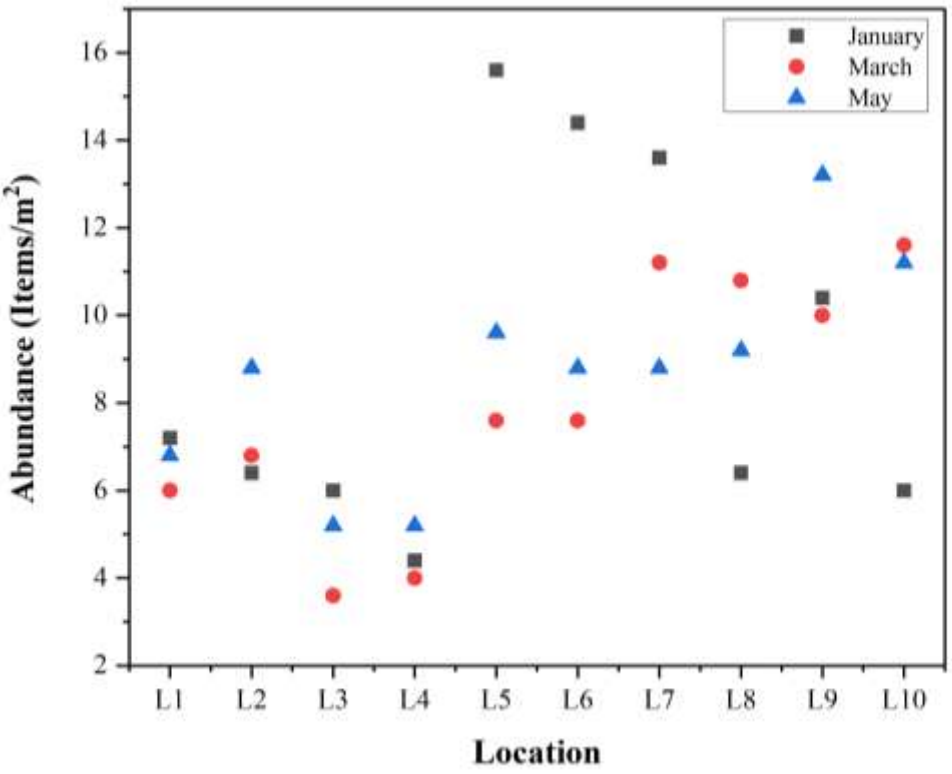


Figure 4. Spatial distribution of macro-litter abundance (items/m^2) across the sampling location

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