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Tracing microplastic pollution in a mangrove delta: Insights from water and sediments of Sagar Island, Indian Sundarbans

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Abstract

Marine pollution involves the introduction of anthropogenic contaminants into oceanic environments, resulting in loss of marine biodiversity. Among these pollutants, microplastics have emerged as pervasive and persistent threats to coastal systems. The Indian Sundarbans, a UNESCO World Heritage mangrove biosphere, is particularly susceptible to microplastic contamination due to intense anthropogenic pressure and dynamic tidal regimes. This study provides the first comprehensive assessment of microplastics in surface waters and intertidal sediments of Sagar Island, located at the southernmost boundary of the Sundarbans. Samples collected from experimental stations with varying human influence were processed through digestion, density separation, and filtration. Microplastics were classified by morphology (fibres, fragments, films) and size (<0.3–5 mm), and examined using bright-field microscopy and Field Emission Scanning Electron Microscopy (FESEM). Polymer composition was determined through Fourier Transform Infrared (FTIR) and Raman spectroscopy. Microplastics were detected across all sampling sites, with higher abundance in sediments compared to surface waters. Fibres dominated, followed by fragments, indicating unregulated fishing activities as a primary source. Polystyrene ($30.8 \pm 2.95\%$) and polyethylene ($18.75 \pm 1.9\%$) were the most prevalent polymers, reflecting strong anthropogenic influence, particularly from tourism. SEM–EDX analyses revealed weathering features and chemical adsorption on particle surfaces. High ecological risk indices (28313 at site 2 and 27865 at site 3) underscore significant environmental stress and pollutant retention driven by tidal deposition. This baseline study identifies Sagar Island as a microplastic contamination hotspot and provides critical insight for future monitoring and coastal management initiatives in the Sundarbans.