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Geochemical Partitioning of Heavy Metals in Pristine Sundarbans Mangrove Sediments Across Contrasting Hydrodynamic Gradient

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Coastal mangrove sediments act as both sinks and potential secondary sources of contaminants, yet the internal partitioning of heavy metals in relatively undisturbed mangrove region remains poorly resolved. In the Indian Sundarbans, at certain distance from the Hooghly estuary mouth, nearly to open ocean and largely isolated from direct human activity, understanding how natural hydrodynamic settings control metal retention and potential mobility is essential for anticipating future environmental responses to increasing upstream pollution.

To address this, three sediment cores were collected from three contrasting hydrodynamic transect within a restricted Sundarbans corridor representing (i) a low-energy purely depositional interior, (ii) a high-energy erosional margin, and (iii) an intermediate setting. Depth intervals were analysed for grain size, pH, total organic carbon (TOC) and nitrogen (TN), C/N, and total concentrations of selected trace metals (Cr, Mn, Fe, Co, Ni, Cu, Zn, Pb, As). A five-step BCR sequential extraction scheme was applied to partition metals into (i) exchangeable, (ii) carbonate-bound, (iii) Fe–Mn oxyhydroxide-bound, (iv) organic-bound and (v) residual fractions, and multivariate statistics were used to relate fractionation patterns to sediment properties across these three regimes.

Initial results indicate that silt-rich horizons with slightly elevated TOC in the depositional core host a greater share of Fe–Mn oxyhydroxide and organic-bound metal pools, whereas the erosional core, despite relatively lower metal contents, is dominated by more inert residual phases. Variations in texture, organic matter and associated sediment chemistry collectively govern the balance between labile and immobile fractions along depth and across these energy settings.

By quantifying these controls in a low-impact mangrove estuary, this study provides an environmentally relevant baseline for the reactive metal matrix of the Indian Sundarbans. The framework offers a reference against which future shifts in metal speciation can be detected as contaminant pressures intensify, and it underpins subsequent work on coupled metal–mineral–organic interactions in this globally significant coastal ecosystem.