



Research Article

Mechanisms and seasonal variability of sediment transport in a small tropical mountainous estuary-coastal system: Insights from the Selangor River, Malaysia

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ARTICLE INFO

Editor: Dr. N Senechal

Keywords:

Small and medium-sized mountainous river estuary
River plume
Sediment transport
Tidal flat
Selangor River estuary

ABSTRACT

Small- and medium-sized mountainous rivers (SMRs) are critical pathways for delivering terrestrial sediment to coastal systems, particularly in the tropical regions where their dynamics are highly sensitive to anthropogenic influences. This study investigates the sediment transport processes and ultimate deposition patterns in the Selangor River estuary, Malaysia - a representative tropical macrotidal estuary characterized by complex near-shore topography and weak Coriolis effects. By combining field measurements (2023–2024) with sediment analysis, this research reveals three key findings. First, approximately 73.5 % of the annual sediment discharge (19.75×10^4 t) accumulates in estuarine tidal flats, with the northern tidal flats receiving twice the deposition of the southern tidal flats. Second, distinct seasonal transport regimes were evident: (i) during the dry season wave-driven sediment resuspension and tidal forces result in northwestward-southeastward transport, (ii) during the wet season stratified flows lead to significant sediment-freshwater decoupling, where river plumes disperse offshore while terrestrial sediments remain trapped near the estuary. Third, the unique sediment trapping mechanism, different from both large river systems and wave-dominated tropical SMRs, resulting from the interaction of strong tidal currents, seasonal river discharge, and offshore water intrusion from the Strait of Malacca. These findings provide a new conceptual framework for understanding sediment retention in tropical macrotidal estuaries, with implications for coastal management under climate change and intensifying anthropogenic pressures.

1. Introduction

Estuaries are important hubs that connect the land and sea; they are also key export pathways for the transfer of terrestrial materials into marine systems. Rivers transport large amounts of freshwater, nutrients, and sediments to the ocean every year (Milliman and Farsworth, 2011). Most terrestrial sediments accumulate in estuarine deltas and near-shore sea areas, forming a series of deposits, while a smaller is transported to the continental shelf and deep sea (Perillo, 1995; Gao and Collins, 2014).

Large river basins deliver substantial quantities of sediment to the sea. In addition to forming deltaic systems, these rivers also transport fine-grained sediment alongshore, contributing to areas of mud deposition (Liu et al., 2007, 2020; Gao and Collins, 2014; Qiao et al., 2017; Sheng et al., 2024). Small and medium-sized rivers also contribute significantly to the global sediment flux to the sea (Milliman and Syvitski, 1992; Syvitski et al., 2005). However, due to variations in river characteristics, estuarine dynamics, and shelf morphology, sediment transport patterns differ considerably among systems.

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<https://doi.org/10.1016/j.margo.2025.107619>

Received 15 January 2025; Received in revised form 14 July 2025; Accepted 14 July 2025

Available online 17 July 2025

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