



Quantifying the level of erosion-induced hazards on tidal riverbanks

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ABSTRACT

One of the most damaging and costly geoenvironmental hazards is riverbank erosion. This study aims to comprehensively determine and map hazard levels of the riverbank subjected to erosion, along the tidal Shatt al Arab River, as a case study, southern Iraq. This research employs hydrological, sedimentological and geotechnical measurements to analyze the susceptibility level of the riverbank's stability. The ratio between the ebb and flood shear stress and the soil bank materials' critical shear stress was suggested as a practical way to comprehensively determine instability levels against erosion. Accordingly, the results showed that the southern and central stretches of the river have hazardous (<1.0) or critical (between 1.0 and 2.0) states of the shear stress ratio, while the northern stretch is in a stable state, typically ranging between 2.0 and 3.0 but may exceed 4.0.

The northern river stretch, where soil layers have less susceptibility to erosion, corresponded to no change in the meanders (no-lateral migration indicated from the satellite imagery data) over the 48-year interval 1972–2020. The northern part of the river has stable conditions on the riverbanks and are gaining soil at a slight deposition rate of about 0.5 m/yr. In comparison, the southern river part showed that the meanders most likely agreed with the satellite imagery data which were prone to erosional processes and loss of bank materials.

It suggests that the shear stress ratio is a key to practically identify erosion-induced bank levels of tidal rivers and it could be used to develop strategies for mitigating the problem. The assessment of riverbank instability levels using the ratio of critical soil shear stress to fluid shear stress is a comprehensive, plausible way to better understand the susceptibility of tidal rivers.

1. Introduction

Despite the steady landscape features, tidal rivers (salt marsh streams) are known to be very sinuous planforms with highly undercut banks and significant bank erosion rates (Gabet, 1998). The erosional streambank process is a continuous critical process in which this hydrodynamic (fluvial) action surpasses the resistive strength of riverbank particles (Sutarto et al., 2014), resulting from inter-particle bonding (Ravisangar et al., 2005). It is the mechanism to be focused on when assessing streambank instability and rates of streambank erosion which have been interested field for the researches (Hasanuzzaman et al., 2023; Saikia and Mahanta, 2024) attempting to quantifying retreat impacts of

the riverbanks due to erosion processes.

The distribution and magnitude of erosion rate and meander migration are highly variable because they are influenced by a variety of factors, including catchment area, bank material, local slope, configuration of water currents, water level, and position on a specific bend in a meander (Hooke, 1980; Abam, 1993), which become more complex when the riverbank sediment is cohesive (Das et al., 2019). Water current velocity is critical in characterizing the flow channel and assessing the erosion rate (Kang and Chan, 2022). In an inland river, where no tidal effects, flow only occurs in one direction and the water velocity is relatively constant; thus, it follows only one direction and magnitude of forces acting on the soil particles in the bed and bank. With tidal rivers,

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