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ANALYSIS OF SEDIMENTATION RATES AT THE MOUTH OF THE MESJID RIVER IN DUMAI CITY: IMPLICATIONS FOR SILTATION AND SEDIMENT TRANSPORT

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ABSTRACT

The Mesjid River Estuary in Dumai City is an area prone to sediment accumulation due to the influence of river hydrology dynamics and interaction with oceanographic processes in coastal waters. The sedimentation phenomenon that occurs has a direct implication on the rate of estuary siltation and sediment transport patterns that affect the balance of the aquatic ecosystem. This study aims to analyze the sedimentation rate and sediment characteristics at the Mesjid River Estuary and examine the impact of sedimentation on siltation and sediment transport patterns. This study was conducted in December 2024 at the Mesjid River Estuary, Dumai City, with the aim of analyzing the sedimentation rate and its implications for siltation and sediment transport. Sedimentation in estuarine areas is an important phenomenon that affects changes in channel morphology, navigation capacity, and coastal ecosystem balance. Data collection was conducted at six research stations from upstream to downstream by recording water quality parameters, sediment characteristics, sedimentation rates, total suspended solids (TSS), and sediment transport. The results showed that the sedimentation rate ranged from 7.0 to 10.3 cm/year, with an average of 8.77 cm/year, which is relatively high compared to other estuaries in Southeast Asia. The average TSS value of 135 mg/l indicates a significant supply of sediment from land erosion and anthropogenic activities, while the sediment transport load reached 338.2 tons/year, confirming the role of the estuary as a center of material accumulation. These conditions accelerate siltation, limit the efficiency of maritime transportation, and alter coastal morphological dynamics, necessitating active management strategies and sustainable mitigation to maintain ecosystem functions and support the sustainability of local economic activities.

Keywords: Sedimentation rate; Estuary; Siltation; Estuaries; Transport patterns

1. INTRODUCTION

Sedimentation at river mouths is a natural process that occurs due to the accumulation of sediment material in the transition area between the river and seawaters. This process gradually changes the morphology of the channel, causing silting, and has significant implications for human activities and ecosystem balance. The direct impacts of sedimentation include reduced navigation capacity, increased risk of ship grounding, and disruption of water mass distribution and exchange. Similar phenomena have also been widely reported in various estuaries and ports in Southeast Asia, where sedimentation is one of the main limiting factors for maritime transportation operations[1,2].

In addition to affecting navigation, sedimentation also influences economic activity in coastal areas. Silting of waterways can hinder the flow of goods and

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services that depend on maritime transport, thereby potentially increasing logistics costs and reducing supply chain efficiency. In the fisheries sector, changes in water depth and bottom morphology can alter the distribution of benthic organisms and fish habitats, which in turn affects the productivity of local fishermen's catches. From an ecological perspective, excessive sedimentation has the potential to cover the substrate that is essential for the survival of benthic communities, reduce the availability of dissolved oxygen, and trigger changes in the structure of biological communities[3].

The sedimentation process at river mouths is generally driven by a combination of sediment transport from upstream and complex tidal dynamics in tropical coastal areas. Sediment carried by river flows originates from various sources, including land erosion in catchment areas, anthropogenic activities such as land clearing and infrastructure development, and runoff from agricultural areas[4]. On the other hand, varying tidal dynamics influence sediment deposition and resuspension patterns, creating conditions that allow for the accumulation of material at specific points. It is this interaction between sediment input from upstream and tidal influences that shapes the unique sedimentation characteristics of each estuary.

2. RESEARCH METHOD

Time and Place

Sampling was conducted at six stations representing the upstream to downstream sections of the Mesjid River estuary in December 2024. Each station was equipped with GPS coordinates and recorded on a bathymetric map of the estuary area.

Procedures

The data collected came from existing sources. Data was collected from the upper and lower reaches of the Mesjid River estuary.

3. RESULT AND DISCUSSION

Sedimentation Patterns and Rates

Measurements of the sedimentation rate at the Mesjid River estuary range from 7.0 to 10.3 cm/year, with an average of 8.77 cm/year. The spatial distribution indicates that the upstream and middle areas of the estuary have the highest sedimentation rates, which are influenced by reduced current speed, thereby accelerating the deposition of suspended material. This condition is consistent with the upper zone of estuaries generally being areas of sediment accumulation due to a combination of tidal forces and decreased flow energy. Compared with other estuaries in Southeast Asia, this value is considered very high. For comparison, the sedimentation rate at the Bokor River Estuary, Riau, is reported to be only 1.4–1.6 cm/year5(8). This significant difference indicates a high sediment supply to the Mesjid River Estuary from anthropogenic activities in the catchment, such as land clearing, port activities, and coastal infrastructure development[6,7].

In addition, the results of suspended solids (TSS) measurements reinforce the assumption of high sediment supply. High TSS values in the upper and middle reaches of the estuary indicate a large input of sediment from land erosion and surface runoff, especially during the rainy season[8]. The combination of hydrodynamic factors, tides, and human activities in the river basin is thought to be the main driver of accelerated sedimentation, which directly impacts channel siltation and changes in estuary morphology[9].

Implications of Siltation

The dominance of silt and sandy silt sediments in the estuary area has significant implications for the dynamics of the aquatic environment. Sediments with fine grain sizes tend to remain suspended in water longer before settling. When currents weaken, this material easily accumulates on the bottom of the water. This process accelerates the formation of thick sediment layers, which in turn trigger changes in

estuary morphology. These changes can include river channel siltation, the formation of a small delta, or changes in the main flow path. Similar phenomena have also been identified in various estuaries and ports in Southeast Asia, where high sediment accumulation has impacted the capacity of shipping lanes and altered coastal ecosystems[9].

Channel siltation due to sediment accumulation is a limiting factor for ship navigation. Reduced water depth can limit the size and capacity of ships that can pass through, thereby reducing the efficiency of maritime transportation. In the long term, this condition requires intensive dredging efforts to maintain the depth of the shipping channel. Dredging, although technically effective, has ecological consequences, including increased turbidity, disturbance of benthic habitats, and the release of pollutants trapped in sediments[10]. Therefore, understanding sediment distribution patterns and sediment accumulation rates is key to planning sustainable estuary management.

To maintain adequate water depth, periodic dredging is often a technical solution applied in various ports and estuaries[11]. Although dredging is effective in the short term, it has significant ecological consequences. The process of removing bottom sediments can increase water turbidity, disrupt the habitats of benthic organisms, and potentially release pollutants or heavy metals that have long been trapped in the sediment layer[12,13]. If not properly managed, these ecological impacts can alter the structure of biological communities and degrade the quality of the aquatic environment.

Therefore, a comprehensive understanding of the spatial patterns of sediment distribution and accumulation rates is a key aspect in designing sustainable estuary management strategies. This information is not only important for supporting technical dredging planning but also for minimizing environmental impacts through an ecosystem-based approach. Proper management will help maintain a balance between navigation needs and coastal ecosystem conservation.

Measurement data show that the concentration of suspended solids (suspended load) at the study site reached an average of 135 mg/l. This value is slightly lower than the average recorded in the Bokor River[3], but it remains within a range indicating a high potential for sedimentation. The high concentration of suspended solids reflects a significant supply of sediment material from upstream areas and from the erosion of river banks around the estuary. This condition is exacerbated by low flow velocity during certain periods, which causes the material to settle more quickly at the bottom of the water. If left uncontrolled, this sedimentation process can accelerate the degradation of the estuary's function both as a transportation route and as a habitat for aquatic ecosystems.

Sediment Transport and Morphological Dynamics

The high flow rate and sediment transport value (Qs) of up to 338.2 tons/year at the estuary confirm it as a center of massive sediment accumulation and distribution. Not only does it accelerate siltation, but it also alters the coastline and estuary bottom morphology. These findings are in line with the global trend that changes in land use patterns, human activities, and tides can have a significant impact on sediment distribution and accumulation in estuarine areas[1,4].

4. CONCLUSION

The sedimentation rate at the mouth of the Mesjid River in Dumai City is relatively high, with mud sediments and significant concentrations of suspended solids. The combination of water and sediment characteristics accelerates siltation, requiring active management to ensure that the estuarine ecosystem remains sustainable and economic activities are not disrupted. Recent studies in similar estuarine areas support the results of this study.

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