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# Sedimentology and Geochemistry of Quaternary Coastal Sediments of Alappuzha District, Kerala, Southwest India: Implications on Coastal Evolution

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## Abstract

The coastal areas are the most dynamic and strategic regions of the world that are under constant threat due to climate and sea level changes. Further, these are densely populated regions undergoing rapid socio-economic development. Hence, information on the coastal environments and their sediment characteristics (surface and subsurface) is very crucial not only for planning future developments but also for mitigating the impact of anthropogenic activities on this crucial ecosystem in the land–sea interface. Among the coastal environments of the world, the southwestern coast of India received special attention because of its outstanding natural beauty and occurrence of economically viable placer mineral resources. The region acts as a "Gate way of Indian Summer Monsoon (ISM)". However, the lack of adequate information on the subsurface sediment characteristics and paleoenvironmental potential is a major setback for the planning sustainable development framework for the region. Here we report the sedimentological and geochemical characteristics of a 30 m-long borehole core retrieved from the coastal area of the Alappuzha, which is covered by a thick layer of Cenozoic sediments. The sediment textural analysis indicates that the upper 14.7 m of the borehole core contains moderately sorted, medium to coarse sand, overlying a poorly sorted, organic carbon-rich, silty clay with broken and complete shells. The microfauna in the borehole sediments include *Ammonia*, *Bolivina*, and *Virgulina* indicating a shallow marine/lagoonal environment that prevailed during the deposition of the finer clastics in the borehole site. Cluster analysis of the geochemical parameters shows that the $SiO_2$ content behaves as a lone member exhibiting a negative correlation with all the other major and trace elements except for the element Zr which occurs mainly in the form of the mineral zircon ($ZrSiO_4$) in the coarser sediments. The ternary plot, CM diagram, and the $SiO_2/Al_2O_3$ ratio indicate that the texturally mature quartz sand in the upper level was deposited under a high-energy (shoreface) environment, whereas the lower silty clay sediments under a comparatively calm (shallow marine-lagoon) environment. These results suggest that the sedimentary framework of the region has been developed from a shallow coastal embayment due to the progradation of sand dominant sediments brought by the longshore currents.

*Keywords*: Coastal Sediments, Coastal Geomorphology, Sediment Texture, Major and Trace Elements, Coastal Evolution

## Introduction

Coastal areas where the land and sea meet are some of the most dynamic regions of the earth that are under the constant interactions of natural and anthropogenic processes (Kumar *et al.,* 2023; Bagul *et al.,* 2025; Bhatnagar *et al.,* 2025). The sediments in this zone have a special capability to dissipate the fury of the sea waves through its different types of sediment transport mechanisms - traction, saltation, and suspension (Hanamgond *et al.,* 2017; Pradhan *et al.,* 2020), thereby protecting the coastal lands from sea erosion. The sea level oscillations and climate changes play a pivotal role in the making up of the coastal environments. Being a densely populated region hosting most of the developmental centers, the coastal environments receive excessive input of nutrients, heavy metals and other pollutants from point and non-point sources which will adversely affect the ecosystem structure and functions in the long run (Vikas and Dwarakish, 2015; Danovaro and Boero, 2019, Chakraborty *et al.,* 2022). Therefore, the environment requires constant monitoring and mitigation measures to maintain the health of this crucial ecosystem that connect the land and the sea/ocean.

Sedimentology and geochemistry of subsurface coastal sediments provide a wealth of information on the nature and characteristics of the deposits. The data base can also be used for unravelling the paleoclimate and paleoenvironmental conditions that prevailed during the deposition of sediments (Cui *et al.,* 2016). The sedimentary archives of the coastal area often embed evidences of human habitation and maritime trades as well (Cheriyan *et al.,* 2012, Das *et al.,* 2024). Coastal sediments of many tropical coasts

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