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Near shore waves, long-shore currents and sediment transport along micro-tidal beaches, central west coast of India

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Abstract

Coastlines are undergoing constant geomorphologic changes with respect to the incident wave climate. Based on waves measured at 9 m water depth, simulation of near shore wave transformation is done using REFDIF-1 numerical model and the near shore breaker parameters are estimated at two micro-tidal beaches along central west coast of India. Model results are validated with measured values. From the breaker parameters, long-shore current and long-shore sediment transport rates (LSTR) are computed by using semi-empirical equations. Estimated long-shore current and LSTR are showing dramatic variations with respect to seasons. Predominant direction of LSTR is observed towards north since the approach waves are from south-west direction during pre-monsoon and post monsoon. During monsoon season, waves are from west south-west and resulted in southerly transport. The estimated annual net and gross LSTR by Cambridge Environmental Research Consultants (CERC) at two locations are in the same order whereas LSTR estimated by Walton & Bruno and Kamphuis equations are showing different estimations because of difference in surf-zone width and foreshore slope between the two locations. For micro-tidal beaches with length less than 6 km, Kamphuis equation is giving agreeable estimation of LSTR. Sensitivity analysis of LSTR estimate shows that coastal inclination is the prominent factor in determining LSTR than incident wave angle.

Key Words: Near-shore sedimentation, Littoral zone, Wave refraction, Wave measurement, Coastal zone management, Karnataka coast

1 Introduction

Understanding of sediment transport along coastlines is crucial for policy makers in coastal zone management. Estimation of sediment transport rate and its predominant direction are important input in the planning of shore protection measures. Near shore waves are prominent among other oceanographic parameters such as winds, tides, and currents in modifying the coastal geomorphology. Wave forces and wave dominated processes such as wave transformation in shallow waters cause spatial variation in wave energy leading to beach erosion/accretion (Short, 1999). Longshore currents generated by the breaking waves are responsible in transporting the sediments along the surf-zone. In the tropical region, influx of sediments is highly variable with season, and the sediment circulation in the near-shore and the vicinity of river mouths also changes with season. In response to sediment influx, beaches in the vicinity of the river mouths and configurations of rivers undergo rapid changes and create management problems especially when the sediment influx is modified by damming of rivers or if the current pattern is modified by construction activities in the mouth region (Abadie et al., 2008). Sedimentation in the river mouth, narrowing of river mouths, shoreline erosion, and rapid changes of the mouth configurations are common problems observed along the central west coast of India (Nayak et al., 2010). In New Mangalore port, sedimentation is mainly due to deposition of seabed material brought into suspension by the monsoon waves (Dattatri and Kamath, 1997), whereas in the Sharavathi estuary, sedimentation is related to the offshore source brought by tidal currents, and interaction of waves and river processes in the channel (Hegde et al., 2004). Sediment transport rate can be estimated mainly by three methods; (1) from direct measurements of longshore transport flux, (2) from empirical formulae using hydrodynamic and empirical formulae using hydrodynamic and sediment data acquired in the field and (3) by inferring net LSTR from observing large scale changes in shoreline and beach erosion and accretion (Esteves et al., 2009). Approaches (1) and (3) require considerable resources to acquire the necessary data. Earlier sediment transport studies along the Indian coast are either based on visual observations of littoral environmental parameters or based on the ship reported data. In the current study we have

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adopted the second methodology by transforming the measured offshore waves by numerical wave model and estimated the LSTR by using semi empirical equations. The objective of the work is to study the near shore wave characteristics and compare the LSTR estimate based on different semi empirical equations. Sensitivity of the LSTR estimate with wave angle and coastal inclination has also been studied.

2 Study area

Study area is located along the central west coast of India and is off Honnavar (Fig. 1). Sharavathi River meets the Arabian Sea at Honnavar and it separates the coastline into two as Pavinkurve beach in the north side and Kasarkod beach in the south side. Coastline is almost straight and open and it is inclined to west by 17° with respect to true north. Depth contours appears as almost parallel and the near shore steepens with the 10 m contour occurring at an average distance of 3.5 km from the coast and the 20 m contour occurring at an average distance of 10.75 km from the coast. Near-shore bathymetry usually becomes complicated because of presence of islands, sandbars, and shoals and hence these factors will influence the sediment transport phenomena. Offshore island named Basavrajadurg Island located 1 km offshore of Pavinkurve influences the near-shore wave climate along the Pavinkurve coast. Wind field over the study area is showing dramatic variations with respect to seasons. During the months June to September which are generally referred as summer (south-west) monsoon and the winds are southwesterly and its strength is significantly larger than that during the rest of the year. During November- February referred as winter (north-east) monsoon and the winds over the study area are observed as northeasterly direction and October and April- May are time of transition between two monsoons (Shetye et al., 1985). The region experiences a tropical climate marked by heavy rainfall, high humidity and hot weather conditions in summer. 87% of the annual rainfall is during summer monsoon period and the remainder during the northeast (winter) and inter-monsoon months with an average annual rainfall of ~3.9 m (IMD, 1999).

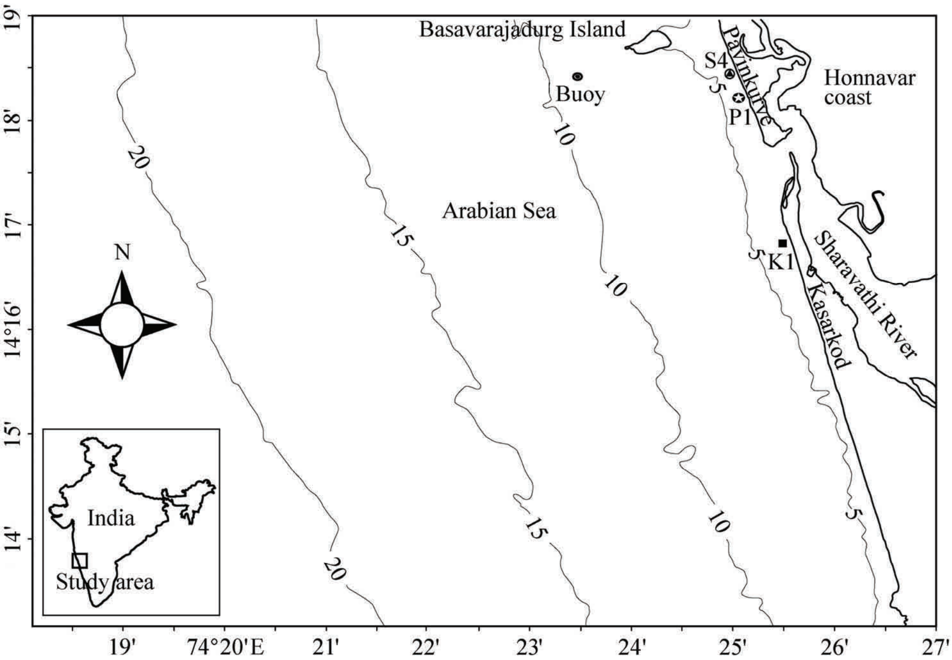

Fig. 1 Map of Honnavar coastline. Locations of offshore wave rider buoy and shallow water wave gauge (S4) are indicated in the figure. Locations of points at which nearshore breaker parameters were extracted at Pavinkurve and Kasarkod beach were also indicated in the figure as P1 and K1

Sharavathi river influences the sediment dynamics at the river mouth and the river discharge is high during summer monsoon period and it brings inland sediments into the sea, whereas during other seasons river discharge is low and hence the input of inland sediments is also low. This variation in the sediment influx into the beach environment results in a complex adjustment of sediments in the sea and the foreshore in the vicinity of the estuary (Hegde et al., 2009). Annual mean discharge of the Sharavathi river is 4,545 million m^3 (Sugunan, 1995). Sand spit on the southern coast is growing from south to north and hence the river mouth is shifting northward causing erosion at north side of river mouth (Vinayraj et al., 2011). Tides of the study area are mixed semi-diurnal dominant and its range is less than 1.5 m (Kumar et al., 2011) and hence the beach is classified under micro tidal beach. Cross shore sediment transport will dominate during the flood and ebb tidal conditions especially in the vicinity of the river mouth. Onshore transport of sediment will occur during the flood tide and offshore transport of sediment will occur during ebb tide (Dean and Walton, 1975). Masselink and Short (1993) studied the effect of tides on beach morphological changes as RTR=TR/Hb