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Quantitative estimation of sediment erosion and accretion processes in a micro-tidal coast

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Abstract

Spatio-temporal cross-shore profiles and textural characteristics are the key parameters for understanding dynamics of the inter-tidal sedimentary environment. This study describes short-term dynamics of the inter-tidal sedimentary environment at beaches along the micro-tidal coast. Further a correlation is estimated in cross-shore morphodynamics and textural characteristics of surface sediments. The sedimentary environment is examined for a complete annual cycle using monthly collected cross-shore profiles and sediment samples. The Devbag beach (northern side) and Ravindranath Tagore beach (southern side) at the Kali river mouth, Karwar, west coast of India are characterized from extremely gentle to average slope, and broadly composed of unimodal sands. The sedimentary environment is significantly composed of textures having fine to medium sand, well to moderately sorted, fine to coarse skewed, and platykurtic to leptokurtic in nature. During the annual cycle a reversal pattern is observed between the two adjacent beaches, where a slower rate of sediment accretion is observed at Devbag beach while Ravindranath Tagore beach exhibited erosion. The beach dynamics along with the propagation of south-west (SW) and south-west-west (SWW) waves towards the coast significantly exhibit a dominance of northward sediment transport with the existence of a northerly alongshore current. In addition, the study reveals that an eroded beach may not be significantly identified composed of coarse grains. The poor correlation in morpho-sedimentary characteristics reveals the prediction of grain characteristics based on beach profile and vice-versa is unrealistic.

Key Words: Cross shore profile, Beach volume, Grain size distribution, Textural characteristics, wave, Kali estuary

1 Introduction

In view of the immense colonization of inhabitants around coastal regions, shore protection is a significant conscious for developing national economy as well as to build a sustainable environment for human society. Shoreline changes can be described as cyclic instability of beach morphodynamics where the degree of beach stability is directly related to the net result of sediment erosion and accretion. Thus an appropriate knowledge on beach morphodynamics is indispensable for shore protection. Beach morphological changes occur not only by the influence of natural phenomena, but also by human activities (Guillen et al., 1999; Daniel and Abkowitz, 2005; Van Rijn, 2011). Spatio-temporal beach profiles are useful for explaining short-term and long-term erosion/accretion processes (Larson and Kraus, 1994; Cooper et al., 2000). Textural characteristics can be used for describing sedimentary environment, sediment provenance, transport history, depositional conditions and also for differentiating wave energy environments (Folk and Ward, 1957; Friedman, 1961; Nordstrom, 1977; Friedman, 1979; Bui et al., 1989; Samsuddin, 1989; Pedreros et al., 1996; Blott and Pye, 2001; Srinivas and Sajan, 2010). Beach profiles and grain sizes are both essential tools in predicting beach morphodynamics and equilibrium beach profiles (Dean, 1977; Gallagher et al., 2011). Therefore, understanding beach morphodynamics and sedimentary environment becomes a requisite task for designing effective coastal zone management strategy. Hence, the intertidal textural characteristics along with cross-shore profiles was analyzed simultaneously for a complete annual cycle to understand the intra- and inter-seasonal beach dynamics of two adjacent beaches [Devbag and Ravindranath Tagore (RT)] at Kali river mouth, Karwar, west coast of India (Fig. 1).

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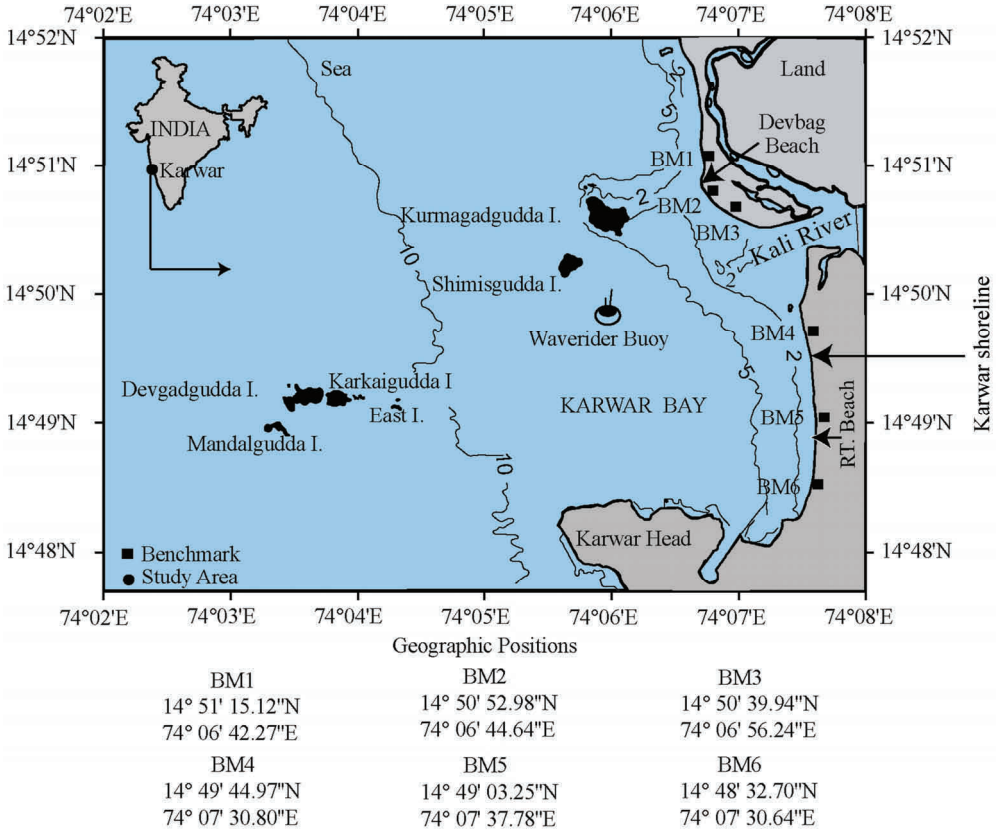

Fig. 1 Study area shows waverider buoy position and six sampling locations (BM1, BM2, BM3, BM4, BM5 and BM6) at two adjacent beaches (Devbag and RT beach) at the Kali river mouth, Karwar, west coast of India

The earlier studies show a slower rate in the hydro-morpho-sedimentary processes during annual cycles. Veerayya and Pankajakshan (1988) observed both southerly and northerly current patterns, whereas Chandramohan et al. (1992) had reported that a northward alongshore current pattern predominately exists with maximum current speed of 0.24 m s^{-1}. Average nearshore current speed off Karwar was 0.2 m s^{-1} with a maximum value of 0.6 m s^{-1} (Kumar et al., 2012a). Also, Veerayya and Pankajakshan (1988) observed the northern part of Karwar shoreline is significantly influenced by high waves that propagate from south-west (SW) direction. Kumar et al. (2012b) reported the significant wave height off Karwar varied from 0.3 to 3.6 m, where the average wave direction was 238°. A significant seasonal variation in the textural characteristics was found by Nayak and Chavadi (1988), where the sediments were drifting both sides of the Kali river mouth (Nayak, 1996). Also, Kunte (1994) observed a bi-directional sediment transport for a long stretch of area along the coast, where the net sediment transport was southward. Using satellite data of 13 years (1989 to 2003), Hanamgond and Mitra (2007) found net erosion of sediment along the shoreline, whereas Vinayaraj et al.(2011) identified accretion of sediments from 1981 to 1998, and erosion of sediments from 1998 to 2008. During last decades, the satellite data exhibited a net erosion of sediments along the Karwar shoreline, whereas in-situ observation showed a slower rate of sediment accretion at northern part of Kali river mouth and a strong winnowing and accretion of sediment at southern part (Mislankar and Antao, 1992). Following these, Dora et al. (2012) observed an accretion of sediments at Devbag beach for consecutive two years from February 2008 to February 2010. Simultaneous observation of beach profiles, sediment characteristics and waves were not carried out in the past studies along this region. Hence, a field observation was planned for understanding of relative dynamics between these two adjacent beaches of Kali river mouth. Further a correlation was examined in morpho-sedimentary parameters.

2 Study area and methodology

Kali estuary is one of the productive estuarine zones along west coast of India, and also a popular tourist place. Kali River drains into Arabian Sea at 14° 50′ 35.634″N & 74° 07′ 10.625″E to 14° 50′ 16.905″N & 74° 07′ 31.196″E, and has a width of around 800 m near the coast. Devbag beach covers ~2 km along north part, whereas Ravindranath Tagore (RT) beach runs for ~4 km along south part of Kali river mouth, Karwar. Offshore region of Karwar shoreline contains few small islands named as Kurmagadgudda, Shimisgudda (Sungniri), Devgadgudda, Mandalgudda, Karkaigudda and East Island (NHO, 2008). The domain is in a micro-tidal coast (tidal range < 2 m) and there is no significant backshore zone. During the study period, the lowest low tide and highest high tide level was at -0.16 m and 2.36 m (Indian Tide Table, 2010 and 2011). Study domain is under the influence of three seasons such as pre-monsoon (February to May),

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