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MONSOONAL EFFECTS ON BEACH AND OFFSHORE SEDIMENTS FROM KALBADEVI BAY, RATNAGIRI, MAHARASHTRA STATE, INDIA

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ABSTRACT
Sediment samples representing the beach and offshore area of Kalbadevi Bay, Ratnagiri, Maharashtra were studied for different seasons along three east-west beach profiles (BP-01, BP-02 and BP-03) which covered berm, dune, high tide, mid tide and low tide area of the beach, and the sea along their extended offshore profiles (OP-01, OP-02 and OP-03). The major constituent of the sediments from both areas is sand followed by silt, with negligible clay. Comparatively, beach sediments show pronounced monsoonal effects on sand content in the berm area. The shallow (<5m depth) offshore area receives loose sand during southwest monsoon and indicates transportation from beach. During post-monsoon period, it is removed and deposited farther at deeper depths (>10m). It appears that the sediment distribution in the Kalbadevi Bay is partly controlled by the east-west trending depression along the central offshore profile (OP-02). The study shows enrichment in sand and clay content during post-monsoon period rather than during pre-monsoon and/ or transitional period.

KEY WORDS: Beach, Environment, Offshore, Ratnagiri, Season, Sand, Sediment,

INTRODUCTION

Placer deposits from the coastal and offshore areas of Maharashtra are well known and many workers (Roy, 1958; Siddiquie *et al.*, 1979, 1982, 1984; Gujar, 1985; Ramana, et al., 1990; Rajamanickam, *et al.*, 1994) have studied these deposits in detail. Ratnagiri coast has number of bays which contain placer mineral deposits. The placer mineral occurrences along Ratnagiri coast are reported up to 91%, where ilmenite ranges up to 52%. These deposits are 100 to 400 m wide and sometimes stretches up to 5 km in length, The major source for the minerals such as augite, diopside, hornblende, ilmenite and magnetite are the Deccan Traps (Siddiquie, et al., 1979), whereas granite is identified as the source for tourmaline and zircon, and Kaladgis and gneisses of south Konkan area are the major source for garnet, kynite and staurolite (Gujar, 1995). Kalbadevi Bay is situated north of Ratnagiri Bay. Studies on the seasonal variations in heavy mineral beach placers from Kalbadevi Bay showed comparatively active environment at berm area in all three seasons (Valsangkar, 2005). The pre- and post-monsoonal changes in the sediments have revealed more interesting results (Valsangkar and Domnica Fer.nandes, 2011).

Kalbadevi beach is 5 km long, 250 m wide and bordered by estuary in northern and southern end. In 2004, the National Institute of Oceanography (NIO), Goa, identified and selected Kalbadevi Bay in Ratnagiri to carry out `Environmental Impact Assessment (EIA) studies for placer mining` under the ‘Capacity Building for Sand Mining, Network Program’ of the Council of Scientific and Industrial Research (CSIR), New Delhi. The beach sediment samples from the Kalbadevi Bay were collected along three profiles during three seasons during 2004. Later, the offshore sediment samples were collected in 2006. Here,, the seasonal variations in sand-silt-clay contents from the beach and offshore sediments of Kalbadevi Bay are compared and discussed.

MATERIALS AND METHODS

The sampling was carried out in three seasons in 2004, which included transitional period (February), pre- monsoon (May), during monsoon (August), and post-monsoon (November) period. Three E-W trending profiles (BP-01, BP-02 and BP-03) were selected (Valsangkar, 2005) to represent the Kalbadevi beach. Each beach profile was separated[8] by a distance of 1.5 km (Figure 1). Beach samples from 25-30 cm depth were obtained during sampling in February, May and November, and up to 20-25 cm in August 2004. During different seasonal sampling, a reference sample was also collected to allow comparison of the parameters and to understand the physical and chemical changes taking place in the beach environment. The beach sediment samples were obtained by push core method using 50 cm long different diameter acrylic core liners. The sampling was performed at dune, berm, hide tide (HT), mid tide (MT) and low tide (LT) areas of the beach in three seasons to study and assess the monsoonal impact. The core sediments were sub-sectioned at 5 cm intervals.

The offshore sediment samples of Kalbadevi Bay were collected in 2006 for the similar purpose. The offshore sampling was carried out along three profiles (OP-01, OP-02 and OP-03) and underwater surface sediments were obtained from 5, 8 and 10 m depths (Figure 2). The three offshore profiles were in fact the extension of the respective beach profiles[8]. Samples along OP-02, and OP-03 profile were obtained in the month of January, May and October whereas those along OP-01 were restricted for the month of January only. Hence, they are omitted here for comparing results. A reference point (SO/!) was established at 5 m depth for offshore sampling during January, May and October.

The underwater sediment surface samples were collected by manually operating a small grab from a launch. The coordinates for onshore and offshore stations were recorded using Garmin GPS hand set (Model No. 76 CSX).

The salt content of the beach and offshore sediment samples was removed by repeated washing with Millipore water in the onshore laboratory. Similarly, the carbonates, organic matter and ferruginous coatings were removed by treatment with solutions of 1:10 HCl, H_2O_2 (30% by volume) and $SnCl_2$ respectively. All the samples were oven dried below 60°C. After coning and quartering, the representing samples were weighed and. sieved to obtain different sized sand fractions. The sand content was determined by wet sieving whereas the silt and clay contents were determined by the standard pipette analysis (Folk, 1968). The mean grain size of the sediment was determined following graphic method (Folk, 1968).

RESULTS AND DISCUSSION

The sand-silt-clay content of the beach and offshore sediments are compared and the seasonal variations are discussed below.

A) Beach sediments

The major constituent of the beach sediment is sand followed by the silt and clay. Compared to HT, MT, and LT environment, variations in the sand content in dune and berm area are more pronounced (Figure 3, 4 and 5). Further, the dune area display small variations in sand as compared to berm area. In dune area, the sand content decreased with depth during pre-monsoon period and increased during post-monsoon period. This observation clearly indicates the deposition of sand mostly during monsoon period.

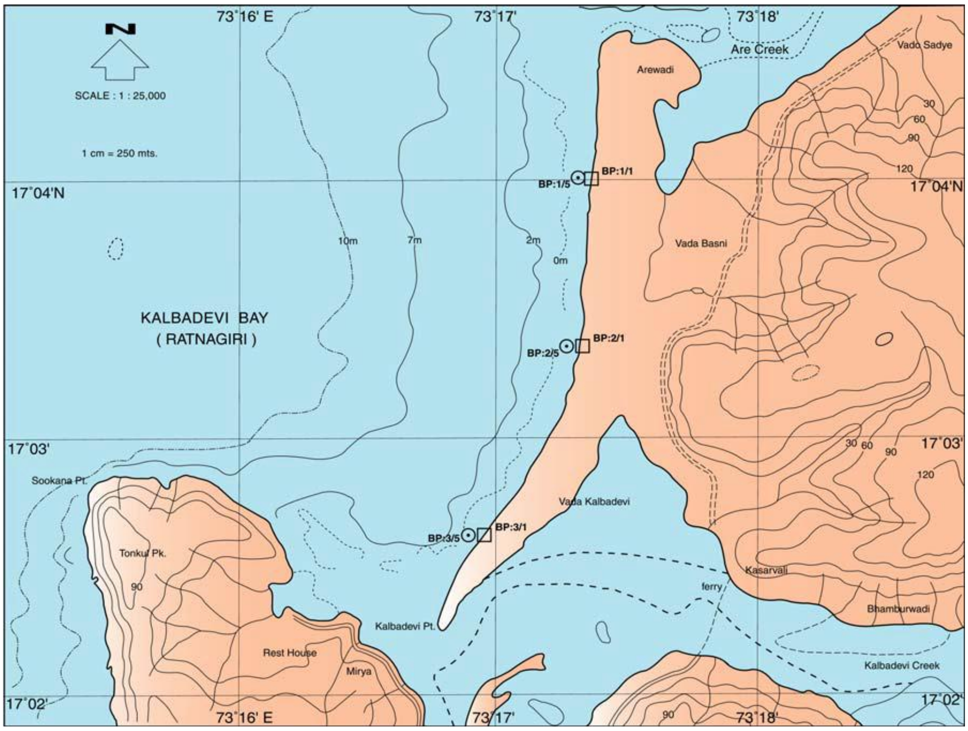

Figure 1. Beach sediment sampling stations along BP-01, BP-02 and BP-03 profile, Kalbadevi, Ratnagiri.

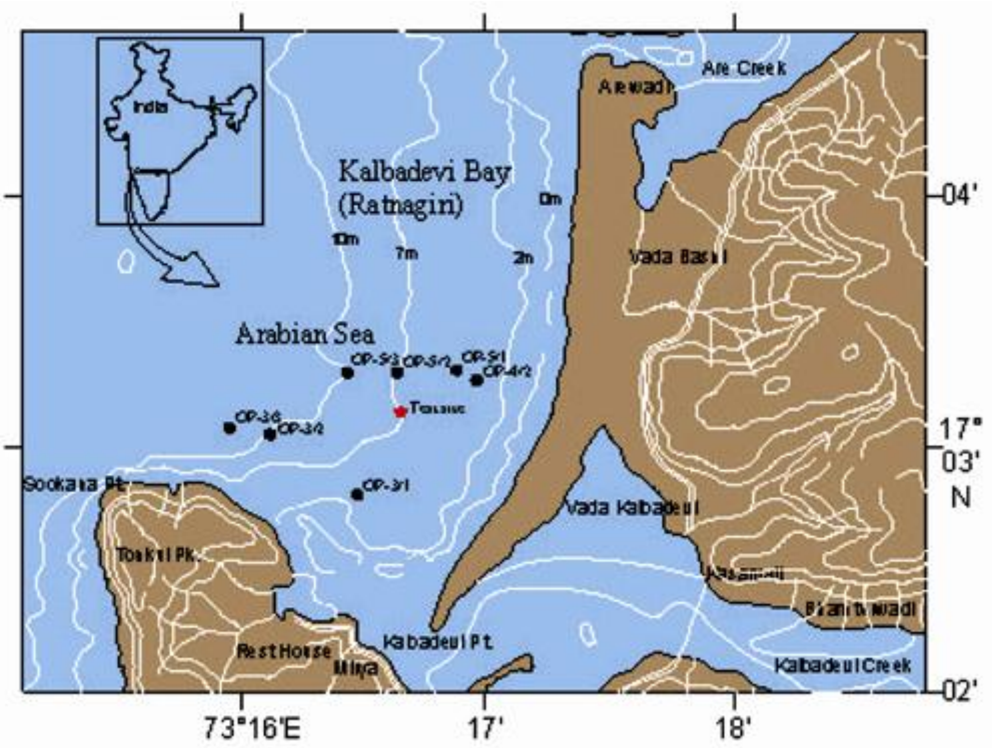

Figure 2. Offshore sediment sampling stations along OP-1, OP-2 and OP-3 profile, Kalbadevi Bay. Ratnagiri.

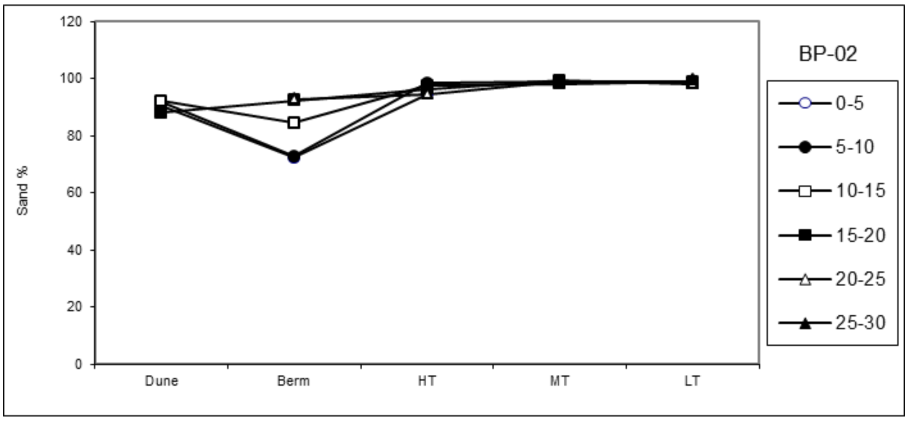

Figure 3. Variations in sand content along BP-02 profile during pre- monsoon period.

Comparatively, sand content in the berm area increased with depth during all three seasons (viz. 72 to 92 % during May; 61 to 80 % during August; and 77 to 89 % during November). The depth wise sand content varied within 20% during pre- monsoon and monsoon period, but reduced to 12% during post- monsoon. The wide range of variation during two seasons therefore indicates that the area is more susceptible to the monsoon environment. The berm area is away from the actual or observable tidal effects. The surface sand (up to 5 cm depth) shows a decrease from 72% (pre monsoon) to 61% (during monsoon) and an increase to 77% (post monsoon), which suggests removal effect of high speed wind blowing during monsoon. However, increase of sand content with depth in berm environment is considered due to deposition via percolation of monsoon water through channels.

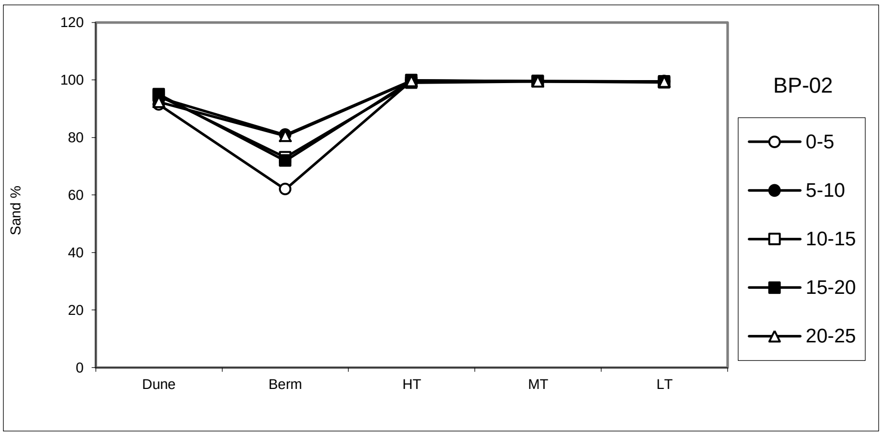

Figure 4. Variations in sand content along BP-02 profile during monsoon period.

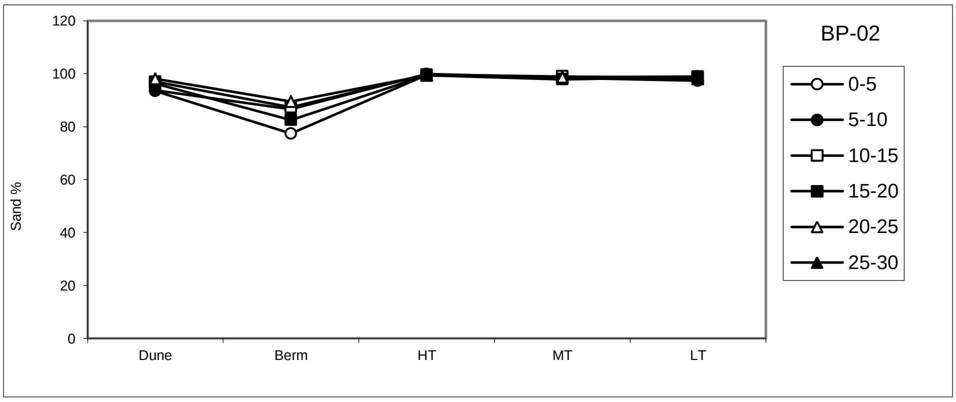

Figure 5. Variations in sand content along BP-02 profile during post- monsoon period.

B) Offshore sediments

The major constituent of the offshore sediment is also sand which varied from 95 to 98% in January, 95 to 99% in May, and 98 to 99% in October. Silt content is minor which varied from 0.5 to 3% in January, 0.01 to 3% in May, and 0.04 to 0.9% in October. Sand content at the reference point (SO/1) recorded 99% in January, 96% in May and 96% in October and thus showed little variation with respect to three seasons. Sediments at reference point showed small variation in sand content which decreased by 2.8% during May and increased by 3.4% during October. Similarly, the comparison of sand, silt and clay content for OP-02 and OP-03 profiles during pre-monsoon (May), post monsoon (October) and transitional period (January) showed small changes, and the maximum variation for sand, silt and clay was recorded up to 2.7, 2.9, and 0.15% respectively.

Dissimilar trends of sand content for OP-02 and OP-03 profile during three seasons reflects influence of other parameters in addition to monsoon. Increase of sand along OP-02 during May and October is related to the monsoonal effects and deposition of loose sand due to wave action. It is opined that presence of E-W trending depression (Siddiquie, et al., 1979) along OP-02 profile in the centre of the Bay probably facilitates transportation of sand to deeper depths. The movements of the convergent and divergent littoral currents (Siddiquie, et al., 1979) are also responsible for the movement of sand in the Bay to deeper levels. Wave measurements (Reddy, 1976) in the Bay showed that the wave direction changes between SW to WNW with wave period of 5-14 seconds. All these observations support the movement of sand in the Bay towards deeper depth.

In contrast, OP-03 profile in the south of the Bay is prone to the monsoonal effect, which is revealed from increase of sand at 10 m depth during May (99.8%) to October (99.6%). The clay content in the offshore sediment is much low to negligible. Although total clay content is quite low, it appears to be sensitive to the season, as it is reduced from ~2.5 %

in January (transition period) to <0.5% in October (through during monsoon. It further implies that the clay accumulation in the Bay begins only after the monsoon period (June-September) is ended. The mean grain size of the sediments showed quite variation along OP-02 and OP-03 profile for the three seasons, but at the reference point the change was minimum (0.008 to 0.009 mm). Comparison between two profiles indicated larger variation along OP-03 (0.09 to 0.16 mm) than along OP-02 (0.07 to 0.12 mm). During pre-monsoon period both profiles displayed minimum range of mean grain size (0.07 and 0.09 to 0.1 mm for OP-02 and OP-03 respectively) while during post- monsoon period, the range enlarged (0.08 to 0.12, and 0.09 to 0.16 mm for OP-02 and OP-03 respectively).

CONCLUSIONS

The beach- and offshore- sediments from Kalbadevi Bay, Ratnagiri show different responses with respect to location. They behave dissimlar with pre-, post- monsoon and transitional period. The beach environment is more active at bern. Although loose sand from shallow depth is transported to the deeper depths during monsoon, the sand content increases noticeably during the post-monsoon period.

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