Beach Erosion and Accretion in Relation to Seasonal Longshore Current Variation in the Northern Kerala Coast, India

M. Samsuddin and G.K. Suchindan

Marine Science Division
Centre for Earth Science Studies
Akkulam, Thiruvikkal P.O.
Trivandrum 695 031, India

ABSTRACT

A one-year set of beach profile and longshore current data measured bimonthly were analysed to understand the relationship of the longshore current to the beach erosion and accretion phenomena in the northern Kerala coast. The study indicated that the longshore current activity can be linked with the following erosional and accretional phases: (1) a depositional phase dominated by a northerly current; (2) a transitional phase with perceptible erosion showing reversal in current direction; and (3) an erosional phase dominated by a southerly current. The intensity of the longshore current and the rates of erosion and accretion are directly related.

ADDITIONAL INDEX WORDS: Erosion, accretion, longshore current, premonsoon, transitional, monsoon, postmonsoon.

INTRODUCTION

The Kerala coast in the southwest part of the Indian subcontinent has a long coastline extending over 560 km. It has been estimated that 360 km is vulnerable to coastal erosion during the SW monsoon period (June-August). The coastal erosion has become critical for Kerala state which is facing an acute shortage of land due to the high density of population in the coastal zone (655 per km²). The problems associated with coastal erosion include loss of valuable beaches, agricultural lands, damage to the coastal vegetation and stoppage of fishing activities during the above seasons. Approximately 50 crores of rupees was proposed to be spent to tackle the problem in the Sixth five-year plan. Some structural measures like seawalls and groynes are adopted to arrest the erosion. Even though 186 km of coast is protected, only 86 km of coast is structurally stable. No alternative other than seawalls (in some cases groynes) have been tried along the Kerala coast mainly due to the non-availability of extensive data on wave, bathymetry, currents and beach volume changes.

The coastal erosion is not a problem of the Kerala state alone, but prevails along the other parts of the east and west coasts of India. Studies on beach changes in Visakhapatnam on the east coast (MOHAN et al., 1981) and off Trivandrum on the west coast (VARMA et al., 1981) showed that the beach erodes during the SW monsoon and accretes during the calm weather period. Study of stability and safety of Goa beach, on the west coast of India, showed that the beach is fairly stable although it undergoes a series of short term cuts and fills during the monsoon and nonmonsoon seasons, respectively (NARAYANASWAMY and VARADACHARI, 1981). Sediment movement in relation to the wave refraction and beach erosion and accretion have been discussed by many authors (REDDY and VARADACHARI, 1973; NAIR et al., 1973; MURTHY and VARADACHARI, 1980; BABA, 1985).

Though data on beach erosion and accretion on small stretches of coast are available, data of this kind covering larger areas of the coast is scanty on
the west coast of India. This work forms part of the project of the Marine Science Division of CESS, namely “Monitoring Planimetric Changes of Beaches of Kerala”. The aim of the project is to assess the beach erosion and accretion and the related processes.

In the present study an attempt is made to relate the erosional and accretional phenomena to the seasonal variation in the longshore current pattern over a large section of a coast.

An important aspect of wave action in shallow water is the generation of longshore currents. It plays an important role in the longshore movement of the material and is fundamental in the formation of many coastal features and numerous instances of coastal erosion and accretion (King, 1949). The strength of the longshore current is directly related to waves breaking at an angle to the shoreline, and this, combined with the agitating action of breaking waves provides energy for moving sediments along the beach.

STUDY AREA

The study area encompasses 150 km of northern Kerala coast between Mahe (lat. 11° 42’ 00” N, long. 75° 31’ 50” E) and Talappadi (lat. 12° 45’ 55” N, long. 74° 52’ 08” E) on the west coast of India (Figure 1), consisting of three beach morphologic types, viz.: (1) medium-grained, wide beaches with moderate slope; (2) fine-grained, wide and low-energy beaches with low gradient; and (3) coarse-grained, narrow, high-energy beaches with steep beach faces. The study areas are grouped into the following three types of coastal environments (Suchindan and Samsuddin, 1984): (a) the strand plain shoreline; (b) clifled shoreline and (c) clifled shoreline with a seasonal beach.

MATERIALS AND METHODS

The primary data base for this study is the surveying of beach profiles along with measurements of longshore currents, breaker height and wave period in alternate months from November 1980 to November 1981. The beach profile is identified by one or more reference stations and is defined by a direction. The beach profile is measured from a reference station to a point seaward up to a few metres beyond the low water line using a dumpy level, levelling staff and tape. The beach profile data were processed in a KELTRON microprocessor. The program compared each profile with that measured at the same location from the previous month and gave beach changes as either erosional or accretional, and as cumulative volume changes (cubic metres/linear metre of the beach). The net volume change represents the algebraic sum of the erosion in one part of the profile line and accretion in another part (Goldsmith et al., 1977).

Any coast can be subdivided into a series of coast line sectors which permit the sectorwise quantification of the beach volume changes (Schubel, 1968). A typical sector begins with a rocky promontory where the supply of sand is restricted or a river outlet where large quantities of sand are available and is bounded by the combination of any of these two. In the present study, by taking into consideration the local changes in geomorphology, 14 coastal sectors are demarcated along the coast and each sector is viewed as a separate entity in calculating the rates of erosion and accretion.

The longshore current velocity and direction were measured by deploying a suitably buoyant drift bottle in the surf zone. The distance travelled by the bottle in 2 minutes is recorded and represented in m/sec.

The wave period was measured using a stopwatch, by observing the time required for 10 wave crests to pass an imaginary fixed point. The breaker height was estimated visually.

RESULTS AND DISCUSSION

The southwest monsoonal season, where the wind blows generally from southwest to west-southwest, is the principal rainy season on the southwest coast of India and provides 80% of the annual rainfall in northern Kerala. The northeast monsoon, when the wind blows from the northeast, is the secondary rainfall season and at this time there is a decrease in rainfall from south to north (Ananthakrishnan et al., 1979). Based on the variation in the longshore current, the erosional or accretional trends will be discussed under the following seasons: (1) premonsoon (January-April); (2) transitional (May); (3) monsoon (June-August) and (4) postmonsoon (September-December).

Table 1 shows the average wave period and breaker height for different seasons and Table 2 gives the sectorwise seasonal beach volume changes. The breaker height increases from premonsoon to monsoon, whereas the wave period shows a decreasing trend. This could reflect the
Figure 1. Map of the study area showing the beach profile locations.
occurrence of short-crested, low period, and high waves in the monsoonal season.

Wave refraction studies along the west coast of India (REDDY and VARADACHARI, 1973) suggest that for waves from the southwest, west-southwest and west, which is the principal wave direction during the southwest monsoon, the littoral transport is directed generally towards the north. However, the present study reveals a different picture. Figure 2 shows the seasonal variation of longshore currents during different months. In the premonsoon season the longshore currents set to the north. The frequency distribution diagram of the velocity of the longshore current (Figure 3) shows that in January 80% of the observations fall within 0.1 m/sec to 0.3 m/sec. During the later stages of the premonsoon season (March) the velocity of the current increases as indicated by the fact that 60% of the observations fall within the range of 0.3 m/sec to 0.5 m/sec. This increase in the velocity of longshore current from January through March is found to be accompanied by an increase in the accretion rate (Table 2). Due to the feeble currents in the month of January, 28.32 m$^3$/m of beach was accreted. With an increase of velocity of the longshore current in March, the coast showed an accretion of 267.02 m$^3$/m of beach. It is estimated that under the influence of low and long period swell waves and northerly longshore currents in the premonsoonal season (wave period 14 sec, breaker height 0.85 m), 295.34 m$^3$/m of beach was accreted in this area.

During the transitional period, reversal of longshore currents towards the south is observed for most parts of the coast where 60% of the observations lie in the 0.1 m/sec to 0.3 m/sec range. During this season the breaker height increases to 1.02 m and the wave period is reduced to 13 sec. Under the influence of this wave climate and feeble southerly currents the coast experiences perceptible erosion and 182.58 m$^3$/m of beach was removed. With the advance of the monsoon, strong southerly currents of 0.3 m/sec to 0.7 m/sec are generated, with 65% of the observations in this range. The strong southerly currents and short
Figure 2. Monthly variation in the longshore current pattern (m/sec).
LONGSHORE CURRENT (m/sec)

Figure 3. Frequency distribution diagram of the intensity of the longshore currents in different months.

period (10 to 11 sec) high waves (1.5 to 2.5 m) could be held responsible for the erosion of about 1,407.42 m³/m of beach.

With the end of the monsoonal winds, in the postmonsoonal season the southerly current ceases and a northerly current is generated. The loss of beach during the monsoon is partly made up during this season. In the initial stages of the postmonsoon period (September), the longshore current is northerly with 70% of the observations falling in the range of 0.2 m/sec to 0.5 m/sec. In the later stages (November) the intensity of the northerly longshore current is reduced (70% of the observations in the range of 0.1 m/sec—0.3 m/sec). In addition, wave period increases again (14 sec) and the breaker height decreases (0.98 m). The influence of the intensity of longshore currents on the accretional behaviour of the beach can be readily seen during this season. In September, due to the strong northerly currents and the long period swell waves, 1,033.06 m³/m of beach was accreted. Reduction in velocity of the longshore current could be the reason why the coast shows a lessened rate of accretion in November (164.76 m³/m). Under the influence of the long period swell waves and northerly currents, 1,197.82 m³/m of beach was accreted during this season.

A scatter plot representing 12 profiles (between stations 22-33) is drawn to relate the erosional and accretional behaviour of the beach to the variation in the longshore current in different seasons. Figure 4 shows that the majority of the data points related to southerly longshore currents fall in the field of erosion; whereas the majority of the data points related to northerly longshore currents fall in the field of accretion. Reverse relations also occur locally, but in such cases the magnitude of erosion or accretion is found to be less.

CONCLUSIONS

A series of 64 beach profiles surveyed from Mahe to Talappadi in the northern Kerala coast from November 1980 to November 1981, together with measurements of seasonal longshore current variation and the wave parameters disclose a relation-
Beach Erosion and Accretion in Kerala

Figure 4. Scatter plot showing the relationship between the speed and direction of longshore current with erosion and accretion.

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LITERATURE CITED


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RESUMEN

Datos medidos bimensualmente, durante un año, de perfiles de playa y corrientes longitudinales fueron analizados en orden a relacionar los fenómenos erosivos y acumulativos de la playa con las corrientes longitudinales en la costa norte de Kerala. El estudio indicó que la actividad de las corrientes longitudinales puede ser articulada con las siguientes fases erosivas y acumulativas: (i) Fase acumulativa gobernada por la corriente del norte; (ii) Fase de transición con erosión perceptible, observándose cambios en la dirección de la corriente y (iii) Fase erosionadora gobernada por la corriente del sur. La intensidad de la corriente longitudinal y los ratios de erosión y acumulación son directamente relacionados.

ZUSAMMENFASSUNG

Jahrlange Messungen der Strandprofil- und Strömungsdaten der Nordküste Keralas ist genommen worden, um die Beziehung zwischen die Strömen und die Strandauswaschungs- und Strandaufbildungsphänomen zu analysieren. Die Forschung zeigt daran, dass die Strömungsaktivität ist mit die folgende Auswaschungs- und Aufbildungsphasen: (i) eine Ablagerungsphase, die von einer nördlichen Strömung herrscht ist; (ii) eine Übergangsphase mit bemerkbarer Auswaschung, der Strömungszurücklaufen zeigt, und (iii) eine Auswaschungsphase, die von einer südlichen Strömung herrscht ist. Die Intensität der Strömung und der Auswaschungs- und Aufbildungs geschwindigkeiten sind direkt verwandt.