Second Indian National Conference on Harbour and Ocean Engineering (Inchoe-97)
Thiruvananthapuram, December 7-10, 1997

SEDIMENT TRANSPORT NEAR THE PENINSULAR TIP OF INDIA

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ABSTRACT

Studies were undertaken at Kolachel on the western side of the Peninsular tip from April 1995 to April 1996, for a period of one year. Monthly measurements were made on littoral environment observations (LEO) and beach level variations. Longshore sediment transport rates were estimated based on the observed data. Study shows that the wave activity was high throughout the year at Kolachel. The annual gross longshore sediment transport rate was higher 0.9 x 10^6 m^3/year and the annual net transport rate was 0.3 x 10^6 m^3/year towards west. The beach level was low in September and high in April and the beach near Kolachel is stable over the annual cycle.

INTRODUCTION

On the southeastern tip of the peninsular India, the Tamil Nadu state encircles nearly 1000 km long coastline, extending approximately 355 km in Bay of Bengal, 275 km in Palk Bay, 315 km in Gulf of Mannar and 55 km in Arabian Sea. It comprises of rocks, islands, shoals, coral reefs, mangroves, salt marshes, estuaries, tidal inlets, sand dunes and wide beaches. The exchange of littoral drift between the west and east coasts, wave sheltering effect due to Sri Lankan Island, large sedimentation in Palk Bay, marine parks in Gulf of Mannar, advancing sand spit from Dhanuskodi to Talai Mannar, and the long stretch of wide beautiful beaches north of Pondicherry are the exclusive characteristics of the Tamil Nadu coast. The coastlines in the peninsular region, near Ovari, Kanyakumari, Pallam, Manavalakurichi, Kolachel, Midalam and Eramanthurai have been reported as undergoing erosion. The important factor which causes the change in the coastal configuration in the peninsular part is the littoral sediment transport. Most importantly the exchange of the drift between the east and west coasts through this peninsular region bears the great significance in determining the littoral drift pattern over the rest of the Indian coast. This paper presents the field studies undertaken at Kolachel, which lies close on the western side of the Peninsular tip (Fig. 1). It further describes the beach variations, wave refraction and the longshore sediment transport with reference to the stability of the coastline in this region.

METHODS OF STUDY

The magnitude and direction of the longshore currents were measured by releasing Rhodamine-B fluorescent tracers in the surf zone and noting the distance it travelled for 2 minutes. Breaking wave heights, surf zone width, and wave period were observed using CERC procedure (Schneider 1981). Variation of the beach level and the sea bed till 5 m water depth was measured with reference to the jetty deck using a lead line. All measurements were made at monthly intervals for a period of one year from April 1995 to April 1996. Numerical wave refraction study was carried out using the procedure explained in Skovgaard et al. (1975). Nearshore bathymetry was adopted from Indian Naval Hydrographic charts. Longshore sediment transport rate was estimated employing the equation (Walton and Bruno 1989):

$$Q = \frac{1290\,\rho\, g\, H_b\, w v\, C_f}{0.78\left(\frac{5\pi}{2}\right)\left(\frac{v}{v_0}\right)} \tag{1}$$

where Q is the longshore sediment transport rate in m^3/year, ρ is the mass density of the sea water, g is the acceleration due to gravity, C_f is the friction coefficient, H_b is the breaking wave height in m, w is the surf zone width in m, v is the measured longshore current velocity in m/s and v/v_0 is the theoretical dimensionless longshore current velocity (Longuet-Higgins, 1970)

RESULTS AND DISCUSSION

Surfzone Characteristics

Monthly variation on the longshore current distribution and the breaking wave characteristics are presented in Table 1. Breaking wave heights were relatively higher exceeding 1.5 m during May to August (southwest monsoon), in November and February (beginning and end of northeast monsoon). It varied around 0.8 - 1.3 during the rest of the year. Relatively higher wave activities were observed even during the fair weather period, due to its direct exposure to Indian Ocean. The wave period persisted around 7 - 10 s. Waves almost break parallel with a slight inclination of 1° - 2° with the coast, except in February, March and June during which the breaker angle exceeds 3° to the coast. Although plunger type wave breaking was found to be common, collapsing breakers were observed in December, January and February. Width of the surfzone was wider about 35 m in June to September and November, and it was less during the rest of the year. The longshore current direction was towards east in September, and November to February, and towards west during the rest of the year. The longshore current speed was higher exceeding 0.3 m/s in June to September, November and February and low showing less than 0.16 m/s in January, March and December.

Table 1. Monthly variation of littoral environmental parameter at Kolachel

Month	H_b (m)	T (s)	α_b (deg.)	W (m)	Longshore current* (m/s)	Monthly net transport* (m^3)
Jan 96	0.8	10	-1	10	-0.15	-6443
Feb 96	1.7	10	-3	20	-0.50	-91272
Mar 96	0.8	10	5	25	0.10	10738
Apr 95	1.3	7	1	30	0.25	52347
May 95	1.5	10	1	15	0.16	20134
Jun 95	1.5	3	3	40	0.46	150330
Jul 95	2.5	7	2	35	0.51	242721
Aug 95	1.6	8	1	40	0.42	143172
Sep 95	1.2	10	-2	35	-0.30	-70467
Oct 95	0.8	9	2	5	0.23	5011
Nov 95	1.5	9	-2	40	-0.46	-150330
Dec 95	1.0	8	-2	10	-0.07	-3579

* (-) towards east, (+) towards west

Annual gross = 0.9×10^6 m^3 /year
Annual net = 0.3×10^6 m^3 /year (towards west).

H_b = Breaking wave height, T = Wave period, W = Surf zone width, α_b = Wave breaking angle w.r.t. coast.

Longshore Sediment Transport

The monthly longshore sediment transport rates estimated for the Kolachel coast based on the observed littoral environmental parameters are presented in Table 1. The sediment transport rate is higher exceeding 0.15×10^6 m^3 /month during June to August and in November. Large volume of transport about 0.24×10^6 m^3 /month was observed in July. The direction of transport is westerly from March to August and October, and towards east during the rest of the year. The annual gross longshore sediment transport rate is estimated as 0.9×10^6 m^3/year and the annual net transport is 0.3×10^6 m^3/year towards west. Chandramohan, Nayak and Raju (1990) reported that the annual net transport at the tip of India peninsula near Kanyakumari East Cape is negligible. Based on the ship reported wave data, they also stated that the annual net transport along Trivandrum - Kolachel coastline is in easterly direction. Sajeev (1993) has verified with measured monthly littoral environmental parameters and reported that the annual net transport along the Trivandrum coast is low about 0.09×10^6 m^3/year, but in westerly direction. The present study also suggests that the net transport near Kolachel is in westerly direction, quite opposite to the general opinion among the Indian oceanographers that along the west coast of India till Kanyakumari, the annual net sediment transport is in southerly direction. It further suggests that there should be a region close to Trivandrum, which would behave as a nodal drift point and precisely break the continuity of the longshore sediment transport cell between the east and west coasts. Hence, the possibility of the exchange of sediments through the surf zone between the east and west coasts is limited. The presence of rocky patches across the surf zones between Thengaipatnam in the west and Chettikulam in the east further suggests that the littoral cells are interrupted and broken at many places in this peninsular region. For further confirmation on the beahviour of the littoral drift, it is necessary to take up detailed studies particularly on the directional wave measurements close to this region.

Beach level

Monthly variation of beach levels at Kolachel is shown in Fig. 2. The beach level was low in September and high in April. To understand the beach accumulation, volume of sediment deposited per meter length of the beach was estimated and presented in Table 2. Volume of sediment was less during June to September and it was more about 332 m^3 in April. Usha and Subramanian (1993) reported that the coast near Ovari is exposed to severe erosion in June whereas alternate erosion and accretion trend have been noticed at Kanyakumari. Kaliasundaram, Govindasamy and Ganesan (1991) reported that the erosion is taking place at Kolachel at a rate of 1.2 m/year. However, the present study indicated that the beaches near Kolachel is stable over the annual cycle, as the April 1995 beach levels have been fully recovered by April 1996 as shown in Fig. 3.

Table 2. Volume of beach sand at Kolachel.

Month	Volume (m^3)
Apr 95	327
May 95	317
Jun 95	218
Jul 95	24
Aug 95	42
Sep 95	0
Oct 95	83
Nov 95	101
Dec 95	184
Jan 96	210
Feb 96	255
Mar 96	294
Apr 96	332

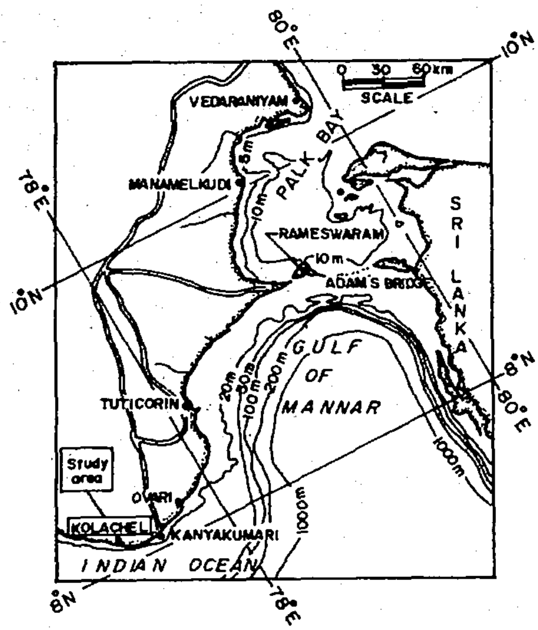

Fig.1 Location map

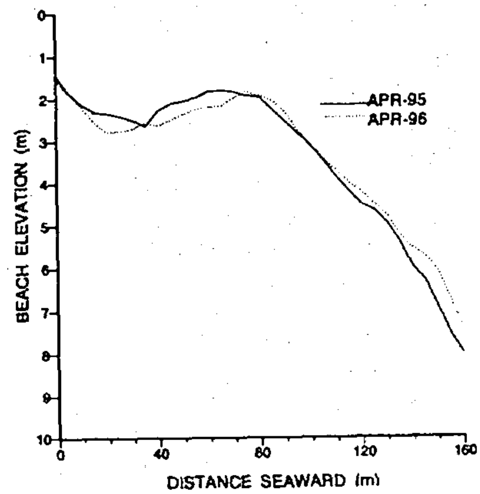

Fig.3 Annual variation in nearshore profile at Kolachel

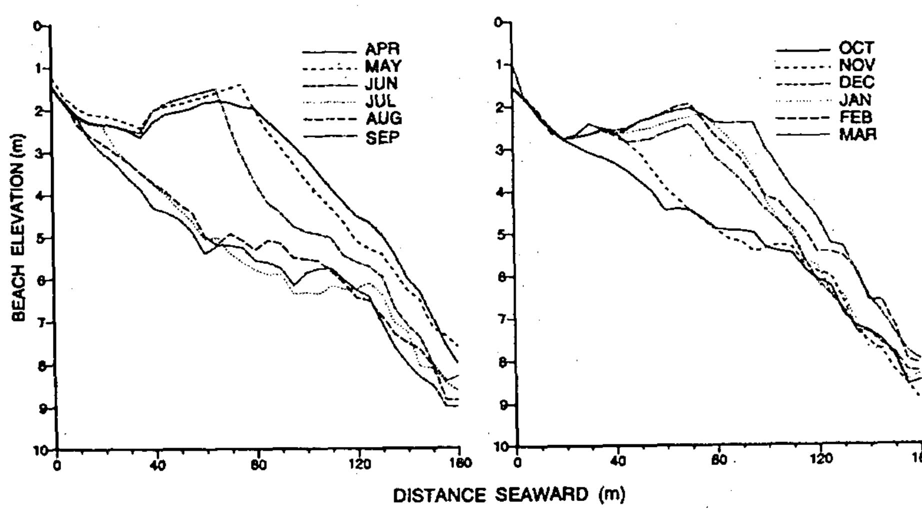

Fig.2 Nearshore profile at Kolachel

Wave Refraction

The wave refraction study was carried out for two deep water wave directions, i) 190° to represent northeast monsoon period and ii) 210° for southwest monsoon period. Predominant wave period of 8 s was selected for the computation and the refracted wave orthogonals are presented in Fig. 4. The wave refraction for the northeast monsoon period indicates convergence of wave energy near Muttam Point, and Puttamtura, and divergence of wave energy near Muttam and Puttalam to Kanyakumari. The wave refraction during the southwest monsoon period indicates convergence of wave energy near Muttam Point, divergence near Thengaipatnam and the wave energy is uniformly distributed at other places. The orthogonals close to the shoreline indicates that the waves tend to break almost parallel to the coast and it is found that there is no significant concentration of wave energy in this region.

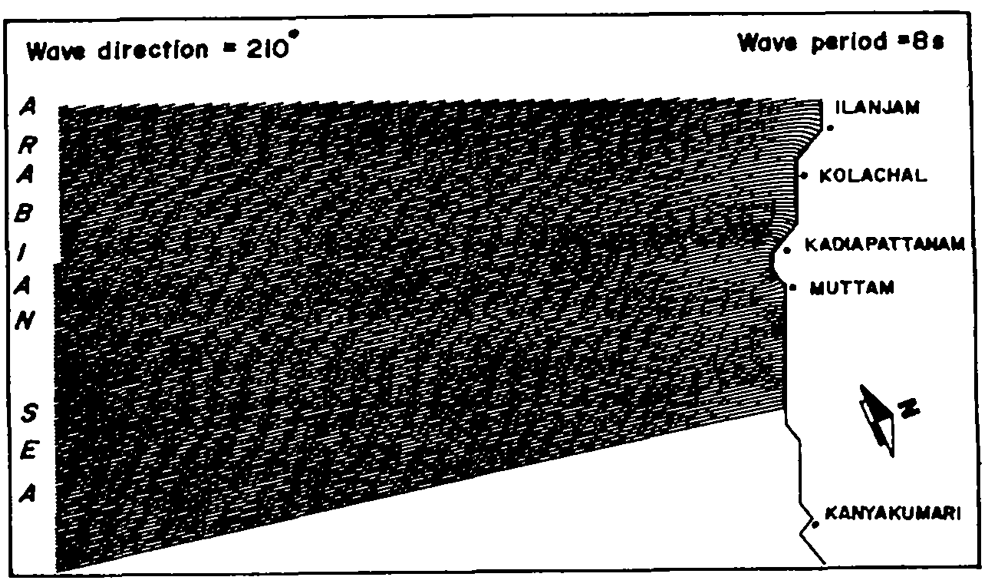

Fig.4 Wave refraction during SW monsoon

CONCLUSIONS

The net transport near Kolachel is in westerly direction, quite opposite to the general opinion among the Indian oceanographers that along the west coast of India till Kanyakumari, the annual net sediment transport is in southerly direction. There should be a region close to Trivandrum, which would behave as a nodal drift point and precisely break the continuity of the longshore sediment transport cell between the east and west coasts. The wave refraction study indicates that the waves tend to break almost parallel to the coast and it is found that there is no high convergence of wave energy in this region. The nearshore placer mining at Manavalakuruchi may add to the problem of erosion in this region. The present study indicated that the beaches near Kolachel is stable over the annual cycle. It is necessary to take up detailed studies particularly on the directional wave measurements close to this region.

Acknowledgements

Authors gratefully acknowledge the Director, NIO for encouragement. They also thank their colleagues for assistance during field studies.

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