ISSN (print): 1698-6180. ISSN (online): 1886-7995
www.ucm.es/info/estratig/journal.htm

Journal of Iberian Geology 36 (1) 2010: 39-54

Journal of Iberian Geology
AN INTERNATIONAL PUBLICATION OF EARTH SCIENCES

Monthly and seasonal variation in beach profile along the coast of Tiruchendur and Kanyakumari, Tamilnadu, India

Variaciones mensuales y estacionales del perfil de playa en la costa de Tiruchendur y Kanyakumari, Tamilnadu, India

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Received: 21/10/09 / Accepted: 16/01/10

Abstract

Beach profile survey has been carried out by the method described by Lafond and Prasada Rao (1954) and Emery (1961) between Tiruchendur and Kanyakumari beach, Tamilday, India. The average beach profile shapes in all stations are not identical. This is due to the large amount of sands that transported into the nearshore by longshore and cross-shore movement. In particular this difference is shown in the location of the high variability of heavy mineral distribution depicts the morphological changes. Record of monthly and seasonal beach profile obtained at the 10 beaches along the study area during the period between 2005 and 2006 yield an extensive dataset that could be used to determine the variations in the beach morphology and the processes responsible for the changes. Based on the beach profile measurements the changes were also critically examined and also the impact of intensive extraction of beach sand minerals along the beach profiles was investigated in order to know the morphological variation in the mining area.

Keywords: beach profile, sand volume analysis, morphology, waves, currents, India

Resumen

Se ha realizado el estudio del perfil de la playa entre Tiruchendur y Kanyakumari, Tamildau, India, siguiendo el método descrito por Lafond y Prasada Rao (1954) and Emery (1961). La media del perfil de la playa a lo largo del año no es la misma. Esto es debido a la gran cantidad de arenas transportadas hacia la costa mediante corrientes paralelas y transversales a la misma. En particular, esta diferencia se muestra en la alta variabilidad de distribución de minerales pesados en relación con los cambios morfológicos. El registro mensual y estacional de los cambios del perfil de la playa obtenido en 10 playas a lo largo de la zona de estudio durante el periodo comprendido entre 2005-2006 proporciona una información que podría ser utilizada para obtener la variación de las morfologías en las playas y las causas que lo producen. Los cambios en el perfil de la playa han sido también examinados en detalle en base a las medidas del perfil de la playa obtenidos, así como fue investigado el impacto producido por la intensiva extracción de minerales de la playa con el objetivo de conocer la variación de la morfología en la zona de actividad minera.

Palabras clave: perfil de costa, análisis del volumen de arena, morfología, olas, corriente, India

1. Introduction

During the past few decades, there has been increased interest in exploitation of heavy mineral placer in the coast of Tamilnadu, India. Monthly and seasonal changes in beach profile constitute an important aspect of the variability of the coastal environment in the coastal mining region. Researchers have recognized that beaches along the coast between Tiruchendur and Kanyakumari experienced a distinct cross-shore sediment transport due to the nature of coastal configuration and nearshore circulation. This has received considerable attention during the last decades in many parts of the world (Haq, 1997). Furthermore, if as is accepted by the majority of the scientific community, the increase in the world's temperature and the changing pattern of rainfall is due to Man's activities (Zhang *et al.*, 2007). Over the past few decades, many field efforts have substantially increased our understanding of the coastal environment and their driving forces specifically the studies done by Komar (1998) and Short (1999).

The morphology of a beach is mainly controlled by wave, climate, tide and sediment characteristics. An equilibrium beach results from a balance of destructive and constructive forces acting on the beach (Bagnold, 1940; Bascom, 1951; Bruun, 1954; Johnson, 1956; Strahler, 1966; King, 1972; Eliot and Clarke, 1988; Komar, 1998). Copper *et al.* (2000) suggested that beach profiles are an important tool for understanding the long-term trends of erosion, accretion and predicting the future evolution of coastal landforms. Inman *et al.* (1993) and Larson *et al.* (1999) divided a beach profile into two independent portions separated at the breaker point on realizing the fact that the forcing mechanisms landward and seaward of the breaker line area significantly different. However the state of our understanding with regards to seasonal variation and heavy mineral has lacked in quantification. An attempt has been made in this paper to establish the relation between the morphological changes in the profile responses to morphodynamic processes.

2. Study Area

The study area is located along the southern coast of Tamilnadu State, India (Fig. 1). It extends over a distance of 32.78 Km of the southeastern coastline borders of the Bengal Bay. The backshore of the beach is limited by urban infrastructures. The Mean Sea Level (MSL) is 2 m above the 0 m depth chart datum (CD). The local mean tidal range is 0.5 m and the maximum tidal level above CD is 1 m. The net longshore transport is directed to the north. The drainage pattern along the study area is controlled by minor streams like Palaiyar, Namiyar, Hanuman Nadhi and seasonal streams like Nilapparai channel and Puttanar channel. Cliffs are along the Kanyakumari coast which projects towards the Indian Ocean forming a promontory. Coastal areas of Rasthakadu and Kuttapuli have sandy beaches and some areas are rocky in nature. The study area includes a fishing harbor, mining sites, salt pans and other developmental projects like a power plant project in Kudankulam (Fig. 2). Break waters were also constructed long ago along the study area. Sand mining is also actively pursued along the coast (Figs. 3, 4a) and (Fig. 4a).

Chandrasekar and Immanuel (2005) insisted that the recent Indian Ocean Tsunami (26th December, 2004) induced sudden erosion unlike seasonal variations along the southeast coast of India. Sheik Mujabar *et al.* (2007) reported that the tsunami induced large amount of beach erosion along the study area. Angusamy (1998) made a panoramic classification of the beaches between Mandapam and Kanyakumari, Tamilnadu based upon the beach composition, beach gradient and beach configuration. Cherian (2003) reported both monthly and seasonal variation in beach profile along the coast between Valinokkam and Tuticorin, Tamilnadu. Chandrasekar *et al.* (2001) proposed that unsystematic garnet sand mining affected the beach morphology especially the littoral zone along the coast between Periyathalai and Navaladi, Tamilnadu.

3. Methodology

Beach profile surveys have been carried out using graduated poles and measuring tape as described by Lafond and Prasada Rao (1954) and Emery (1961). Beach profiling was carried out every month before the full moon day at the time of lowtide to beyond the low water level as far as wading depth (Fig. 4b). Beach morphology was monitored monthly for 12 months and seasonally

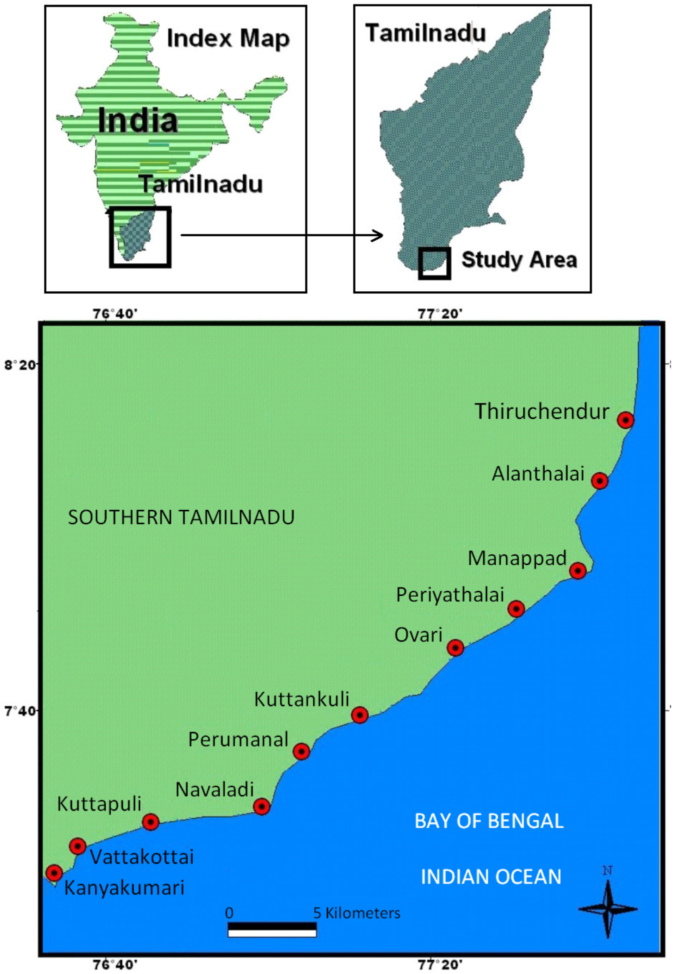

Fig. 1.- Location of the study area.
Fig. 1.- Localización del área de estudio.

from February 2005 to December 2006 at 10 locations selected in the study area. Altogether 876 surface samples were collected from dune (if present), backshore (berm), hightide zone (high water line), midtide zone and lowtide zone (low water line). From the data collected during these surveys, the monthly and seasonal beach profile variations are graphically represented to appreciate the variability in beach profile configuration. From these data, changes in the volume of sediments are calculated using a computer package to scrutinize the temporal variation.

4. Coastal geomorphology

The coastal geomorphology of the study area exhibits various landforms like beach ridges, swale, spit, sand dunes, mudflats, marine terrace and wave-cut platforms (Fig. 2). In the absence of any river input, well developed spit formation is noticed along Kanyakumari coast which proves the influence of northerly moving littoral currents. Well developed marine terraces are observed in Manappad and Kanyakumari. Headland is present in the coast of Thiruchendur, Manappad and Kanyakumari. On the basis of various dominant depositional landforms, the study area could be classified as depositional plain type or coast of prograding nature or emergent type.

5. Continental shelf morphology

The continental shelf and slope of India occupy an area of little less than a million km^2 shown in the Table 1.

Description	Shelf	Slope
Eastern shelf and slope	0-200 m	200-2000 m
Western shelf and slope	90,800 Km^2	79,200 Km^2
Andaman Nicobar	310,000 Km	163,000 Km
Andaman Nicobar (Shallow submerged platform and slopes of Island arc)	38,400 Km	118,800 Km
Laccadives (Shallow submerged platform and slopes of the ridge)	8,400 Km	101,200 Km
Total	447,600 Km	462,400 Km

Table. 1.- Continental shelf morphology of India.
Tabla. 1.- Morfología de la plataforma continental de la India

6. Shelf gradient

In the study region, prominent changes are observed in the bathymetry between Kanyakumari and Tuticorin (Table 2). The gradient with respect to the 20 m isobath is greater than that with the 50 m isobath (Cherian, 2003).

	Shore to 20 m	Shore to 50 m
Kanyakumari	1: 90	1: 756
Tuticorin	1: 1500	1: 900

Table.2.- Shelf gradient in the study area.
Tabla 2.- Gradiente de la plataforma en la zona de estudio.

In Kanyakumari the gradient is low due to the presence of Wadge bank while the same increases off Tuticorin. The shelf in the Gulf of Mannar shows increasingly irregular nature beyond 39 m. This irregular topography has a relief of 5 m. Bottom profiles, drawn using Echo sounder in the Gulf of Mannar, show shallow water (15.25 m) sand waves. The wave length of the sand waves is less and in the range around 250 m and wave height is greater in the deeper part which is of the order of 2000 m in wave

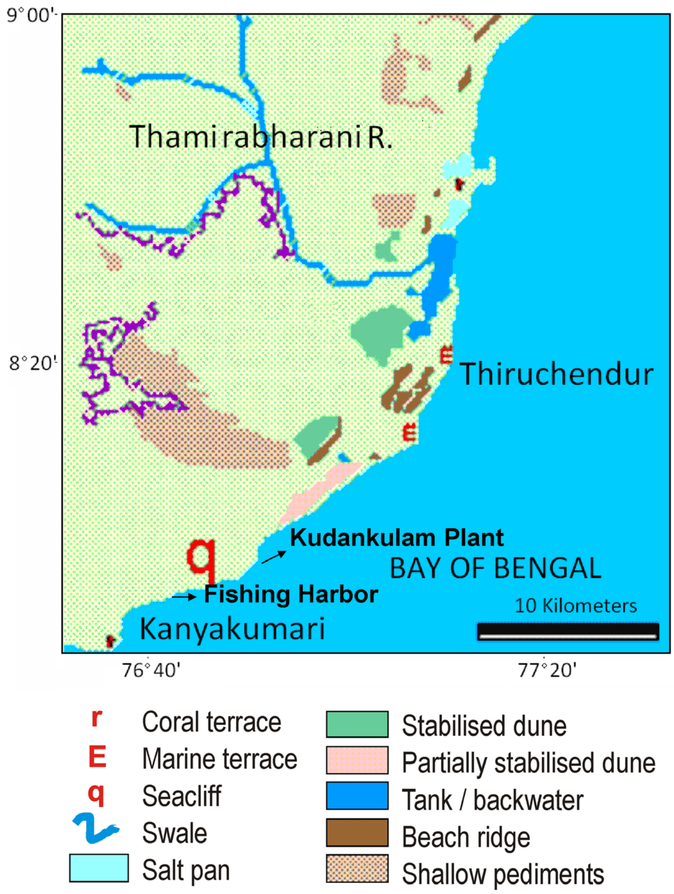

Fig. 2.- Coastal gemorphology along the study area.
Fig. 2.- Geomorfología a lo largo de la costa del área de estudio.

length. In the Kanyakumari – Tuticorin region, the silt percentage of 0.49-48.49%, (Av. 9.76) is less than 5%. However, off east of Kanyakumari there are 2 patches with higher percentages 48.49% and 30.5%. The general pattern of carbonate content varies from 6.95% to 94.47% with an average of 71.45%. The reduction in terrigenous contribution is reflected in the progressive increase of carbonate content.

The slope off the Eastern Indian Peninsula is steeper than that off the Ganges having inclination of 4-6^{o}. Palk Strait separating India and Sri Lanka is 75 km in width with water largely 9-13 m in depth, except where local coral reefs rise above this shallow floor, particularly to the NW near Adams Bridge (Katz, 1978). The sea basin is structurally a graben and it owes its origin to the breaking up of the Gondwana land and the subsequent drifting of Sri Lanka from the southeastern part of India. The narrow continental shelf bordering this graben of regional subsidence has provided the platform for the growth of corals. The chain of coral reefs appears to have originated as fringing reef during Pleistocene when there was a worldwide lowering of sea level (Naval Hydrographic Chart 262, 1976).

7. Shoreline configuration

In the study region, shoreline configuration appears to have been controlled and influenced by the predominant monsoonal wind directions of both NE and SW. Waves and longshore currents have also played an important role for shaping the shoreline. The shoreline of the study region displays a varying trend in E-W, N-S, NE-SW and NNE-SSW directions (Fig. 5).

7.1. NE -SW Direction

This part of the coast is higher than that of any other areas in Gulf of Mannar with undulating sand hills and the hinterland mostly of reddish soil. In due south, from Periyathalai to Vatakkottai the NE - SW trend is represented by minor zig-zag patterns at few places.

7.2. N -S Direction

The other direction of configuration is in N-S direction from Vembar - Tuticorin. Otherwise the N-S configuration is seen in the study area as a very narrow strip to fill up the gap developed between the two different configurations of NNE - SSW and NE - SW in places like Kanyakumari, Tuticorin, Navaladi and Valinokkam.

7.3. NNE - SSW Direction

The next prominent configuration is from Tuticorin - Manappad in the direction of NNE - SSW. The river

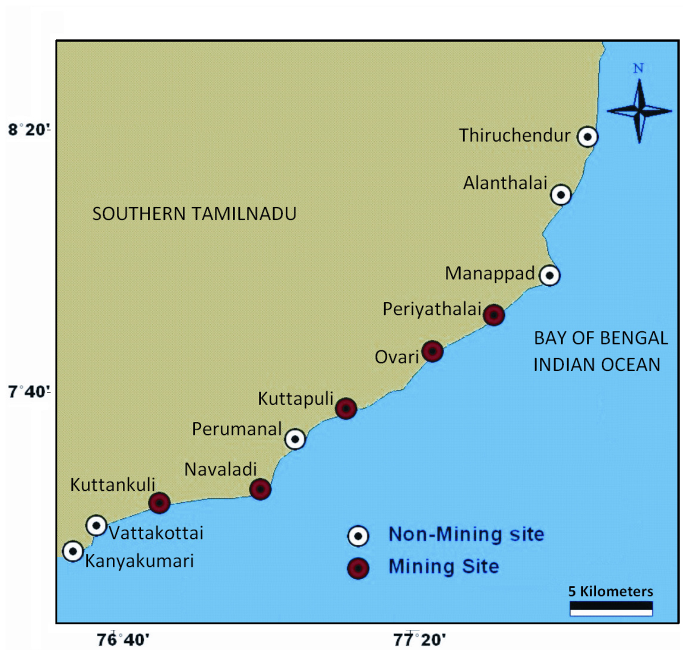

Fig. 3.- Mining and non-mining sites along the study area.
Fig. 3.- Zonas con uso y sin uso minero dentro del área de estudio.

mouth of Thamirabharani is indented with numerous creeks with a chain of backwaters running parallel to the coast. Thiruchendur is a low rocky headland projecting into the sea where, well developed marine terraces are exposed, depicting the events leading to the formations of Quaternary landform developments.

7.4. NE - SW Direction

From Vattakkottai - Kanyakumari, once again the coastal configuration reverts back to E-W direction and finally joins with west coast by showing a trend of N-S direction for a smaller distance. Various natural processes are found to prevail in the coastal segment between Vattakottai and Kanyakumari.

In short, major part of the study area is aligned in the direction of NE-SW. It is worth to note that economically viable heavy minerals are found to get segregated only in this configuration. It may probably due to the role played by the NE-SW monsoons.

8. Oceanographic parameters

The oceanography of the Indian continental region is dominated by three seasons viz., Southwest monsoon (June to September), northeast monsoon (October to January) and fair weather period (February to May). Southwest and northeast monsoons have equal impact along the southern part of the east coast. The currents are monsoonal in character. Away from the coast in the southern part of the region the predominant current is south-easterly from May to September (Southwest monsoon), the average rate being highest (about 0.5 knot) from June to August. The predominant current is west to south, and southwest with an average speed rate of 0.75 knot between December and January. Where as, the currents are variable in October and from February to April (Fig. 6). During the southwest monsoon, there is a branching towards the northeast from the northerly flank, and south-easterly flow across the entrance of the gulf. This continues as a northerly flow through the narrow channels connecting the northern gulf with Palk Strait. In December and January (NE monsoon), the flow is southward through these channels which implies mainly south westerly flow across the gulf, turning more westerly as it converges with the W to W.SW flow in the more open waters in the south. In Pamban, the current some times reaches 5-6 knots, making the passage difficult. The currents may, on occasion be markedly different from these conditions and rates up to 2 knots may occur with prolonged strong winds (Angusamy, 1995).

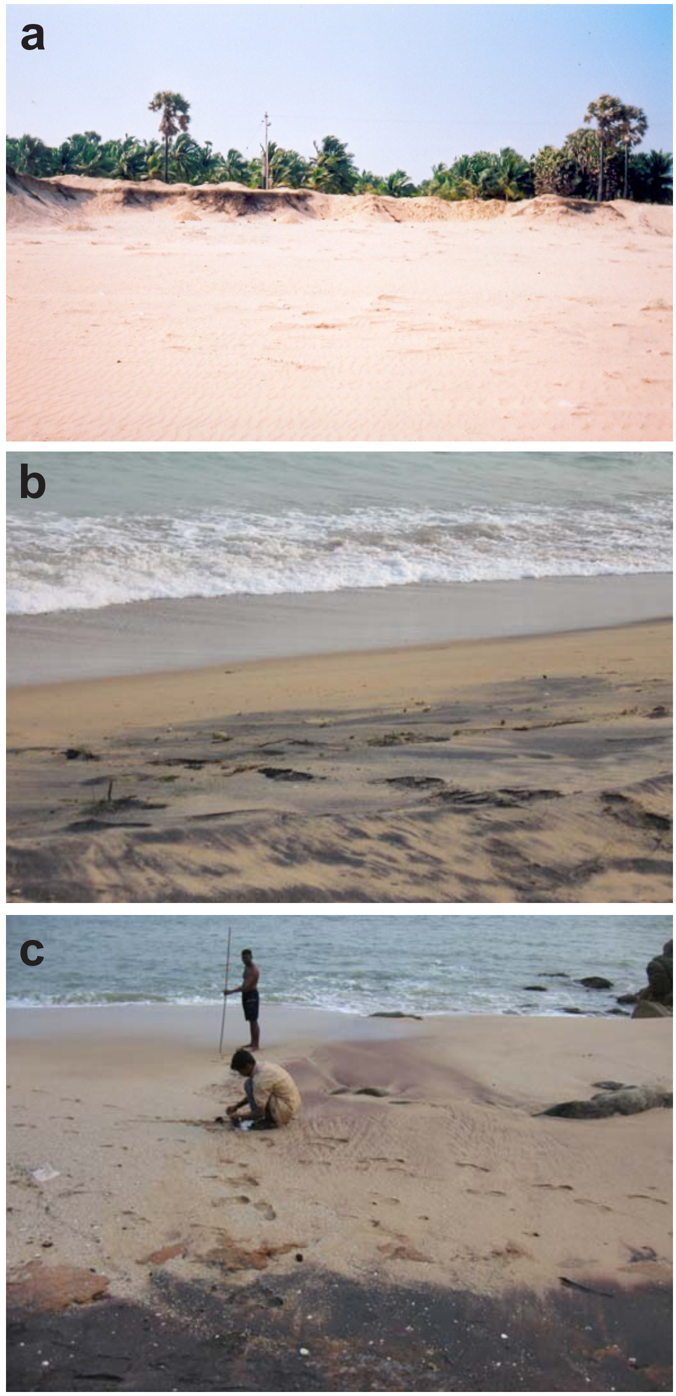

Fig. 4.- a: Morphology of the beach at Navaladi coast after placer mining. b: Beach slope configuration due to wave action. c: Beach profile survey along the study area.

Fig. 4.- a: Morfología de la playa en la costa de Navaladi después de la explotación minera. b: Configuración de la pendiente de la playa debido a la acción de las olas. c: Perfil de la playa en la zona de estudio.

Wind generated surface waves are the principal source of energy input into the littoral zone. They are responsible for the erosion of the coast and for the formation of depositional beach features. In the study region, wave parameters are controlled by the change in monsoonal

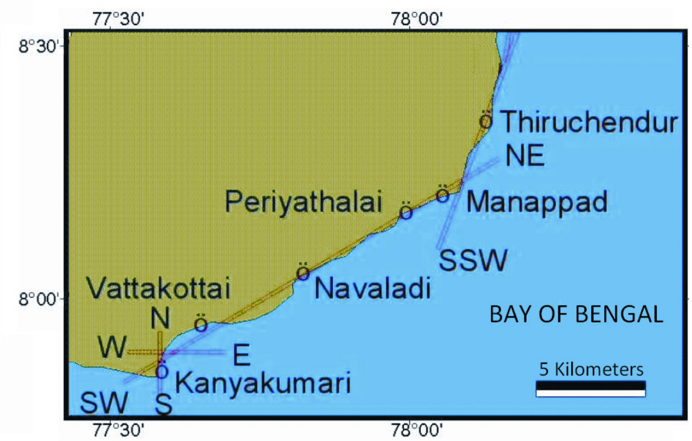

Fig. 5.- Shoreline configuration along the study area.
Fig. 5.- Configuración de la línea de costa en la zona de estudio.

cycle. Waves approach the coast in SE, S and NE direction with wave period varying from 5 sec to 15 sec. In NE monsoon, wave heights exceeding 2 m are observed. The predominant wave directions prevailing in the study regions are SE (45°) during SW monsoon and NW (270°) during the NE monsoon (Angusamy *et al.*, 1998).

In the study area, the salinity ranges from 33.4% to 35.28% during summer. From May to October salinity in the Gulf of Mannar and Palk Strait is increased (37%) because of the northward flowing currents from the Indian Ocean and Arabian Sea. Low salinity 23.9‰ is observed during December and January due to the mixing of freshwater and industrial discharge by the coastal flood in the NE monsoon.

9. Waves, currents and tides

As the waves, currents and tides contribute significantly in the redistribution of the sediments, supplied to the depositional basin, the rate of these oceanographic physical agents is discussed with sediment distribution and littoral transport in the study area. Waves are found to provide necessary energy for the movement of water and sediments within the nearshore zone. They govern the evolution of beaches that act as buffer zones for the impinging wave energy. The shape and size of these deposits, in turn, give rise to change in the incoming wave energy through changes in the nature of the wave breaking. When one considers the changes of this dynamic zone over a long time scale, the dominating effect of waves in deciding the orientation of this near elastic and energy absorbing zone becomes evident.

In order to define the shallow water wave climate, knowledge of the nature of propagation of waves into the shallow region is essential. As the deepwater waves approach the coast, a change in the wave height occurs because of changes in their velocity of propagation. This is known as the shoaling effect. Since the phase velocity is a function of depth in shallow water, when the wave front propagates over the bottom of variable bathymetry, the wave front bends and tries to get aligned to the bottom contours. This is known as the refraction of waves. Refraction causes convergence and divergence of wave energy along the wave crest. As the waveform finally approach the shore, the wave energy gets dissipated through shoaling, refraction, percolation and breaking. Much of this energy loss occurs due to the frictional effects. Knowledge of wave field is a pre-requisite to study the nearshore wave climate along any coastal environment (Fig. 4c)

Moni (1972), Murthy (1977), Prasannakumar and Murthy (1987), Chandramohan and Nayak (1991), Rajamanickam *et al.* (1986), Veerayya and Pankajashan *et al.* (1988) and Gujar (1996) have indicated from their studies along west coast of India that the predominant direction of waves in the area are from SW, W.SW, W and W.NW with periods ranging from 6 to 12 seconds. Anbarasu (1994), Chandrasekar (1992), Angusamy *et al.* (1998), Chandrasekar *et al.* (2001) have discussed about the wave refraction pattern and its role in the redistribution of sediments along the east coast of India.

The monthly longshore sediment transport rates estimated based on the monthly observations on breaking wave height, surf zone width and the longshore currents are presented in the Tables 3 to 6. The monthly volume of longshore sediment transport rates and directions are estimated for the coast at Kuttankuli, Vattakottai, Thiruchendur, Alanthalai, Manappad, Periyathalai, Ovari and Kanyakumari (Table 7). In general, the sediment transport is northerly during March to October and southerly during

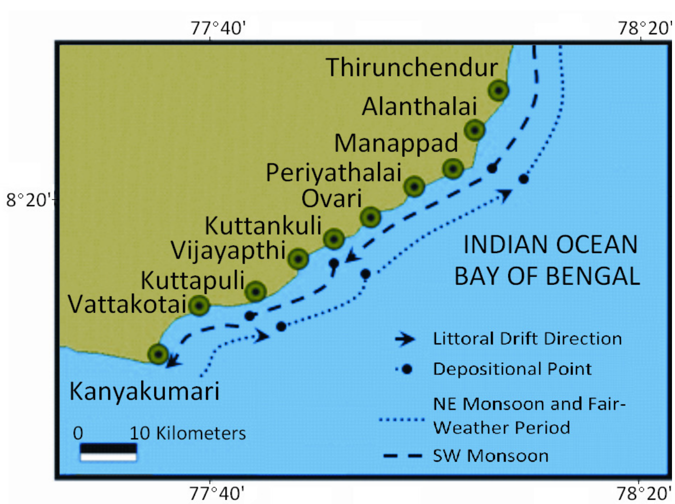

Fig. 6.- Longshore current direction along the study area.
Fig. 6.- Dirección de corriente costera en la zona de estudio.

Station	A	M	J	J	A	S	O	N	D	J	F	M
TUR	0.30	0.40	0.25	0.25	0.35	0.60	0.20	0.45	0.60	0.25	0.35	0.20
ALT	0.40	0.45	0.40	0.25	0.30	0.70	0.30	0.60	0.80	0.30	0.45	0.30
MNP	0.40	0.20	0.25	0.20	0.25	0.35	0.85	0.50	0.55	0.35	0.55	0.50
OVR	0.50	0.20	0.20	0.50	0.30	0.45	0.70	0.45	0.60	0.45	0.50	0.50
PERU	0.50	0.35	0.15	0.20	0.30	0.20	0.45	0.20	0.55	0.45	0.35	0.45
KUT	0.50	0.50	0.25	0.20	0.20	0.15	0.50	0.20	0.25	0.40	0.55	0.55
NAV	0.40	0.45	0.30	0.15	0.40	0.30	0.55	0.40	0.35	0.45	0.445	0.60
KUP	0.30	0.40	0.20	0.15	0.25	0.10	0.60	0.30	0.45	0.25	0.40	0.40
VAT	0.25	0.15	0.05	0.25	0.10	0.25	0.20	0.20	0.20	0.05	0.15	0.20
KAN	0.20	0.20	0.25	0.20	0.15	0.30	0.35	0.35	0.15	0.25	0.20	0.20

Table 3.- Monthly data of breaking wave height (HH) along the study area (m). TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari.

Tabla 3.- Datos mensuales de altura de ruptura de la ola (HH) en la zona de estudio (m). TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari.

Station	A	M	J	J	A	S	O	N	D	J	F	M
TUR	20	22	20	17	19	20	17	16	18	19	22	22
ALT	13	12	12	11	12	14	13	12	14	12	12	14
MNP	17	17	16	18	17	19	20	17	20	18	20	20
OVR	18	20	20	22	15	19	18	17	20	18	20	20
PERU	17	20	15	15	20	18	17	15	17	15	20	20
KUT	18	16	15	15	20	18	17	15	17	15	20	20
NAV	19	20	16	18	17	20	16	16	20	20	20	20
KUP	20	18	15	16	17	20	18	17	16	18	19	20
VAT	16	14	18	14	14	17	15	14	17	18	16	16
KAN	16	14	13	16	15	12	14	15	14	17	18	16

Table 4.- Monthly data of surf zone width (W) along the study area (m). TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari.

Tabla 4.- Datos mensuales de la anchura de la zona de rompiente de olas en la zona de estudio (m). TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari.

November to February. The longshore sediment transport is higher in the northerly direction as compared to southerly direction at all locations except Kanyakumari (Table 8).

10. Variation in Beach Profile

The monthly variation in the beach profiles along the study area is given in Table 9 a-j and shown in figure 7. Seasonal variation in beach profile is shown in figure 8. Record of monthly and seasonal beach profile obtained at the 10 beaches along the study area during the period between 2005 and 2006 yield an extensive dataset that could be used to determine the variations in the beach morphology and processes responsible for the changes.

The steep slope of the beach denotes long term erosion while the gentle slope point out gradual accretion. In general, these changes in beach profile configuration are related to the onshore-offshore transport of sand by waves. This onshore-offshore movement of sand was reflected in the beach morphology by the construction and destruction of the sub aerial berm growth and migration of near shore sand bars in the surf zone. The development of sand bar in the low water line during monsoon and pre-monsoon indicates the onshore-offshore sand transport.

Beach profiles respond to the overall physical energy imparted by waves and currents. There are essentially two general shapes assumed by the beach; a low energy, accretional profile and high energy erosional profile (Shepard, 1963). The accretional profile is characterised by a flat, gently landward sloping back-beach zone, a prominent berm, and a fairly steep foreshore zone. The erosional profile displays a nearly uniform and gently sloping, slightly concave upward profile (Fig. 4b).

Some suffer destruction in beach morphology due to mining and other anthropogenic activities and some are free from those eco-threatening aspects. The chief factors which determine the beach profile variation are the wave climate, coastal configuration, cross shore/long shore sediment transport and mining activities in particular. The unexpected event of Tsunami on 26th December 2004 modified the coastal land forms of various parts of Indian

Station	J	F	M	A	M	J	J	A	S	O	N	D
TUR	20	22	20	17	19	20	17	16	18	19	22	22
ALT	15	18	22	11	12	14	13	12	14	21	12	14
MNP	17	17	22	18	17	19	20	17	20	18	21	20
OVR	18	23	23	22	15	19	18	17	20	18	22	20
PERU	17	22	25	25	22	28	27	25	22	25	20	20
KUT	18	16	15	25	22	18	17	15	17	15	20	20
NAV	19	20	16	18	17	20	16	16	20	20	22	20
KUP	20	28	25	26	27	20	18	17	26	18	21	20
VAT	26	24	28	24	34	27	25	24	27	28	26	26
KAN	36	34	33	36	35	20	21	25	24	27	28	26

Table 5.- Monthly beach slope estimated along the study area. TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari.
Tabla 5.- Pendiente mensual de la playa estimada en el área de estudio. TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari.

Station	A	M	J	J	A	S	O	N	D	J	F	M
TUR	0.30	0.12	-0.10	-0.06	-0.28	-0.09	-0.07	-0.04	0.06	-0.13	0.06	0.08
ALT	0.31	-0.10	-0.09	-0.07	-0.21	-0.08	-0.07	-0.01	0.03	-0.11	0.04	0.04
MNP	0.39	0.02	-0.07	-0.04	-0.1	-0.07	-0.3	-0.4	0.05	-0.07	0.01	0.16
OVR	0.48	0.01	-0.16	-0.01	-0.18	-0.06	-0.36	-0.39	-0.43	-0.09	0.14	0.29
PERU	0.42	0.04	-0.20	-0.13	-0.26	-0.10	-0.29	-0.14	-0.34	-0.06	0.12	0.18
KUT	0.40	0.14	-0.21	-0.33	-0.24	-0.24	-0.30	-0.33	-0.33	-0.10	0.12	0.18
NAV	0.44	0.13	-0.20	-0.32	-0.22	-0.22	-0.30	-0.22	-0.32	-0.16	0.11	0.20
KUP	0.38	0.02	-0.23	-0.20	-0.23	-0.31	-0.26	-0.16	-0.32	-0.04	0.16	0.16
VAT	0.50	0.03	-0.05	-0.10	-0.01	-0.21	-0.31	-0.16	-0.30	-0.08	0.10	0.16
KAN	0.34	0.14	-0.04	-0.20	-0.07	-0.20	-0.30	-0.15	-0.30	-0.17	0.10	0.16

Table 6.- Monthly data of long shore current (V) along the study area (m/s). TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari. (-) Northerly direction (+) Southerly direction
Tabla 6.- Datos mensuales de las corrientes a lo largo de la costa (V) en el área de estudio (m/s). TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari. (+) dirección hacia el norte, (-) dirección hacia el sur..

coast. Few beaches like Kanyakumari and Vattakottai experienced the force of tsunami but due to their elevation and rocky exposure along the coastline.

11. Discussion

The beach morphology of Thiruchendur zone depicts a typical convex profile indicating the depositional activity prevailing in this coastal zone in almost every season. The wave climate and coastal configuration is such that the beaches in this zone experiences deposition especially during NE monsoon and the cross-shore sediment transport is predominantly towards the onshore. The beach gradient is gently sloping in all the beaches in this zone but for Alanthalai. In this latter one, the beach gradient is steeply sloping irrespective of season. This is may be ascribed to the strong wave convergence prevailing in this coastal zone creating a high wave energy condition. This leads to the intense erosion of sand from foreshore giving a concave beach profile. Thiruchendur beach displays a typical wave-cut bench during the NE monsoon particularly during the months of November and December due to sudden increase in the wave energy.

Except Periyathalai beach, all the other beaches of Periyathalai zone exhibit concave profile due to high wave energy condition and sand mining activities which leads to the intensive erosion. Even though, Periyathalai beach experiences high wave energy condition and intense sand mining, it displays a typical convex profile due to the accumulation of sediments by longshore drift in the coast due to its bay-like configuration in which the sediments are trapped by the headlands located on either side of this coast. The beach profile of Kanyakumari zone is typically different from other beaches of the study area. Due to mining and other anthropogenic activities the beach profile of most of the beaches in the zone is significantly altered. The beach morphology does not show any steady variation due to seasonal changes. All the beaches have narrow backshore and are devoid of dunes. The foreshore is steeply sloping indicating the high wave energy pre-

Beach	J	F	M	A	M	J	J	A	S	O	N	D
TUR	201.25	74.14	-44.48	-62.91	-43.21	-38.13	-143.00	-59.42	-69.9	-38.13	66.41	104.86
ALT	186.42	55.76	-47.66	-40.67	-88.55	-65.91	-139.82	-83.89	-112.7	-76.26	47.19	127.11
MNP	96.6	5.93	-43.85	-22.24	-42.63	-27.91	-123.92	-35.59	-129.75	-9.53	54.23	54.23
PET	132.4	3.81	-23.83	-5.29	-0.85	-38.92	-62.39	-33.9	-47.66	-3.6	14.3	25.42
OVA	95.33	25.2	-8.47	-42.37	-10.01	-397.2	-85.79	-52.83	-25.42	-22.96	21.18	25.42
KUT	111.64	-40.51	-30.5	-16.68	-56.72	-48.3	-11.12	-5.4	7.63	-17.48	9.53	10.17
VAT	200.19	11.86	-23.83	24.78	-82.61	-21.18	-73.72	-23.73	-158.46	-17.16	44.49	85.8
KAN	70.22	1.27	-1.27	-2.33	-0.95	-1.48	-41.31	-22.24	-14.83	1.59	6.67	26.69

Table 7.- Longshore sediment transport Rate (Q) (10^3 m^3/month) (2005). TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari.

Tabla 7.- Grado de transporte de sedimento a lo largo de la costa (Q) (10^3 m^3/mes) (2005), TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari.

vailing in this sector throughout the year. The beach gradient is moderate to steep slope.

11.1. Impact of mining on beach morphology

Mining has been taking place along the coast of Periyathalai, Ovari, Vijayapathi, Kuttapuli and Vattakottai since 1980. The extractions area mainly from the intertidal zone and also occur seaward along shore bar.

The seasonal beach profile reveals that erosion is prevailing in all the mining sites during SW monsoon. Beach profile analysis shows that the variability in cross-shore elevation pattern and volume change is prominent along the profile contour. The response of beach profile to garnet sand mining can be interpreted from geometric and volumetric comparison of beach profile data in the mining sites. The erosion/accretion pattern is mostly in foreshore and nearshore. Seasonal changes were examined by superimposed representative beach profiles of NE monsoon, SW monsoon at all beaches show erosion. The sand eroded from the upper berm and backshore of Vijayapathi and Kuttapuli is deposited across the mid to upper nearshore. The proportion of coastal erosion is intercepted by mining as sediments are returned to onshore. The post monsoon backshore accretion at Periyathalai is limited by sand mining and successive monsoon resulting in a net landward translation of the beach profile. This shows that the quantity of sand mined exceeds the rate of onshore sediment transport. Accretion occurs in all the mining sites during NE monsoon. A predictable post monsoon recovery is prevalent but in the context of coastal mining it is not the causative factor for replenishment.

During typical seasonal cycle exchange of sand that occurs between foreshore and offshore region with less sand in the subaerial part of the profile in the SW monsoon and more sand in the summer and NE monsoon. However if sand is removed from the upper berm and dune region then recovery can take place only through wind transported sands which promote buildup. Another probable cause of short and long term changes in beach topography is the differential longshore transport due to coastal mining. The onshore and offshore movement of sand is also reflected in the profile configuration by the constrction and destruction of sub-aerial berm, the growth and migration of nearshore bars in the surf zone at all the three stations. The volume of shoreward sediment translation is greater than that required to replenish the swash zone take by mining sand extracted from shallow nearshore that gets replenished by offshore transport of inner shelf sand (Chandrasekar *et al.*, 2001).

Beach	South	North	Net	Annual Gross
TUR	446.67	-499.21	-52.53	945.88
ALT	416.48	-659.47	-242.99	1076
MNP	210.99	-435.44	-224.44	646.44
PET	175.93	-195.029	-19.09	370.96
OVA	167.14	-287.579	-120.43	454.72
KUT	138.97	-226.72	-87.75	365.7
VAT	342.34	-425.49	-83.14	767.83
KAN	106.45	-84.42	22.03	190.87

Table 8.- Seasonal and annual sediment transport rate (Q). TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari.

Tabla 8.- Grado de transporte anual de sedimento a lo largo de la costa (Q). TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari.

11.2. Beach sand volume change

The monthly beach sand volume change was calculated from the beach profile data using a computer

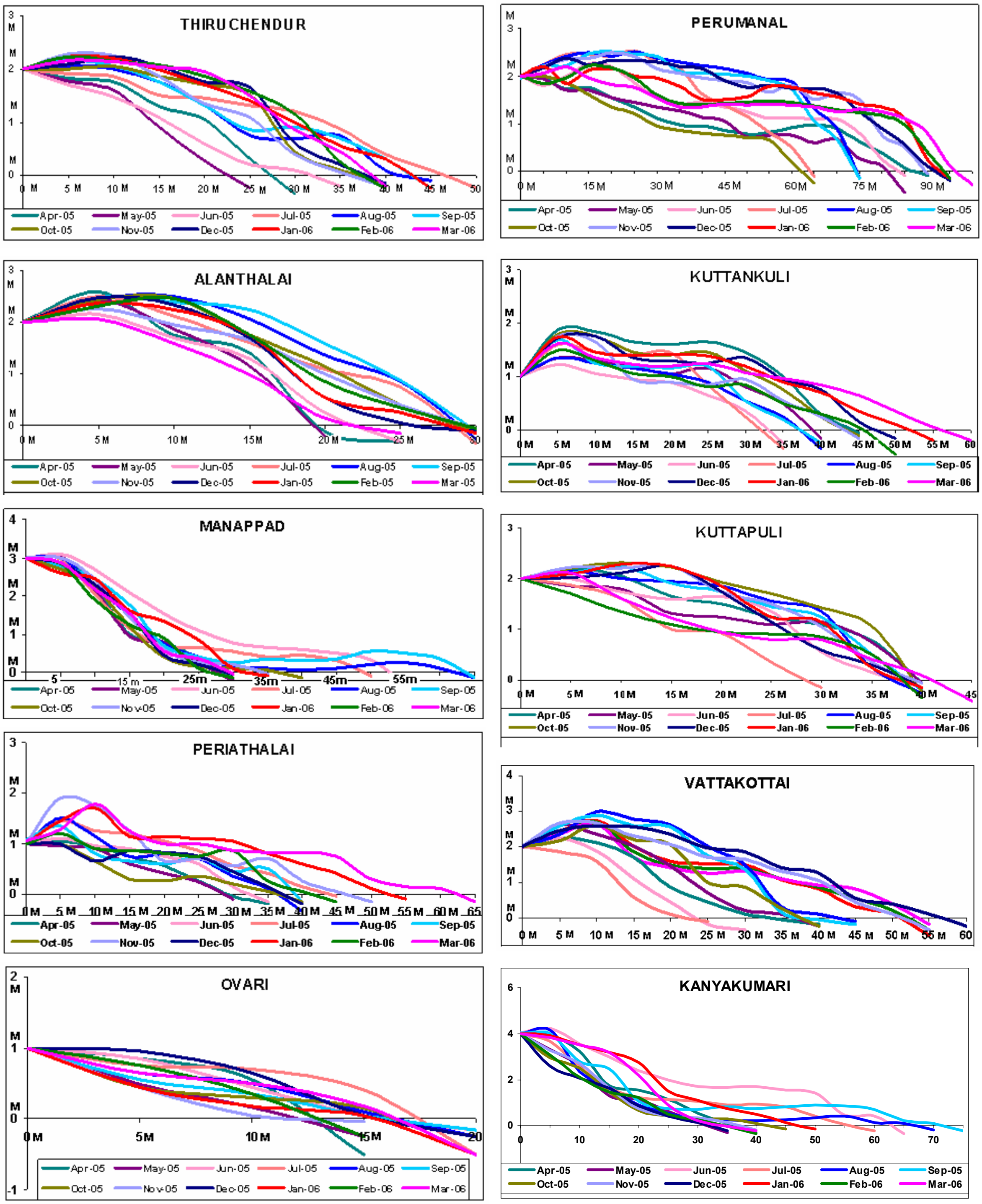

Fig. 7.- Monthly variation in beach profile along the study area. X-axis indicates distance from the reference point (m); Y-axis indicates elevation point (m).

Fig. 7.- Variación mensual del perfil de la playa en la zona de estudio. El eje X indica la distancia desde el punto de referencia (m); el eje Y indica el punto de elevación (m).

package namely Beach Profile Analysis developed by Chandrasekar and Sheik (2009). Table. 10 shows the monthly beach sand volume change along the study area. Thiruchendur beach experiences accretion during the period from January to March. Remaining all the other period it undergoes erosion. Alanthalai beach experiences accretion during the months of February, April, June, September, November, and December. The northward transport is controlling the nature of sediment deposition. The shape of profile is here highly influence by the

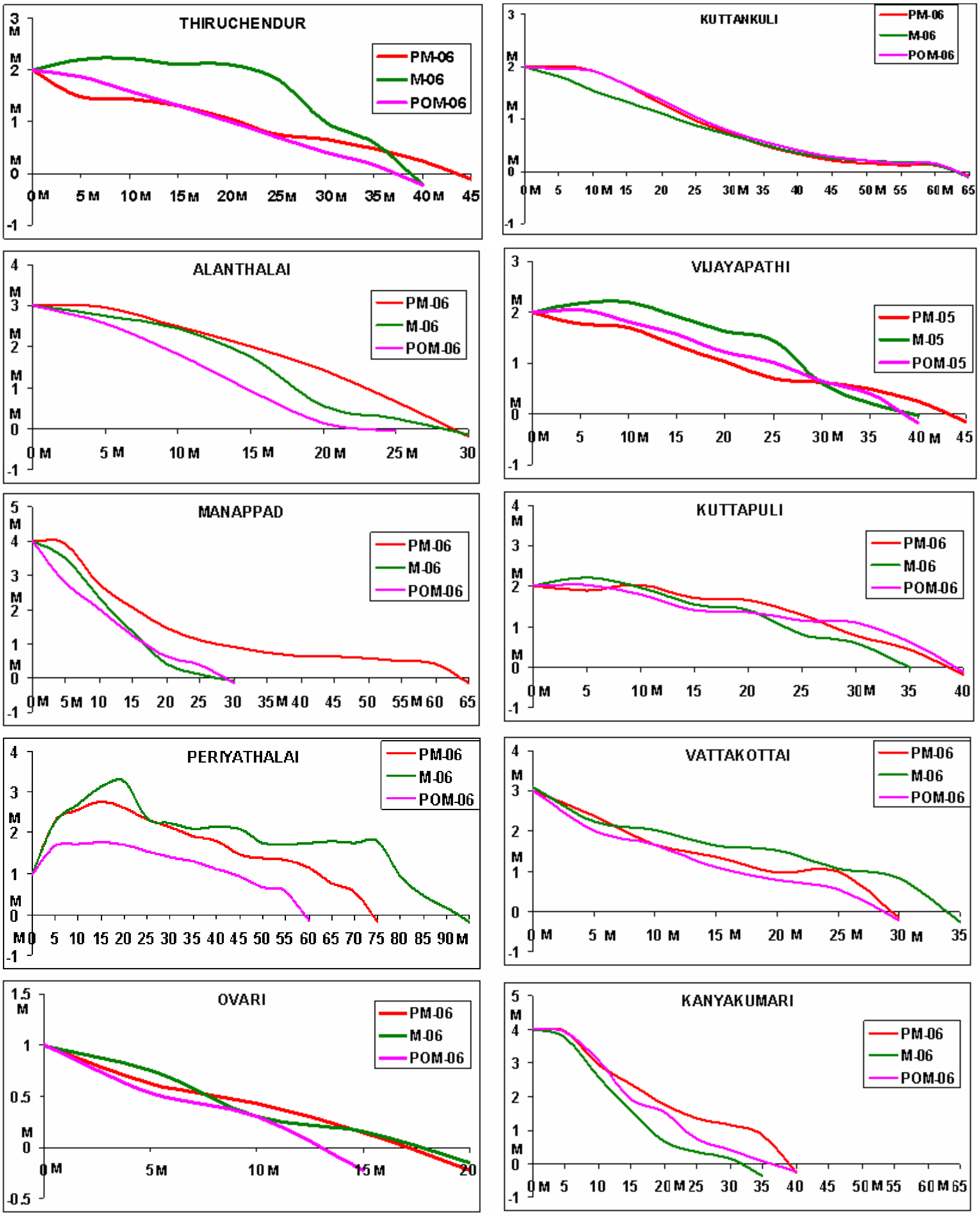

Fig. 8.- Seasonal variation in beach profile along the study area. X-axis indicates distance from the reference point (m); Y-axis indicates elevation point (m). (PM-Pre Monsoon, M-Monsoon, POM-Post Monsoon).

Fig. 8.- Variación estacional del perfil de la playa en la zona de estudio. X-axis indicates distance from the reference point (m); Y-axis indicates elevation point (m). (PM: Premonzón, M: Monzón, POM: Postmonzón).

local hydrodynamic of the coastal configuration, where the other currents different from wave induced play an important role in the process of sediment accretion. The Alanthalai beach configuration is cusbatic in nature. This change in coastal configuration is characterized by decrease of northward longshore transport both in seasonal and monthly. Where as reversal in the sediment transport is also notice during northeast monsoon period. Further, the beach is bounded by the existing of several submerged beach rock both in high and low tide areas. Table.8

a. IRUCHENDUR

Apr-05 RP	May-05 RP	Jun-05 RP	Jul-05 RP	Aug-05 RP	Sep-05 RP	Oct-05 RP	Nov-05 RP	Dec-05 RP	Jan-06 RP	Feb-06 RP	Mar-06 RP	PM-06 RP	M-06 RP	POM-06 RP
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1.65	1.45	0.6	1.6	2.05	2.15	2	2.08	2.3	2.17	2.19	2.24	1.49	2.55	1.88
1.05	1.15	0.5	1.65	2	2.05	2.05	2.12	2.35	2.11	2.2	2.2	1.45	2.5	1.59
0.9	0.55	0.35	1.5	1.75	1.75	1.85	1.85	2.05	2.08	2.16	2.08	1.32	2.45	1.32
0.45	0.05	0.15	1.55	1.3	1.3	1.7	1.35	1.75	2.12	1.85	2.02	1.08	2.2	1.03
0.3	-0.25	0.2	1.3	0.75	0.85	1.5	1.25	1.65	1.55	1.8	1.8	0.77	1.9	0.71
-0.35		0.1	1.2	0.7	0.9	0.45	0.4	0.6	1	1.15	0.85	0.66	1	0.41
		-0.2	1	0.75	0.7	0.1	0.05	0.2	0.55	0.25	0.45	0.47	0.6	0.17
			0.4	0.1	0.3	-0.15	-0.2	-0.15	0.3	-0.25	-0.2	0.25	-0.2	-0.23
			0.1	-0.1	-0.25				-0.25			-0.12		
			-0.25											

b. ALANTHALAI

Apr-05 RP	May-05 RP	Jun-05 RP	Jul-05 RP	Aug-05 RP	Sep-05 RP	Oct-05 RP	Nov-05 RP	Dec-05 RP	Jan-06 RP	Feb-06 RP	Mar-06 RP	PM-06 RP	M-06 RP	POM-06 RP
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3.27	2.7	2.15	2.5	3.35	3.55	2.7	2.25	2.9	2.75	2.9	2.05	2.96	2.75	2.55875
1.75	1.85	1.55	2.25	2.5	3.15	2.45	2.1	2.45	2.45	2.6	1.35	2.50625	2.45	1.82375
1.4	0.5	1.3	1.6	2.05	2.65	1.75	1.65	1.7	1.75	1.75	0.75	2.00625	1.75	0.93125
-0.1	-0.2	0.25	1.1	1.75	2.25	1.15	1	0.55	0.55	0.85	0.15	1.4325	0.55	0.1425
-0.3		-0.3	0.75	0.85	1.35	0.4	0.4	0.05	0.25	0.35	-0.15	0.6625	0.25	-0.055
			-0.35	-0.25	-0.1	-0.1	-0.05	-0.1	-0.15	-0.05		-0.2	-0.15	

c. MANAPPAD

Apr-05 RP	May-05 RP	Jun-05 RP	Jul-05 RP	Aug-05 RP	Sep-05 RP	Oct-05 RP	Nov-05 RP	Dec-05 RP	Jan-06 RP	Feb-06 RP	Mar-06 RP	PM-06 RP	M-06 RP	POM-06 RP
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3.2	3.05	3.7	4.05	4	4.15	2.7	3	2.85	3.5	2.85	2.87	3.93	3.5	3.00
2.25	2.15	2.8	2.05	2.25	2.45	2.25	2.45	2.3	2.6	1.9	2.17	2.35	2.35	2.10
1	0.95	2.25	1.15	1.5	1.75	1.2	1.45	1.55	1.6	1.25	1.35	1.60	1.35	1.14
0.8	0.8	1.65	0.7	0.75	0.7	0.4	0.6	0.45	1.35	0.9	0.55	0.95	0.4	0.76
0.35	0.25	1.25	0.65	0.4	0.4	0.15	0.25	0.2	0.85	0.1	0.35	0.65	0.1	0.31
-0.15	-0.2	0.95	0.55	0.15	0.25	0.1	0.2	-0.05	0.1	-0.15	-0.05	0.51	-0.1	-0.12
		0.9	0.4	0.1	0.35	0.05	-0.05		-0.1			0.49		
		0.95	0.45	0.05	0.3	-0.15						0.49		
		0.8	0.3	0.1	0.35							0.41		
		0.65	-0.1	0.2	0.55							0.33		
		-0.3		0.25	0.5							0.17		
				0.1	0.35							0.19		
				-0.15	-0.15							-0.14		

Table 9.- Monthly and seasonal beach profile data along the study area. PM-Pre Monsoon, M-Monsoon, POM-Post Monsoon, Rp- Reference Point. Note: This table continues in the next two pages.

Tabla 9.- Datos mensuales y estacionales del perfil de la playa en la zona de estudio. PM: Premonzón, M: Monzón, POM: Postmonzón, RP-Punto de Referencia. Nota: esta tabla continúa en las dos páginas siguientes..

clearly quantify the nature of erosion and accretion with reference to the wave height and increase angle between wave direction and profile orientation up to value of 45 degrees (Chandrasekar *et al.*, 2001).

Erosion prevails in all the remaining months in this beach. At Manappad beach, accretion happens during the months from August to October 2005 and from July to September 2006. In the remaining all the other seasons show erosion of sand. Periyathalai beach exhibits accretion during August and December. Remaining all the other months undergoes erosion. Except in the month of May, Ovari beach experiences accretion significantly in all the other period. Kuttankuli beach experiences erosion invariably in all the months. Except the monsoon season, Vijayapathi beach undergoes erosion in all the other seasons. Kuttapuli beach shows accretion during the period from September to December and erosion in all the other seasons. During the months of August, September, October and December, Vattakottai beach undergoes erosion. Kanyakumari beach shows accretion invariably in all the seasons which may be attributed to the fact that the study site in that beach falls on the updrift side of the groins.

Currents are monsoonal in character. The currents are variable with respect to monsoonal climate. During SW monsoon (May-October) the currents are branching towards the NE from south easterly direction that flows is southward which implies mainly southwesterly flow of currents across the study area. It was less during the

d. PERIYATHALAI

Apr-05 RP	May-05 RP	Jun-05 RP	Jul-05 RP	Aug-05 RP	Sep-05 RP	Oct-05 RP	Nov-05 RP	Dec-05 RP	Jan-06 RP	Feb-06 RP	Mar-06 RP	PM-06 RP	M-06 RP	POM-06 RP
1	1	1	1	1	1	1	1	1	1	1	1	1.85	2.15	1.26
1.05	0.95	1.3	2.45	2.55	2.4	1.25	2.2	2.35	1.57	1.43	1.55	2.29	2.27	1.69
1.72	1.6	2	2.95	2.95	2.75	1.85	2.65	2.8	1.83	1.96	2.35	2.56	2.7	1.74
1.75	1.7	2.25	2.88	3.25	3.05	1.6	3.2	3.25	2.4	2.22	2.3	2.78	3.15	1.79
1.55	1.55	2.2	3.11	3	2.9	1	3.25	3.35	2.55	2.17	2.05	2.61	3.25	1.70
1.35	1.45	1.85	2.93	2.6	2.45	1.05	2.4	2.55	2.4	1.95	1.75	2.33	2.35	1.55
1.11	1.2	1.55	2.48	2.5	2.4	0.9	2.15	2.3	1.95	1.61	1.52	2.16	2.25	1.40
0.97	1.1	1.4	2.17	2.3	2.1	0.85	2.05	2.25	1.77	1.43	1.35	1.91	2.1	1.32
0.95	1.05	1.45	1.62	2.35	2.05	0.8	1.95	2.15	1.73	1.41	1.35	1.80	2.15	1.10
0.85	0.8	1.35	1.22	2.15	2.03	0.75	1.9	1.9	1.72	1.43	1.4	1.49	2.1	0.95
0.77	0.72	1.25	0.92	2.25	2	0.8	1.85	1.75	1.75	1.44	1.39	1.67	1.75	0.66
0.82	0.75	1.1	0.38	2.35	2.1	0.65	2.05	1.8	1.77	1.46	1.4	1.60	1.7	0.57
0.91	0.75	1.1	-0.05	2.05	1.9	0.1	1.8	1.9	1.75	1.44	1.38	1.30	1.75	-0.15
0.97	0.79	1.08	-0.2	1.3	1.05	-0.25	1.95	2.05	1.65	1.37	1.35	0.75	1.8	
0.9	0.67	1.08		0.9	0.7		2	2.1	1.57	1.28	1.25	0.81	1.75	
0.62	0.45	0.8		-0.15	-0.15		1.85	1.95	1.4	1.22	1.3	-0.16	1.8	
0.37	0.1	0.25					0.75	0.9	1.35	1.17	1.25		0.95	
0.07	-0.45	-0.1					0.5	0.55	1.1	0.97	1.1		0.45	
-0.1							-0.05	0.1	0.25	0.4	0.8		0.15	
								-0.2	-0.15	-0.15	0.1		-0.2	
											-0.3			

e. OVARI

Apr-05 RP	May-05 RP	Jun-05 RP	Jul-05 RP	Aug-05 RP	Sep-05 RP	Oct-05 RP	Nov-05 RP	Dec-05 RP	Jan-06 RP	Feb-06 RP	Mar-06 RP	PM-06 RP	M-06 RP	POM-06 RP
1	1	1	1	1	1	1	1	1	1	1	1	1.00	1	1.00
0.85	0.3	0.85	0.85	0.65	0.55	0.45	0.45	0.95	0.45	0.75	0.65	0.62	0.75	0.54
0.55	0.16	0.45	0.7	0.5	0.35	0.3	0.05	0.65	0.18	0.35	0.5	0.43	0.3	0.31
-0.5	-0.25	0.05	0.4	0.1	0.05	0.15	-0.035	0.05	0.05	-0.25	0.18	0.14	0.15	-0.22
		-0.15	-0.5	-0.25	-0.15	-0.5		-0.25	-0.5		-0.5	-0.22	-0.15	

f. KUTTANKULI

Apr-05 RP	May-05 RP	Jun-05 RP	Jul-05 RP	Aug-05 RP	Sep-05 RP	Oct-05 RP	Nov-05 RP	Dec-05 RP	Jan-06 RP	Feb-06 RP	Mar-06 RP	PM-06 RP	M-06 RP	POM-06 RP
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1.96	1.98	1.99	1.96	2.04	2.02	1.92	1.62	1.64	2.06	1.99	1.9	2.04	1.92	1.98
1.93	1.91	1.92	1.88	1.96	1.92	1.39	1.31	1.39	2.04	1.93	1.92	1.96	1.39	1.93
1.62	1.69	1.56	1.51	1.72	1.8	1.32	1.07	1.12	1.76	1.62	1.58	1.72	1.32	1.71
1.26	1.42	1.21	1.16	1.39	1.42	1.2	0.86	0.89	1.46	1.39	1.24	1.39	1.2	1.37
0.96	1.04	0.92	0.78	1.05	1.12	0.92	0.66	0.7	1.18	1.1	0.99	1.05	0.92	1.03
0.78	0.8	0.64	0.59	0.8	0.9	0.84	0.49	0.52	0.91	0.79	0.78	0.8	0.84	0.7
0.6	0.55	0.43	0.33	0.59	0.62	0.64	0.41	0.33	0.64	0.56	0.61	0.59	0.64	0.57
0.43	0.36	0.24	0.19	0.42	0.48	0.49	0.34	0.15	0.44	0.44	0.42	0.42	0.49	0.39
0.31	0.22	0.16	0.05	0.28	0.32	0.34	0.28	0.06	0.29	0.31	0.33	0.28	0.34	0.24
0.24	0.16	0.09	0.04	0.2	0.25	0.36	0.21	0.09	0.16	0.23	0.26	0.2	0.36	0.18
0.2	0.1	0.12	0.02	0.15	0.18	0.26	0.18	0.1	0.14	0.2	0.21	0.15	0.26	0.13
0.16	0.12	0.08	0.01	0.17	0.19	0.18	0.19	0.03	0.15	0.15	0.18	0.17	0.18	0.15
-0.13	-0.08	-0.03	-0.05	-0.12	-0.14	-0.15	-0.13	-0.11	-0.1	-0.12	-0.12	-0.15	-0.1	

g. VIJAYAPATHI

Apr-05 RP	May-05 RP	Jun-05 RP	Jul-05 RP	Aug-05 RP	Sep-05 RP	Oct-05 RP	Nov-05 RP	Dec-05 RP	Jan-06 RP	Feb-06 RP	Mar-06 RP	PM-06 RP	M-06 RP	POM-06 RP
2	2	2	2	2	2	2	2	2	2	2	2	2.00	2.00	2.00
1.85	1.65	1.44	1.55	1.9	2.25	2.1	2.36	2.15	2.15	2.31	2.4	1.44	2.70	1.96
1.25	1.35	1.2	1.6	1.85	2.15	2.15	2.35	2.2	2.1	2.29	2.35	1.37	2.65	1.69
1.1	0.75	0.63	1.35	1.6	1.85	1.85	1.95	1.9	2	2.16	2.25	1.19	2.60	1.41
0.65	0.25	0.23	1.4	1.15	1.4	1.7	1.5	1.6	1.75	1.95	2.04	1.03	2.30	1.08
0.5	-0.05	0.15	1.15	0.65	0.9	1.5	1.45	1.5	1.35	1.85	1.75	0.65	2.00	0.73
-0.15		-0.05	1.05	0.6	0.95	0.45	0.6	0.55	0.85	1.3	0.8	0.46	1.10	-0.10
		-0.25	0.85	0.65	0.75	0.1	0.15	0.15	0.5	0.4	0.4	0.30	0.70	
			0.35	0.1	0.35	-0.15	-0.05	-0.2	0.3	-0.1	-0.25	0.08	-0.20	
			-0.05	-0.2	-0.2				-0.2			-0.15		
			-0.3											

Table 9.- (Cont.).
Tabla 9.- (Cont.).

h. KUTTAPULI

Apr-05 RP	May-05 RP	Jun-05 RP	Jul-05 RP	Aug-05 RP	Sep-05 RP	Oct-05 RP	Nov-05 RP	Dec-05 RP	Jan-06 RP	Feb-06 RP	Mar-06 RP	PM-06 RP	M-06 RP	POM-06 RP
2	2	2	2	2	2	2	2	2	2	2	2	2.00	2.4	2.00
2.2	1.85	2	1.87	2.27	2.34	2.22	2.47	2.32	2.45	1.64	2.12	1.90	3.15	2.02
2.05	1.8	1.75	1.62	2.19	2.25	2.3	2.38	2.12	2.32	1.35	1.62	2.03	3	1.79
1.65	1.32	1.6	1	1.95	1.9	2	2.25	2.08	2.16	1	1.22	1.70	2.2	1.41
1.5	1.25	1.65	0.93	1.85	1.75	1.77	1.75	1.75	1.85	0.95	0.95	1.66	1.4	1.36
1.25	1.1	1.35	0.35	1.55	1.45	1.6	1.5	1.15	1.25	0.9	0.8	1.30	0.8	1.14
1.1	1.15	0.55	-0.15	1.35	1.25	1.33	1.05	0.6	1.15	0.85	0.8	0.79	0.6	1.10
0.77	0.75	0.15		0.25	0.5	0.74	0.35	0.3	0.25	0.5	0.4	0.44	-0.01	0.62
-0.05	-0.05	-0.15		-0.25	-0.2	-0.22	-0.05	-0.15	-0.15	-0.35	0.1	-0.18		-0.11
											-0.4			

i. VATTAKOTTAI

Apr-05 RP	May-05 RP	Jun-05 RP	Jul-05 RP	Aug-05 RP	Sep-05 RP	Oct-05 RP	Nov-05 RP	Dec-05 RP	Jan-06 RP	Feb-06 RP	Mar-06 RP	PM-06 RP	M-06 RP	POM-06 RP
2	2	2	2	2	2	2	2	2	2	2	2	2.14	2.00	2.00
2.25	2.42	2.25	2.1	2.33	2.28	2.4	2.39	2.51	2.42	2.38	2.35	3.00	2.96	3.00
1.75	2.15	1.65	1.43	2.52	2.48	2.45	2.26	2.4	2.51	2.57	2.36	2.38	3.10	2.01
1.7	2	1.1	0.99	2.44	2.39	2.2	2.3	2.55	2	1.85	1.7	1.65	2.25	1.67
0.85	1.45	0.45	0.23	2.26	2.24	2.05	2.05	2.35	1.6	1.5	1.4	1.37	2.03	1.11
0.45	0.7	-0.2	-0.1	2	1.75	1	1.7	1.95	1.52	1.38	1.25	0.96	1.63	0.77
0.1	0.2	-0.35		1.5	1.35	0.85	1.65	1.85	1.48	1.39	1.3	0.98	1.52	0.56
-0.05	0.1			0.3	0.15	0.25	1.3	1.4	1.08	1.09	1.1	-0.14	1.05	-0.21
-0.2	-0.25			0.1	-0.05	-0.25	1.05	1.25	0.8	0.85	0.9		0.84	
				-0.1	-0.2		0.45	0.55	0.3	0.55	0.8		-0.25	
							0.1	0.4	0.1	0.2	0.4			
							-0.35	0.1	-0.5	-0.35	-0.2			
								-0.25						

j. KANYAKUMARI

Apr-05 RP	May-05 RP	Jun-05 RP	Jul-05 RP	Aug-05 RP	Sep-05 RP	Oct-05 RP	Nov-05 RP	Dec-05 RP	Jan-06 RP	Feb-06 RP	Mar-06 RP	PM-06 RP	M-06 RP	POM-06 RP
4	4	4	4	4	4	4	4	4	4	4	4	4	**4**	4
3.95	3.3	3.71	3.52	4.15	3.84	2.95	3.25	2.6	4.16	3.05	4.03	3.96	3.75	3.93
3	2.6	3.55	2.55	2.35	2.8	2.5	2.7	2.05	3.88	2.1	3.74	2.96	2.6	3.10
1.75	1.3	3	1.65	1.65	2.1	1.45	1.6	1.6	3.55	1.45	3.2	2.38	1.6	1.94
1.55	1.15	2.4	1.2	0.9	1.05	0.65	0.75	0.85	2.9	1.2	2.2	1.77	0.65	1.54
1.15	0.6	2	1.15	0.55	0.75	0.4	0.4	0.4	1.5	0.5	0.9	1.35	0.35	0.75
0.55	0.15	1.7	1.05	0.3	0.7	0.25	0.35	0.15	1.1	0.25	0.2	1.15	0.15	0.40
-0.19	-0.3	-0.14	-0.27	-0.22	-0.27	-0.17	-0.27	-0.25	-0.27	-0.05	-0.19	0.85	-0.36	0.07
												-0.25		-0.23

Table 9.- (Cont.).
Tabla 9.- (Cont.).

SW monsoon (June to October) and fair weather (March to May) conditions. Its direction is northerly during fair weather and SW monsoon seasons whereas towards southerly during NE monsoon period. Current affecting the coast is mainly longshore current. Prevailing south westerly wind produce large powerful swell waves which approach the coastline from the south west direction. The wave breaks obliquely on the southern most tip of the coast there by generating longshore currents and consequently produce high energy environment. Chandrasekar (2007) measured the current range from 0.15 m/sec to 0.85m/sec. Rip currents are strong along the barrier islands of the area where plumes of sediments perpendicular to coast can be observed.

12. Conclusions

Along the coast between Thiruchendur and Kanyakumari, large quantities of garnet deposits are being extracted. In order to understand the impact of garnet mineral extraction, beach profiling was carried out to know the morphological variation of these beaches in the mining area. The mining of beach sand has disturbed the stability of beaches. The beach profile deviates from the actual profile in the extraction area. The profile is smooth in the non-mining area whereas the mining area represents the formation of ridges and runnels.

The sediments in the mining area is very fine than the non-mining area. It indicates that the profile is not an equi-

STA-TIONS	Apr-05	May-05	June-05	July-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	Feb-06	Mar-06	PM-06	M-06	POM-06
TUR	-25	-35.25	-49.63	-0.78	-12.45	-5.62	-0.92	6.06	-8.18	5.08	8.03	-19.23	-3.84	-19.82
ALT	1.63	-13.12	-11.12	3.4	14.55	-6.11	-0.07	-3.45	6.19	2.1	-15.71	4.03	0.56	-8.20
MNP	-20.42	-22.36	25.77	5.6	11.61	0.29	-11.49	-7.1	-15.86	-13.79	-14.79	11.48	-13.44	-16.65
PET	-66.07	-114.16	-80.91	-43.31	14.17	-40.1	-99.69	-58.06	13.02	-9.38	-46.71	-39.05	-45.15	-74.62
OVA	4.89	-0.16	7.34	12.51	7.83	3.34	6.29	1.07	12.21	3.82	3.71	6.40	4.50	2.34
KUT	-3	-3.3	-9.5	-15.3	-2.8	-0.7	-10.2	-24.3	-4.4	-2.6	-5	-18.50	-26.70	-15.10
VJP	-25.16	-38	-43.97	-11.1	-6.05	2.24	-6.46	-4.45	-6.63	11.26	13.09	-15.28	8.89	-16.23
KUP	-9.89	-4.12	-6.64	-30.91	-0.56	0.04	31.7	9.58	6.41	-16.78	-10.79	-10.57	-7.37	-15.13
VKT	-29.65	-30.27	-38.96	-57.01	10.91	11.33	-15.83	9.31	22.56	-0.32	-5.38	-23.81	1.84	-28.57
KAN	49.81	12.03	107.47	85.81	81.58	41.31	34.78	38.85	23.74	2.96	55.26	66.04	14.21	27.90

Table 10.- The monthly beach sand volume along the study area (w.r.f to Jan 06). TUR – Thiruchendur; ALT – Alanthalai; MNP – Manappad; OVR – Ovari; PERU –Perumanal; KUT – Kuttapuli; NAV – Navaladi; VAT – Vattakottai; KAN – Kanyakumari. (PM-Pre Monsoon, M-Monsoon, POM-Post Monsoon).

Tabla 10.- Volumen mensual de arena en la playa en la zona de estudio (referencia enero 2006). (PM: Premonzón, M: Monzón, POM: Postmonzón).

librium concave shape where beach has highly eroded and the equilibrium profiles are shallower than the actual profile (non-mining site) reflecting the grain size variation (either fine or medium). It shows an erosional trend in Periathalai, Manappad, Kuttapuli and Vattakottai, reflecting the beaches are maintaining their un-equilibrium to the extraction. The monthly variation in beach profile shown in the figure reflects the above said phenomena. In order to understand the fragile nature of beaches research is needed to improve the beach profile analysis to explain the stability and instability of coast. A detailed study on beach profile evolution, sediment deposition pattern and their resulting grain size distribution with the physical processes active at extraction area is progress in our laboratory.

Acknowledgements

This study is a part of Beach Placer Project, sponsored by Department of Science and Technology of Manonmaniam Sundaranar University. We wish to thank the Dr. Bhoop Singh, Director, NRDMS Division, DST, New Delhi for their generous financial assistance in carrying out this project. We thank the anonymous referees for their valuable suggestions to improve the quality of manuscript.

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