Wave and Littoral Processes at Thengapattanam Coast, Kanyakumari District, Tamil Nadu State, SW India

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ABSTRACT

The field investigations were carried out on the beach profiles, breaking wave parameters and longshore currents for a period of 25 months from December 2006 to December 2008 to study the beach dynamics of Thengapattanam coast, Kanyakumari district, Tamilnadu state, SW India. The Thengapattanam beach is well known for its long history, estuary, tourism, manmade structures and fishing activities. Monthly measurements were prepared on littoral environmental observations (LEO) and beach level variations. Longshore sediment transport rates were estimated based on the observed data. The estimated annual gross longshore sediment transport rate was higher due to recent manmade structures and the net transport was towards southerly direction . The beach profile level was lowest in July and high in April and the variation was 35 m. The total volume of sand transported was 840 m^3/yr during 2007 and 710 m^3/yr during 2008. The wave heights varied between 0.4 to 2.5 m during 2007 and 0.45 to 1.8 m during 2008, whereas wave period was between 8 sec to 15.5 sec and 7 sec to 21 sec for 2007 and 2008 respectively. The study concluded that the beach is experiencing significant erosion. Thengapatanam beach is being subjected to erosion phase during both monsoon seasons and get stable profiles by fair weather seasons. Longshore currents were stronger in June, July and August and steady during rest of the year. The net southerly transport was $1.2*10^6$ m^3/yr during 2007 and $0.577*10^6$ m^3/year during 2008. The volume variations of the sediments, an account of accretion/erosion were estimated considering the January 2007 profile as the base reference over which the values of other months were compared. The study area is highly vulnerable due to its erosion and other factors.

Keywords: Longshore current, sediment transport, beach profile, LEO, breaking waves etc.

INTRODUCTION

Inlets are important economically to many littoral states because harbours are often located in the back bays, requiring that the inlets are maintained for commercial navigation. A better understanding of inlet sedimentation patterns and their relationship to tidal and other hydraulic processes can hopefully contribute to better management and engineering design. Beaches and sediment movement along the shore have been subjects of popular and scientific interest for over a century. Beaches are popular recreation areas and of vital economic importance to many states [1]. Beaches are critical buffer zones protecting wetlands and coastal plains from wave attack. One feature of coastal areas that is often studied and analyzed are the profiles of beaches, cliffs and coastal landforms. These cross sections through coastlines can give a good idea as the changes that can occur over time at one point on the coast, either in the shape of a beach or cliff, or on its size and volume. Careful examination of the sediment transport pattern is very essential to maintain the balance and the stability of the coastline.

India has a long coastline of over 6000 km along the mainland in addition to that of the Andaman and Nicobar islands in the Indian ocean and Lakshadweep islands in the Arabian sea. The vast coastal zone has been playing a major role in the economic development of the country since ancient times by its contribution to sea trade, fishing, ocean industry and human settlement. But coastal ecosystem is under threat due to anthropogenic activities, increased human settlement, industrial pollution, manmade structures etc. The geomorphology of beach is controlled mainly by the wave characteristics and the nearshore sediment transport. The hydrodynamic process in the surf zone is quite complex due to wave breaking, presence of longshore and onshore – offshore currents, littoral sediment transport, erosion or accretion of beach sediments etc. Responding to the various forces acting in the surf zone, the coast readjusts itself and tends to be in a dynamic equilibrium. Longshore current plays a predominant role in transporting the sediment in the beach. For practical purposes, the average longshore current measured in the surf zone would be sufficient for estimating the sediment transport rate.

With regards to the measurement of beach profiles, Delgado and Lloyd (2004) describe in their paper one of the simplest methods of measuring beach profiles[2]. Cooper et al. (2000) briefly explained the history of beach profile measurement in their paper on the measurement, theory and analysis of beach profiles [3]. Pickett et al. (1997) describes the application of the model in the analysis of the beach profiles of the Bay of Plenty, New Zealand [4]. Krause and Soares (2004) described a beach profile monitoring programme for the state of Para in northern Brazil , which was the investigation of coastal morphodynamics to be undertaken in an area of extensive mangrove forest [5]. Lacey and Peck (1998) documented morphological changes that occurred on the beaches of Rhode Island by observed both short and long term periodic cycles [6]. Saravanan and Chandrasekar (2010) studied the monthly and seasonal variation in beach profile along the coast of Tiruchendur and Kanyakumari, India [7]. Larson et al. (2000) analyzed the relationship between wave action and beach profiles [8]. The longshore current velocity varies across the surf zone, attaining the maximum value close to the wave breaking point [9]. The sediment transport between Kanyakumari to Trivandrum is southerly from May to December and northerly from January to April [10]. Wind, waves and tides are the important factors responsible for the movement of material on the beach and the resultant sediment distribution [11]. The variation in grain size for any type of beach is primarily a function of variation in wave height and to a lesser degree, the wave period [12]. The textural parameters, in addition to the degree of sorting, also reflect the mode of transportation and the energy levels of transportation media. The grain size and grain size distribution of sediments can be utilized for assessing the energy conditions prevailing along the coast. Nevertheless, grain size parameter provides an insight, into the mode of sediment transportation and deposition. The references used to study beach profile studies and earlier profile studies at nearby study area.

The main objective of this paper is to monitor the beach profile changes, to estimate longshore current and sediment transport from measured wave data and Littoral Environmental Observation (LEO) data and to ascertain what changes have occurred in Thengapattanam beach profile shapes on a temporal scale using beach profile data from December 2006 to December 2008 . Also, the aim of the present investigation is to determine statistically the significant variations in grain size distribution of the beach sediments along the location under study. In order to get a comprehensive picture about the seasonal changes in the size characteristics of the sediments along the beach, average moment measure statistics viz. mean, standard deviation, skewness and kurtosis were computed.

Study area details

Kanyakumari is the smallest district situated in the southwest of Tamil Nadu, South India with a land spread of 1,684 km^2. It has almost all ecosystems - forests, wetlands, freshwater resources, marine etc. The coastal ecosystem of this district comprises 68 km in length and is studded with 44 coastal fishing villages. Since this district is situated at the extreme south of the Indian subcontinent, the coastline is formed nearly by the three seas, namely the Arabian Sea, the Indian Ocean and the Bay of Bengal. But the main part of the coast faces the Arabian Sea. The coastal landscape of Kanyakumari District is mainly composed of beach ridges of rocky, sandy, clay in salt pan region and swampy nature in the estuarine regions. The coastal geomorphologic features observed in the district are Teri sand, sand dune, sandy plain, pediment, river side plain, flood plain, alluvial plain, deltaic plain, estuary, beach ridge, swampy, mudflat, saltpan, lagoon, sandbar, creek, rock shore, sandy beach, cliff, tidal flat, cusp, groins, off shore hillocks etc. The 68 km long coast has a heavy concentration of fisher folk, almost one village per 1.5 km. Coastline of Kanyakumari coast is exposed to relatively higher waves than the rest of the Indian coast due to its direct exposure to the Indian ocean . The oceanography of this region is controlled by three different seasons a) Southwest monsoon (June to September) b) Northeast monsoon (October to December) c) fair-weather period (February to May). In the Indian Ocean mixed tides are mainly semi-diurnal type. The tidal range along the west coast of India increases from 0.65 m to 0.76 m towards south.

The study area, Thengapatanam beach is a beautiful town located in latitude N 8^0 14' 27.1'' and longitude E $77^0$10' 7.3'' on the shores of Arabian Sea in the southern part of Kanyakumari district in Tamil nadu. It is an open coast with deep in bathymetry and the transect of the proposed research area is shown in fig 1. The history of this beautiful coastal town dates back to more than 2000 years to the reign of Chera Kings. It was, then an important port of Chera Nadu, when trade relations boomed with the Middle East and the Arab world. There was direct cargo boat service between Thengapattinam and other foreign maritime towns around the world. Part of the culture and tradition found here was inherited through its trade relations with the Arab world. The king Cheraman Perumal had passed through this tiny town when he went to Mecca to embrace Islam after witnessing the moon splitting miracle. It was part of the Travancore State until 1956 before it merged with Tamil Nadu. This Muslim town has a Juma Masjid known as Valiya Palli, which is more than 1200 years old. It is a coastal town which is 35 km away from Nagercoil, headquarters of Kanyakumari District and 45 km away from Trivandrum, capital city of Kerala. It shares borders with Mullimoodu and Erayummanthurai on the western side, Panankalmukku and Mulloorthurai on the east, Amsi on the north and the Arabian Sea on the south. It is well connected with nearby villages and town by road and waterways. It is a flat, plain land with intermittent rocky hills - Chentapalli rock - on the eastern side and Aarttupalli rock on the western side. The Kovalam - Colachel Canal, popularly known as AVM Canal (Ananda Victoria Martanda Varma Canal) which passes through this town linking up to Kanyakumari was encroached by settlers. This waterway was operation from Mandaikadu to Poovar 70 years ago. In some places it is filled with coconut trees and suffered encroachment. AVM Canal merges with Kuzhithurai River at Thengapattanam and known as Valliyar. AVM canal which connects the Thengapattinam estuary of Thamiraparani River, Kanyamuari District and Neyyar river Estuary at Poovar of Neyyatinkara, Kerala. The AVM canal runs along the west coast. The canal well served the freshwater needs of the local people. The drainage channels from the paddy fields and AVM canal are the main sources for the flow of sewage and domestic wastewater into the estuary. AVM canal is used for retting activities round the year (www.kanyakumari.nic.in).

During Southwest and Northeast monsoons, it overflows and causes much damage to the lives and properties of those who live on the banks of the river. During the rest of the period the river is almost dry. The alluvial soil along the coastal strip is well adapted for the cultivation of paddy and coconuts. “Thengapattinam”, ‘Thennaipattinam” and “Thenpattinam” are the other relevant names of this town, it is called so because of the dense coconut groves found everywhere here. Thengapatnam estuary is one of the major estuaries in Kanyakumari District, Tamil nadu as shown in plates 1a,b. It is a bar-built estuary and sand bar is a permanent barrier, which prevents the entry of sea water during post monsoon and pre monsoon season. Near shore bathymetry is depth with 19 m from 200 m distance from the shore. The terrain comprises largely of Precambrian crystalline rocks of charnockites, khondalites and migmatitic gneisses. According to Raju and Singh [13], Thengapatanam hinterlands’ have radioactivity of 1.87 Gy/h and Thengapatanam beach sector 0.64 Gy/h. Now, Government of Tamil nadu constructs a fishing harbour in the Thengapattanam estuary is underway. Therefore the observations will be more useful to monitor the possible coastal changes resulting during and after the construction of fishing harbour.

MATERIALS AND METHODS

The beach profiling measurements were made out at Thengapatanam beach every month from December 2006 to December 2008 at the lowest tide level. So that the maximum lengths of the beach cross section was exposed for the measurement. At times, inner bars were accessible and the measurements were carried out. The stake and horizon method [14] was adopted to measure the sand level at the transect with the fairly fixed reference point. The profile direction was kept perpendicular to the coast and all the measurements made at the station. Monthly changes for 25 months in beach levels were measured at the study area at every 5m interval along a transect from backshore dune to seaward till 1m water depth during the low tide.

Surveyor's dumpy level and a graduated staff were used for measuring beach levels. Heights of 10 consecutive breakers were usually measured and the average of them were noted as significant wave height at breaking. Total time required for 10 waves to break was noted using a stop watch and the average was considered as breaking wave period. Long shore current velocity and direction were measured by using current meter. Based on the data collected, the long shore sediment transport rates were computed using the Walton's equation [15],

$$Q = \frac{1290\ \rho g H_b W V C_f}{0.78\ (5\pi/2)(V/V_o)}$$

Where, Q is the longshore sediment transport rate in m^3/year, ρ is density of sea water = 1025 kg/m^3, g – acceleration due to gravity = 9.81 m/sec^2, C_f is the friction coefficient = 0.01, H_b is breaking wave height in meter, W is surf zone width in meter, V is the measured longshore current velocity in m/sec and V/Vo is the theoretical dimensionless current velocity = 0.4 [16]. From the data collected during these surveys, the monthly and seasonal beach profile variations are graphically represented to show 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 in figs 2 a,b. [17].

Monthly beach sediment samples were collected over a period of 12 months (Dec 2006 to Nov 2007) from the berm, low tide, mid tide and high tide regions of the transect during low water level when the beach exposure was maximum above the water line. Total of 48 (12*4) samples were collected and analyzed for the present study. Sieve analysis was carried out to study the grain size distribution. Beach samples were subjected to size analysis by the simple sieving method. The samples were collected by scoop sampling. Approximately 1 kg in weight was washed free of salt, silt and clay and finally oven dried. From that 100 gm was separated by the conning and quartering method. Shells and shell fragments, if any present in the samples were separated by hand-picking method, as the presence of this would distort the trend of analysis. The samples were then sieved for 15 minutes in a semi automatic, motor driven mechanical Ro-Tap sieve shaker using a set of standard ASTM sieves (mesh nos. 40, 60, 80,100,120,140,170,200,230 and pan). The weight of each fraction representing a particular grain size was measured using an electronic balance. The graphic mean, median, standard deviation, skewness and kurtosis were calculated based on the formula of Folk and Ward [18].

RESULTS AND DISCUSSION

Beach profile studies

The variations in monthly beach levels at Thengapatanam beach are shown in Table 1, 2 for the years 2007 and 2008 respectively. The drawings of beach level variations for 25 months from December 2006 to December 2008 for SW, NE monsoons and fair weather seasons during 2007, 2008 years are given in figs (3 – 10). Beach level variations at Kolachel were presented earlier by Jena and Chandra Mohan [19] as beach level was low in September and high in April. Kaliasundaram et al.[20]reported that the erosion was taking place at Colachel at a rate of 1.2 m/year. Relative changes in the volume of sediment per meter length of the beach up to 1m water depth at Thengapattanam were estimated and presented in table 3 .Volume changes over an annual cycle were estimated at 840 m^3/yr for the year 2007 and 710.64 m^3/yr for the year 2008. The volume changes of the study area for months are given in fig 11.

The beach level is at the lowest in July and August for both years and at the highest in March and April. Normally beach levels are at the lowest in the southwest monsoon period for majority of west coast beaches also found to continue their erosion processes during the northeast monsoon period also . But, the present study established that the variation of beach levels over an annual cycle showed that the Thengapatanam beach is experiencing significant erosion. The beach profile is highly influenced by estuary connected by Thamiraparani river mouth. The beach width (m) , mean slope angle (deg) and total cross sectional area (m^2/m) of the beach for various months are given in table 4. The maximum beach width per meter of beach was determined as 59.88 m during July 2007 and 50.14 m during March 2008.The minimum beach width obtained as 24.23 m in July 2007 and 26.31 m in June 2008. The mean slope of the beach Vs months are given in fig 12. The slope variation has maximum during June and July months and minimum during April. The high slope angled Thengapattanam beach is given in plate 2.

Breaker characteristics

The variation of breaking wave height, period and the width of a surf zone are measured and presented as Littoral Environmental Observations in table 4.The maximum wave height is measured as 2.5 m in June 2007 and 1.8 m in July 2008. The wave height remained below 0.8 m in the fair weather season. Usually the study area has plunging breaker type except November and December which have surging wave type. The variation of wave height for different months is given in fig 13. The wave period persisted high during the southwest monsoon season months June to August and spilling breaker occurred during January and February. The relation connecting between period Vs month is given in fig 14. The surf zone width was larger during June to August at about 60 to 100m. The surf zone width was only about 5 to 20 m during November to February. The study of surf zone Vs month is given in fig 15. The floodplain region and wave cut platform of study location is given in plate 3 and plate 4.

Wave refraction

Wave refraction phenomenon is an important process responsible for effecting changes in coastal configuration. Based on wave atlas, wave refraction pattern prepared for the Indian coast, the predominant deep water wave direction is 210^0 with reference to north with period 8 sec. The bathymetry points are collected by NIO was considered for extracting digital bathymetry using Arc Map software. Numerical refraction procedure is adapted from Mahadevan [21]. Referring to Fig.16 for waves coming from 210^0 during southwest monsoon, convergence of wave orthogonal or concentration of wave energy is observed along the stretch of Muttom, Kadiyapattinam and Enayam. Immediately adjacent to the convergence zone, there is a wave divergence zone in the Colachel and Thengapattanam and south of Muttom. The sediments, eroded in the wave convergence zone, find the way to get deposited on the beach situated along the wave divergence of region. In southwest monsoon period the refracted wave orthogonal for the SSW direction and for the periods 8 sec is shown in fig 16.

Longshore current

Longshore currents are generated due to waves breaking at an angle to the shoreline. The shape of the coastline, beach face slope, estuary, nearshore profile, bathymetry, presence of sand bars and shoals significantly influence the distribution of longshore currents. The measured longshore current velocity and direction are shown in table 4 and longshore current for months are drawn in fig 17. The study indicates that the average longshore current velocity remains 0.2m/sec in the fair weather season. The variation in the longshore current velocity and direction is expected to occur due to the change in coastal geomorphology and nearshore bathymetry. The study also indicates that the Thengapattanam beach is quite sensitive to the both (SW & NE) monsoons. The variation in the near shore bottom topography , variation of breaker height , presence of wind set up , rip currents and manmade structure like RMS wall etc. plays an important role in the formation of longshore current. Longshore current was predominantly in the southerly direction except months of January to April. Anyhow the difference in the distribution of longshore current direction could not much influence the redistribution of littoral sediment within the study region, leading to erosion of the coast over an annual cycle.

Longshore sediment transport

The longshore sediment transport rates are estimated using Walton’s equation and presented in table 4. Earlier the annual longshore sediment transport rate of Colachel from April 1995 to April 1996 was estimated at $0.9*10^6$ m^3/yr and net transport was $0.3*10^6$ m^3/yr by Jena and Chandramohan [19]. Hentry et al.[22] assessed the longshore sediment transport rate relatively high, about $0.9*10^6 m^3$/yr during 2007 and $0.3*10^6 m^3$/yr during 2008. Now the present study assessed the longshore sediment transport rate of Thengapatanam coast is, about $1.17*10^6$ m^3/yr during 2007 and $0.57*10^6$ m^3/yr during 2008. The longshore sediment transport rate was lowest in November, January and February. Chandramohan and Nayak [23] reported that the annual net transport at the tip of India peninsula near Kanyakumari was negligible and southerly direction. Now, the present study also indicates that the net sediment transport near Thengapatanam is in the southerly direction. The presence of estuary in the Thengapatanam coast plays a very important role in the coast . The damming across the Thamiraparani river and river bed sand mining in the estuarine region blocks the sediments to reach the coast which maintains the coast as the erosional coast in the region. Also the manmade structure RMS wall enhances the erosion in the long run. The sediment transport rate for various months is given in fig 18.

Grain size analysis

The monthly variation of graphic mean, standard deviation , skewness and kurtosis were calculated for the samples from different locations are presented in fig 19 & fig 20 for mean size, fig 21 for sorting, fig 22 for skewness and fig 23 for Kurtosis. The monthly grain size analysis of sediments of all locations in the entire study area is given in table 5. The mean values of grain size analysis of sediments for all 12 months are given in table 6. At Thengapattanam, the average value of the mean grain size shows the presence of' medium size sand to coarse size (0.27 mm - 0.57mm) except in May where fine sand is present (0.21 mm). The maximum grain size in June, July and October shows the severe erosion during these months. The sorting values show moderately well sorted to moderately sorted nature during SW monsoon. The samples show negatively skewed nature during most of the period except during November and December, they are symmetrical. This shows that the beach in general undergoes erosion during the period of study.

CONCLUSIONS

The study of beach profiles over time highlights the annual variations in the beach shape and the level caused by varying wave and weather conditions. The correlation between the beach profiles and a number of other factors including wave height, wave period , surf zone width, weather conditions and human interventions are studied. The present study also brings out the nature of the wave climate acting on the coastline. The net sediment transport near Thengapattanam is in the southerly direction. From the monthly wave breaker height analysis, it is evident that this beach has all typical characteristics of a high energy beach with the onset of monsoon, an increase in southerly drift value is observed . Factors like steep slope of the shelf and open sea conditions must lead to the accumulation of the coarse grained sediment in the foreshore region of the study location. The foreshore samples are negatively skewed, indicating the prevalence of high energy conditions. The RMS walls put along the coast enhance the erosion recently. The erosion is very high in all months except March to May during 2007 and 2008. The damming of Thamirabharani River causes sediment starved shoreline; low lying topography and highly damaged toe of the RMS (Rubble Mount Sea) wall in the beach are the major reasons for very high erosion hazard of this beach. The present study indicates that Thengapatanam beach is erosional over the annual cycle. The heavy mineral deposits ilmenite presents in the mid tide region and garnet in the low tide region of the study area. In Thengapattanam, seawalls are fully slumped. Many sections of the seawall are getting severely damaged during every monsoon. The same situation is repeated year after year. Additional stones are stacked where ever the seawalls get damaged. In many places the seawalls are sinking. In some places seawalls have collapsed during monsoon and got submerged in the sand during fair season. The huge RMS wall is shown in plate 5 . The studies have revealed that this coast has been showing eroding tendencies for the last 30 years. The coast which maintained a wide beach is now devoid of beaches. Coastal armoring structures cause reflection in wave energy, which can increase seaward erosion of these structures. High wave energy condition and steep slope close to the seawall causes high energy dissipation on the seawalls. Ramanthurai – Thengapattanam Arayan thope is proposed to be protected from erosion with groin structures. Beach nourishment is recommended at the down drift end to prevent erosion of the adjoining area. While construction of dams across rivers is unarguably necessary for irrigation and electricity generation, there should be adequate provision for letting water through the downstream courses at least during peak flows, so that deltas are not starved of the much needed sediment inputs for coastal stability. Similarly, remobilization of sediments that are currently trapped in reservoirs may also be accomplished through appropriate engineering methods, which would have a double benefit of maintaining the reservoir capacity as well as sediment budget at the deltas and littoral drift in the coast.

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REFERENCES

1. **Houston, James R**., 1996. The Economic Value of Beaches. Extracted from the Internet. Point of contact: j.houston@cerc.wes.army.mil.
2. **Delgado. I.** and Lloyd.G. (2004), A simple low cost method for one person beach profiling, Journal of Coastal Research, 20 (4), pp 1246 -1252.
3. **Cooper. N.J.,** Leggett. D.J. and Love J.P. (2000) Beach profile measurement ,theory and analysis : Practical Guidance and applied case studies, Journal of the Chartered Institution of Water and Environment Management , 14(2), pp 79- 88.
4. **Pickett. V.,** Healy. T.R. and De-Lange. W.P. (1997) Equilibrium status of beach profiles on Bay of Plenty beaches , application of the Dean profile for coastal hazard identification. In combined Australian coastal engineering and ports conference, New Zealand ,pp 353- 358.
5. **Krause. G.,** and Soares. C. (2004) Analysis of beach morphodynamics on the Bragantinian mangrove peninsula (Para , North Brazil) as prerequisite for coastal zone management recommendations, Geomorphology 60(1- 2) pp 225-239.
6. **Lacey, E.M**. and Peek, J.A. (1998) Long term beach profile variations along the south shore of Rhode Island, U.S.A., Journal of Coastal Research , 14 (4),pp 1255-1264.
7. **Saravanan. S** and Chandrasekar.N (2010). Monthly and Seasonal Variation in Beach Profile along the coast of Tiruchendur and Kanyakumari, Tamilnadu, India, Journal of Iberian Geology 36(1), 39-54.
8. **Larson, M., Capobianco, M., Hanson, H**., (2000). Relationship between beach profiles and waves at Duck, North Carolina, determined by Canonical Correlation Analysis. Marine Geology 163, 275–288.
9. **Basco, D.R.** (1982) Surf zone currents , Miscellaneous Report No.82- 7(I), Coastal Engineering Research Centre , U.S. Army Corps of Engineers), p 89.
10. **Chandra Mohan. P**., Nayak.B.V. (1991) Longshore sediment transport along the Indian coast , Indian Journal of Marine Sciences , Vol.20, June 1991.(pp 110- 114).
11. **Komar, P.D.**,1976. Beach Processes and Sedimentation, Prentice-Hall, Englewood Cliffs, N.J., 429 p.
12. **Wright, L.D. and Short, A.D.,** 1984. Morphodynamic variability of surf zones and beaches: a synthesis. Mar. Geol., 56(1-4), pp.93-118.
13. **Raju** G.K., H.N. Singh, (2001). Studies on radioelement in river basins of Western Ghats, Southeast Tamil Nadu, Final Technical Report No. CESS-PR-33- 2001, pp. 98.
14. **La Fond, E.C. and Prasada Rao, R.** (1954). Beach Erosion Cycles near Waltair on the Bay of Bengal, Andhra Univ., India. Memoir in Oceanography.1, 63-77.
15. **Walton, T.L.** and Bruno, R.O. 1989 Longshore transport at a detached breakwater , phase II, Journal of Coastal Research, 65 (9), pp 667- 668.
16. **Languet – Higgins, M.S**. 1970 Longshore currents generated by obliquely incident waves , 1 & 2, Journal of Geophysical Research 75 (33) pp 6678- 6801.
17. **Chandrasekar, N. & Sheik Mujabar, P.** (2010): Computer application on evaluating beach sediment erosion and accretion from profile survey data. – Computational Geosciences, DOI 10.1007/S10596-009-9172-8, Vol. **35**, No. 4.
18. **Folk RL, Ward W C.**1957.Brazos River bar: a study in the significance of grain size parameters. Journal of Sedimentary Petrology 27:3-26.
19. **Jena, B.K.** and Chandra Mohan, P. (1997) Sediment Transport Near the Peninsular Tip of India, Second Indian National Conference on Harbour and Ocean Engineering , pp 1054- 1060.
20. **Kalia Sundaram, G., Govinda swamy. S. and Ganesan, R.** (1991) Coastal erosion and accretions, Coastal zone Management in Tamil Nadu state, India pp 73- 82.
21. **Mahadevan, R. and P.S. Renukaradhya** (1983) Numerical calculation of wave refraction. Proc. Second Indian Conference in Ocean Engineering (INCOE, 83), Pune, India p. 1-82.
22. **Hentry C**, Chandrasekar N, S. Saravanan S (2013), **Beach dynamics of Colachel open coast, Kanyakumari District (SW India)** , Annals of Geomorphology, NF Volume 57 Issue 1 (*2013*), p. 75

– 95.

23. **Chandramohan. P.** and Nayak. B.U. 1989, Distribution of Longshore Sediment Transport along the Indian Coast based on Empirical Model , Third National Conference on Dock & Harbour Engineering, pp 501-508.

Table 1 Beach Profile Survey (m) at Thengapattanam (Dec 2006 to Dec 2007)

Dist	Dec'06	Jan'07	Feb'07	Mar'07	Apr'07	May'07	Jun'07	Jul'07	Aug'07	Sep'07	Oct'07	Nov'07	Dec'07
0	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2.14	2.18	2.18	2.2	2.15	2.2	2.3	2.13	2.22	2.35	1.9	2.1	1.4
10	2.39	2.28	2.22	2.32	2.4	2.32	2.5	2.62	2.48	2.68	2.1	2.3	1.7
15	2.28	2.4	2.5	2.5	2.45	2.4	2.96	2.77	2.32	1.48	2.2	2.5	1.9
20	0.82	2.46	2.62	2.68	2.5	1.58	1.3	1.4	1.1	0.95	2.3	2.6	2.2
25	-0.15	1.75	2.58	2.7	2.7	0.9	0.32	-0.1	-0.1	0.48	2.6	2.7	2.4
30		0.8	1.6	2.3	2.6	0.32	-0.4			0.18	2.9	2.8	2.7
35		-0.18	0.7	1.85	2.3	-0.4				-0.2	0.8	1.9	1.8
40		-0.5	-0.2	0.95	2.1						-0.3	0.95	0.7
45				0.7	1.7							0.4	0.5
50				0.1	1.2							-0.4	-0.3
55				-0.4	0.8								
60					-0.1								

Table 2 Beach Profile Survey (m) at Thengapattanam (Jan 2008 to Dec 2008)

Dist	**Jan'08**	**Feb'08**	**Mar'08**	**Apr'08**	**May'08**	**Jun'08**	**Jul'08**	**Aug'08**	**Sep'08**	**Oct'08**	**Nov'08**	**Dec'08**
0	2	2	2	2	2	2	2	2	2	2	2	2
5	2.08	2.2	2.2	2.2	1.4	2.3	2.2	2.1	2.1	1.9	2.05	2.35
10	1.9	2.4	2.25	2.4	1.9	2.4	2.39	2.4	2.2	2.1	2.15	2.65
15	1.8	2.9	2.2	2.45	2.2	2.7	2.59	2.7	2.4	2.2	2.22	2.35
20	1.9	1.5	1.8	1.65	2.5	1.2	2.38	1.6	2.5	2.3	2	1.65
25	2	0.9	1.5	1	1.2	0.3	1.03	1.2	0.6	2	1.2	0.95
30	2.05	0.4	1.2	0.75	0.2	-0.6	-0.1	0.2	0	1.6	0.82	0.8

35	1.5	0.1	0.9	0.5	-1.1		-0.4	-0.3	-0.5	0.8	0.35	0.5
40	0.75	-0.3	0.5	0.2						-0.3	-0.1	0.1
45	0.1	-0.7	0.2	-0.3								-0.3
50	-0.4		-0.2	-0.6								

Table 3 Beach morphology study at Thengapattanam

S.No	**Month**	**Vol (m^3/m)**	**Vol change (m^3/m)**	**Mean slope(deg)**	**Beach width(m)**	**Cross Sec. area(m^2/m)**
1	Dec’ 06	42.4412	-21.2737	6.9115	23.9191	42.4412
2	Jan’ 07	63.7149	0	5.1475	33.8546	63.7149
3	Feb’ 07	76.2625	12.5476	5.8792	38.6338	76.2625
4	Mar’ 07	95.4358	31.7209	3.3648	50.8289	95.4358
5	Apr’ 07	118.611	54.8961	1.9266	59.8826	118.611
6	May’ 07	120.65	56.9351	4.4077	54.3907	120.65
7	Jun’ 07	50.6823	-13.0326	8.4978	26.7842	50.6823
8	Jul’ 07	48.7505	-14.9644	8.6388	24.2323	48.7505
9	Aug’ 07	45.0064	-18.7085	7.1844	24.284	45.0064
10	Sep’ 07	52.9257	-10.7892	4.9843	32.045	52.9257
11	Oct’ 07	55.5051	-8.2098	5.1238	37.2068	55.5051
12	Nov’ 07	77.3412	13.6263	7.8063	41.3285	77.3412
13	Dec’ 07	77.5023	13.7874	6.5073	38.0598	77.5023
	Total	**882.3877**		**Ave = 5.789**	**Ave = 38.4609**	**882.3877**
14	Jan’ 08	75.0503	11.3354	5.8976	45.8585	75.0503
15	Feb’ 08	56.2263	-7.4886	5.8202	35.9427	56.2263
16	Mar’ 08	67.6599	3.945	5.3237	50.1413	67.6599
17	Apr’ 08	60.2299	-3.485	3.3544	41.8533	60.2299
18	May’ 08	51.043	-12.6719	8.8746	30.3905	51.043
19	Jun’ 08	48.4408	-15.2741	8.3654	26.3084	48.4408
20	Jul’ 08	57.3071	-6.4078	6.578	29.2378	57.3071

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21	Aug' 08	55.2971	-8.4178	5.9508	31.7314	55.2971
22	Sep' 08	53.3919	-10.323	6.5612	29.5817	53.3919
23	Oct' 08	66.0692	2.3543	6.5683	32.155	66.0692
24	Nov' 08	58.6082	-5.1067	7.3569	38.7655	58.6082
25	Dec' 08	61.3154	-2.3995	7.2568	41.0899	61.3154
	Total	**710.6391**		**Ave = 6.4923**	**Ave = 36.088**	**710.6391**

Table 4 Littoral Environment Observation at Thengapattanam

S.No	Month	Hb	Period	Surf zone	L.S. current	Monthly net	Wave type
		m	sec	m	m/sec	m^3/month	
1	Dec'06	1	12.33	8	-0.26	-9179.9522	surging
2	Jan' 07	0.55	14.44	15	-0.27	-9830.9344	plunging
3	Feb' 07	0.75	15.5	20	-0.24	-15888.379	plunging
4	Mar' 07	0.75	14	75	-0.18	-44686.065	plunging
5	Apr' 07	0.5	9	40	-0.17	-15005.691	plunging
6	May' 07	0.5	10.8	50	0.32	35307.5084	plunging
7	Jun' 07	2.5	5.7	100	0.5	551679.819	plunging
8	Jul' 07	2.4	8	60	0.55	349544.333	plunging
9	Aug' 07	2.5	7.5	35	0.47	181502.66	plunging
10	Sep' 07	1	9	30	0.32	42369.0101	plunging
11	Oct' 07	1.5	10	100	0.15	99302.3674	plunging
12	Nov' 07	0.4	10.6	5	0.2	1765.37542	surging
13	Dec' 07	0.75	8.7	5	-0.16	-2648.0631	surging
	Mean	**1.175**	**10.27**	**44.58333**	**Total**	**1173411.94**	
14	Jan' 08	0.6	14	18	-0.21	-10009.679	plunging
15	Feb' 08	0.9	21	25	-0.23	-22839.545	plunging
16	Mar' 08	0.85	13.5	55	-0.15	-30949.238	plunging
17	Apr' 08	0.45	12	35	-0.18	-12512.098	plunging
18	May' 08	0.9	11.5	60	0.29	69114.4477	plunging
19	Jun' 08	1.5	14	40	0.47	124458.967	plunging
20	Jul' 08	1.8	5.8	65	0.53	273677.325	plunging
21	Aug' 08	1.8	7.8	45	0.4	142995.409	plunging
22	Sep' 08	1.5	7	20	0.27	35748.8522	plunging

23	Oct' 08	1.3	11.4	20	0.16	18359.9044	plunging
24	Nov' 08	0.7	11.4	7	0.22	4757.6867	surging
25	Dec' 08	1	10	20	-0.25	-22067.193	plunging
	Mean	**1.108**	**11.6167**	**34.16667**	**Total**	**570734.84**	

Table 5 Grain size analysis at Thengapattanam (Dec'2006 – Nov'2007)

Month	Location	Mean size mm	Sorting		Skewness Phi (Ø)	Kurtosis Phi (Ø)	Description
			Phi (Ø)	Phi (Ø)			
Dec	Berm	0.2978	1.748	0.745	0.089	3.074	Medium Sand
	HT	0.4962	1.011	0.642	0.289	1.582	Medium Sand
	MT	0.5632	0.828	0.626	1.115	3.169	Coarse Sand
	LT	0.4552	1.135	0.654	0.029	1.778	Medium Sand
Jan	Berm	0.2978	1.748	0.745	0.089	3.074	Medium Sand
	HT	0.4962	1.011	0.642	0.289	1.582	Medium Sand
	MT	0.4962	1.011	0.642	0.289	1.582	Medium Sand
	LT	0.3797	1.397	0.625	-0.339	3.015	Medium Sand
Feb	Berm	0.2978	1.748	0.745	0.089	3.074	Medium Sand
	HT	0.4962	1.011	0.642	0.289	1.582	Medium Sand
	MT	0.5373	0.896	0.681	1.057	3.205	Coarse Sand
	LT	0.6362	0.652	0.505	1.931	6.07	Coarse Sand
Mar	Berm	0.278	1.847	0.782	0.07	2.756	Medium Sand
	HT	0.4249	1.235	0.605	-0.502	1.722	Medium Sand
	MT	0.4218	1.245	0.737	0.288	2.465	Medium Sand
	LT	0.3137	1.672	0.778	0.177	3.051	Medium Sand
Apr	Berm	0.3244	1.624	0.492	-0.372	6.162	Medium Sand
	HT	0.2825	1.824	0.576	0.427	4.273	Medium Sand
	MT	0.3742	1.418	0.671	-0.053	3.194	Medium Sand
	LT	0.5714	0.807	0.649	1.447	4.404	Coarse Sand
May	Berm	0.2675	1.902	0.866	-0.044	2.393	Fine Sand
	HT	0.2091	2.258	0.679	-0.179	2.119	Fine Sand
	MT	0.4356	1.199	0.622	-0.33	1.601	Medium Sand
	LT	0.4731	1.08	0.704	0.464	2.249	Medium Sand
Jun	Berm	0.5028	0.992	0.698	0.747	2.711	Coarse Sand
	HT	0.5569	0.845	0.629	1.027	2.92	Coarse Sand

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	MT	0.3864	1.372	0.666	-0.098	2.94	Medium Sand
	LT	0.5021	0.994	0.747	0.953	3.047	Coarse Sand
Jul	Berm	0.4055	1.302	0.771	0.362	0.362	Medium Sand
	HT	0.5028	0.992	0.698	0.747	2.711	Coarse Sand
	MT	0.2998	1.738	0.761	0.017	2.817	Medium sand
	LT	0.4977	1.007	0.747	0.906	2.967	Coarse Sand
Aug	Berm	0.3062	1.707	1.052	0.184	1.828	Medium Sand
	HT	0.3863	1.372	0.783	0.319	2.745	Medium Sand
	MT	0.3831	1.384	0.78	0.254	2.599	Medium Sand
	LT	0.518	0.949	0.69	0.861	2.808	Coarse Sand
Sep	Berm	0.482	1.224	0.726	0.304	2.573	Medium Sand
	HT	0.3476	1.525	0.859	0.191	2.25	Medium Sand
	MT	0.4174	1.261	0.763	0.376	2.594	Medium Sand
	LT	0.5246	0.931	0.692	0.966	3.056	Coarse Sand
Oct	Berm	0.2966	1.753	0.722	0.294	3.618	Medium Sand
	HT	0.4114	1.281	0.629	-0.318	2.293	Medium Sand
	MT	0.4948	1.015	0.706	0.719	2.736	Coarse Sand
	LT	0.5676	0.817	0.611	1.063	2.859	Coarse Sand
Nov	Berm	0.278	1.847	0.782	0.07	2.756	Medium Sand
	HT	0.3413	1.551	0.928	0.42	2.507	Medium Sand
	MT	0.2872	1.8	0.801	0.226	3.02	Medium Sand
	LT	0.4972	1.008	0.754	0.933	3.043	Coarse Sand

Table 6 Mean grain size analysis of sediments along Thengapattanam (Dec'06 – Nov'07)

Month	Mean size(mm)	Mean size(ϕ)	Sorting (ϕ)	Skewness (ϕ)	Kurtosis (ϕ)
Dec	0.453	1.181	0.667	0.381	2.401
Jan	0.418	1.292	0.664	0.082	2.313
Feb	0.492	1.077	0.643	0.842	3.483
Mar	0.36	1.5	0.726	0.008	2.499
Apr	0.388	1.418	0.597	0.362	4.508
May	0.346	1.61	0.718	-0.022	2.091
Jun	0.487	1.051	0.685	0.657	2.091
Jul	0.426	1.26	0.744	0.508	2.214
Aug	0.398	1.353	0.826	0.405	2.495

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Sep	0.443	1.235	0.76	0.459	2.618
Oct	0.443	1.217	0.667	0.44	2.88
Nov	0.351	1.552	0.816	0.412	2.832
Mean	**0.417**	**1.312**	**0.709**	**0.378**	**2.702**
Std. Devi	**0.05**	**0.179**	**0.069**	**0.253**	**0.69**

Fig.1 Location of the Study area

Fig 2 (a) Home Page of the Sand Volume Calculation Package

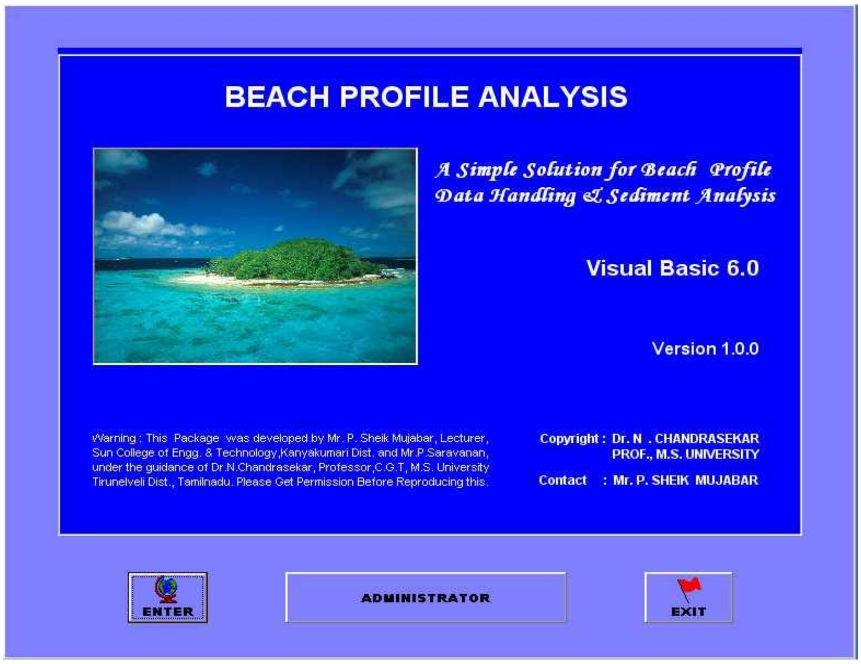

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Fig 2 (b) Options Available in the Sand Volume Calculation Package

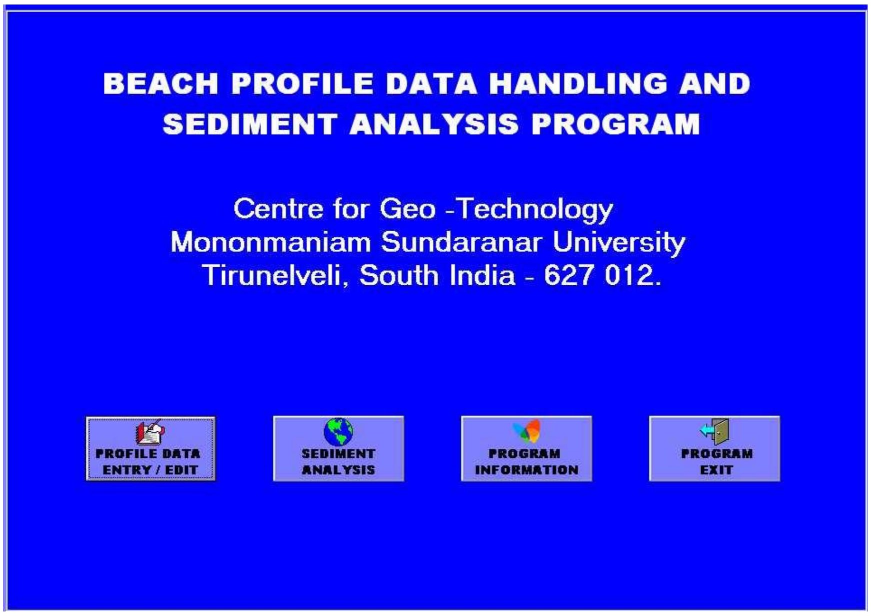

Fig 3 Beach profile Survey along the study area (2007)

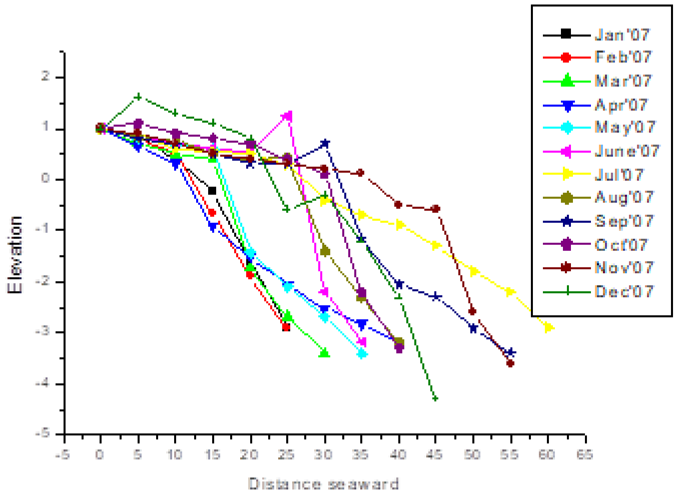

Fig 4 Beach profile Survey along the study area (SW Monsoon 2007)

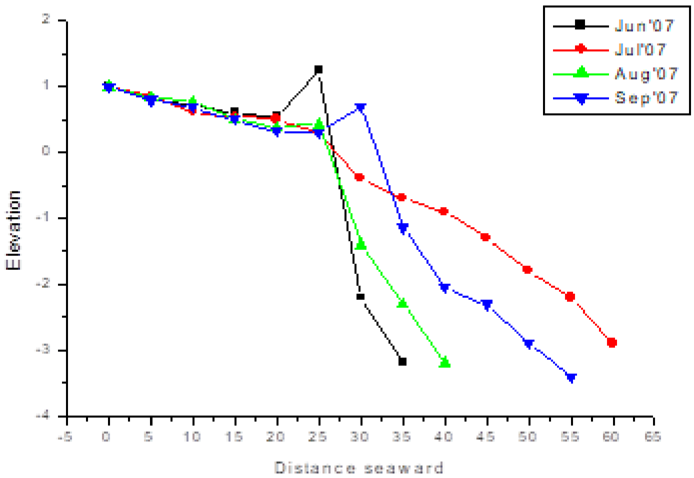

Fig 5 Beach profile Survey along the study area (NE Monsoon 2007)

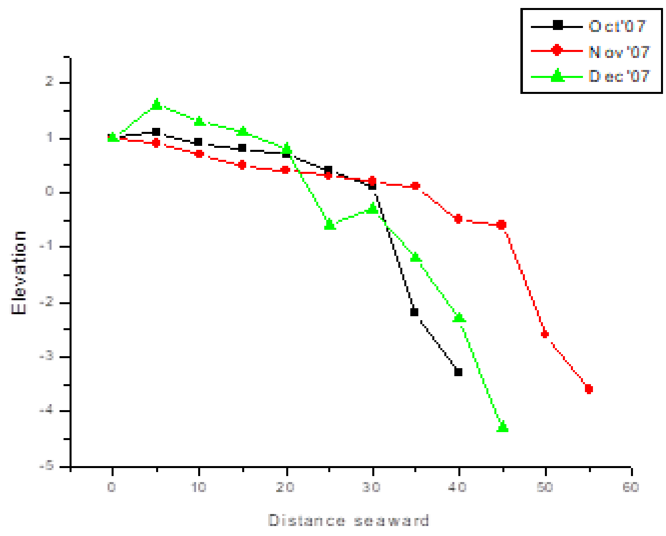

Fig 6 Beach profile Survey along the study area (Fair weather 2007)

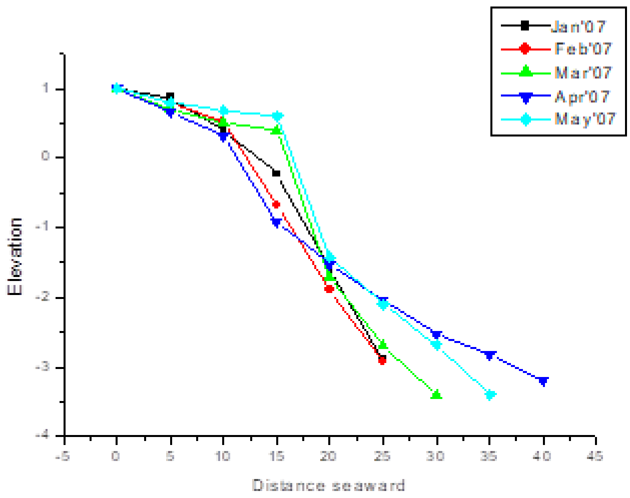

Fig 7 Beach profile Survey along the study area (2008)

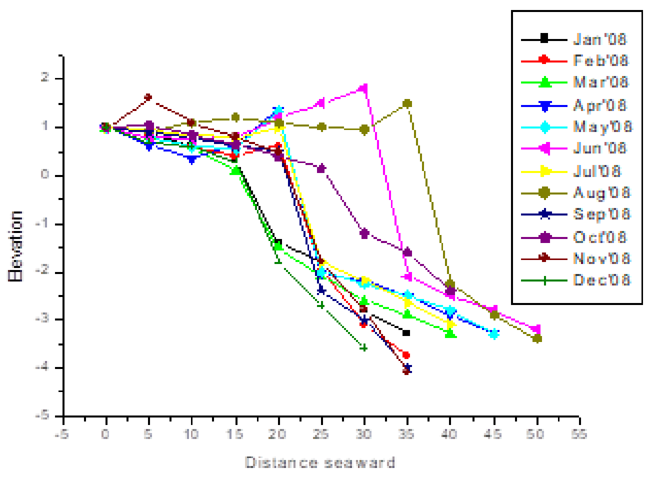

Fig 8 Beach profile Survey along the study area (SW Monsoon 2008)

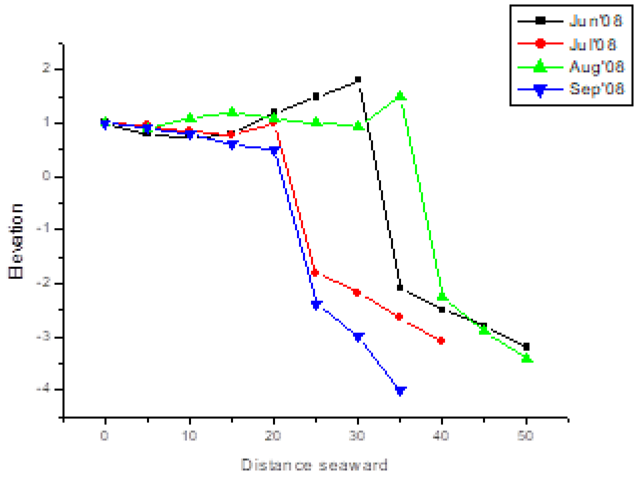

Fig 9 Beach profile Survey along the study area (NE Monsoon 2008)

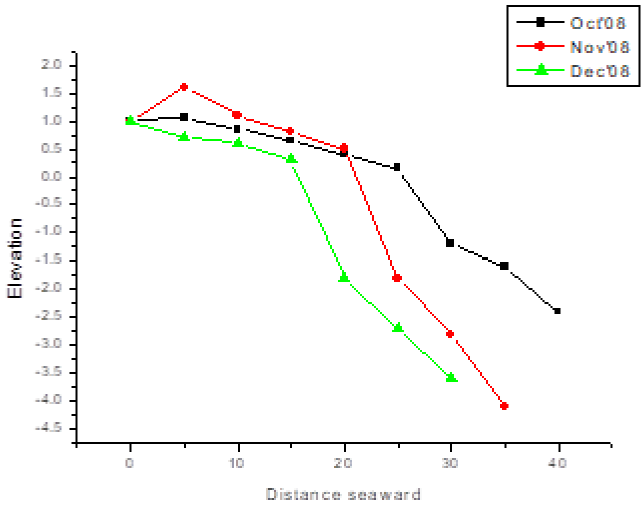

Fig 10 Beach profile Survey along the study area (Fair Weather 2008)

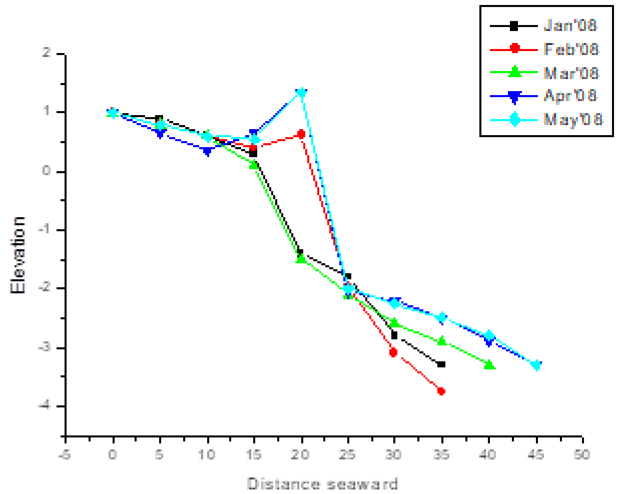

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Fig 11 Beach Sediment Volume changes along the study area

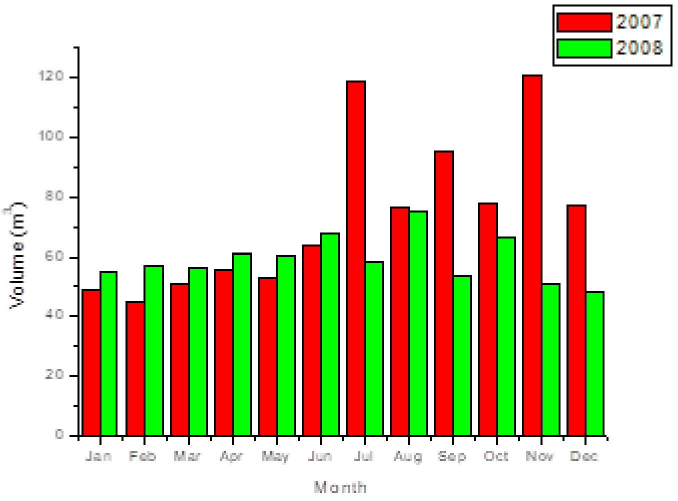

Fig 12 Beach slope angle along the study area

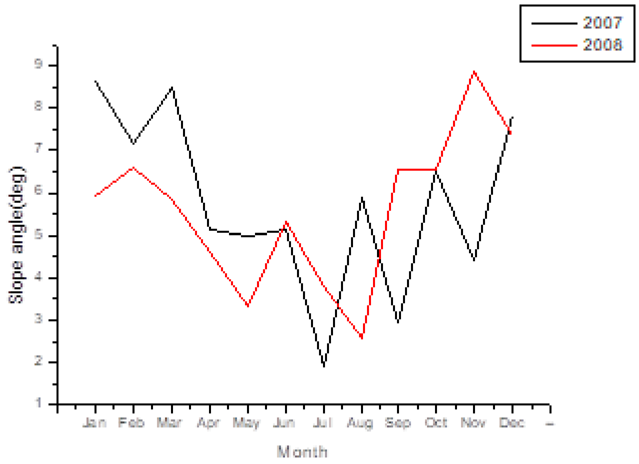

Fig 13 Wave height along the study area

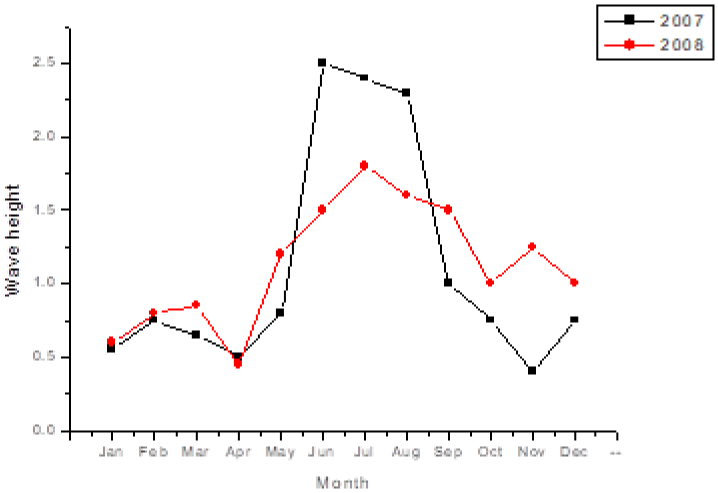

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Fig 14 Wave period along the study area

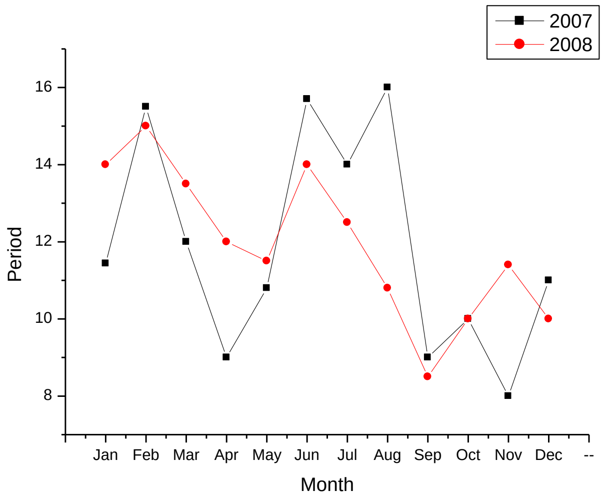

Fig 15 Beach surf zone width along the study area

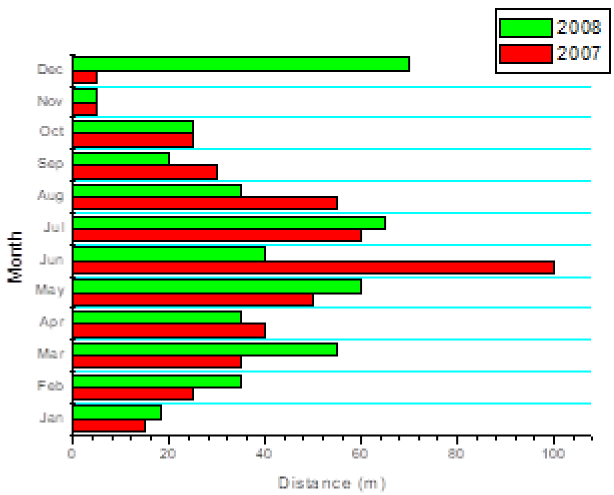

Fig 16 Wave Refraction pattern along the West Coast of India (SSW 8 secs)

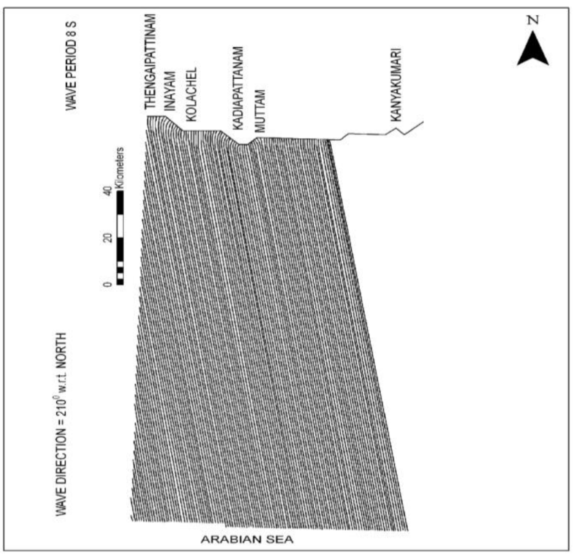

Fig 17 Longshore current along the study area

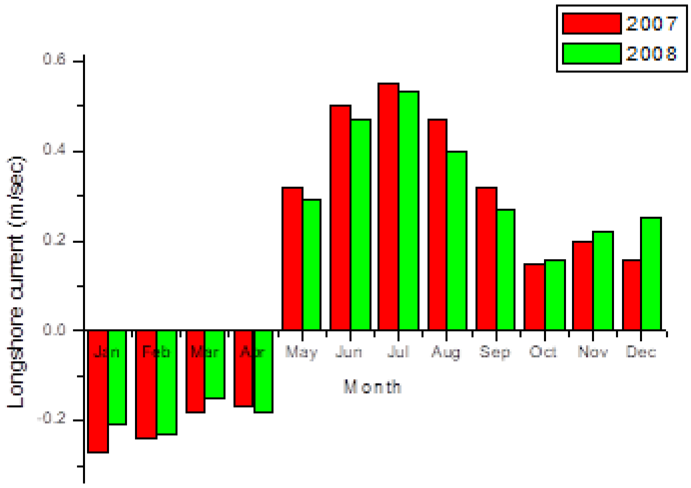

Fig 18 Sediment transport along the study area (+ Southerly direction, Northerly direction)

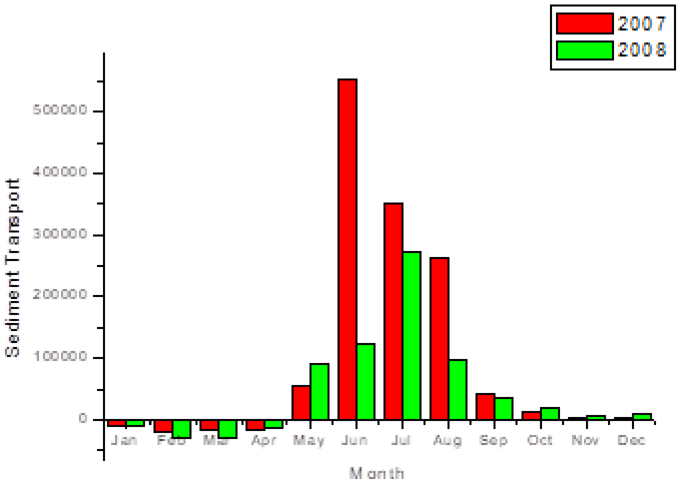

Fig 19 Mean size of sediments (mm) along the study area (Dec'06 – Nov'07)

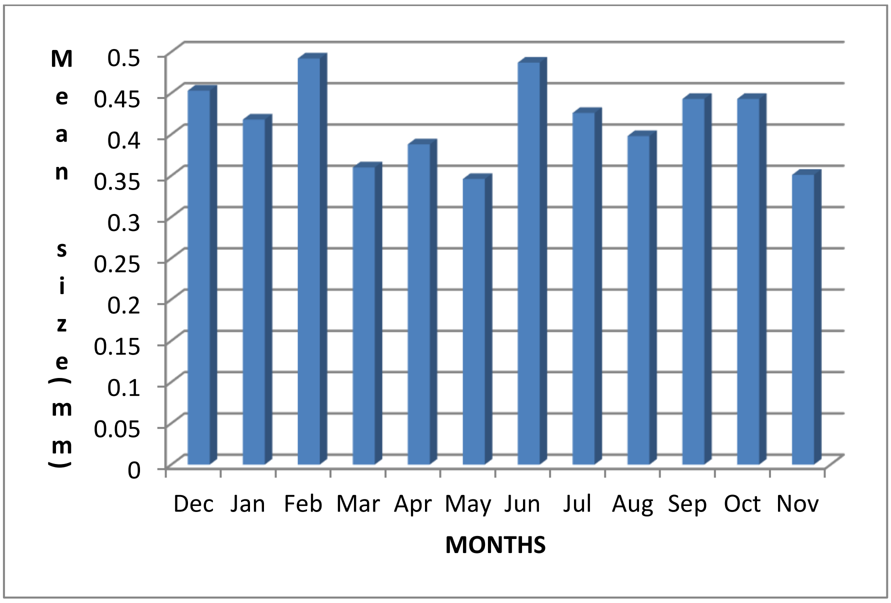

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Fig 20 Mean size of sediments (Ø) along the study area (Dec'06 – Nov'07)

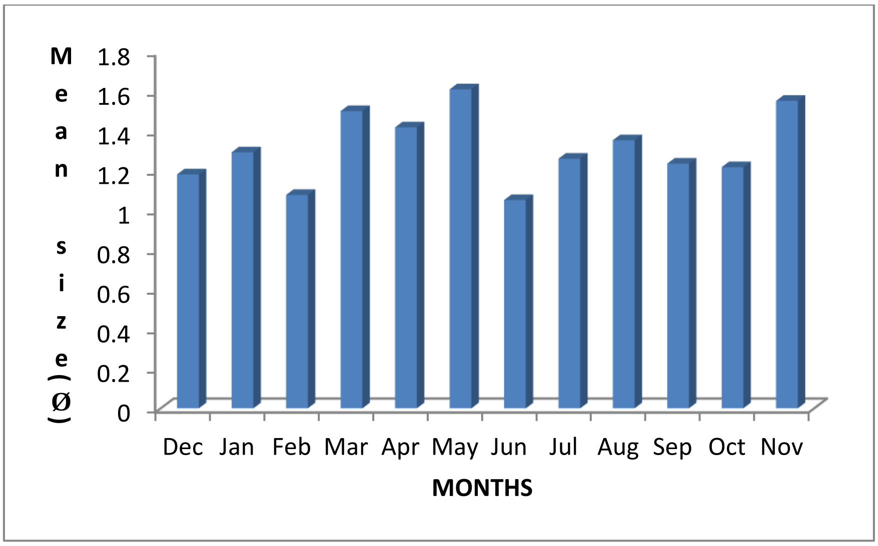

Fig 21 Mean sorting of sediments along the study area (Dec'06 – Nov'07)

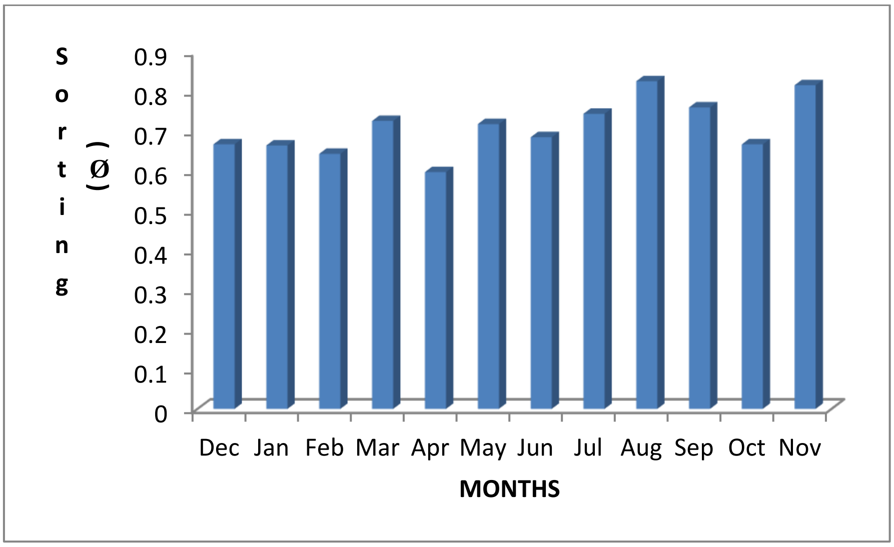

Fig 22 Skewness of sediments along the study area (Dec'06 – Nov'07)

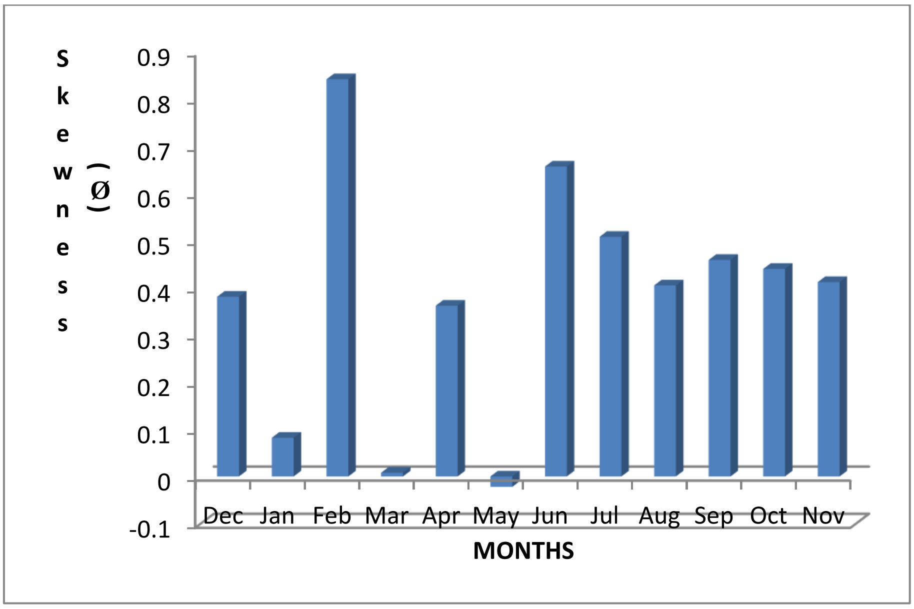

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Fig 23 Kurtosis (Ø) of sediments along the study area (Dec'06 – Nov'07)

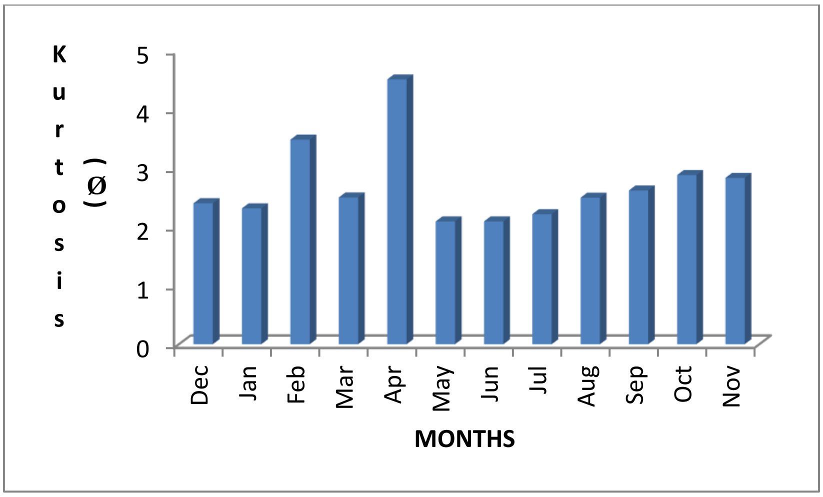

Plate 1 a, b Estuary regions in the study area

Plate 2 High slope angled beach at Thengapattanam

Plate 3 Flood plain at Thengapattanam (SW monsoon)

Plate 4 Wave cut platform shows heavy mineral deposit layers in the study area

Plate 5 R.M.S. Huge Wall enhances the erosion at Arayan Thope, Thengapattanam