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Morphological Changes in the Beaches Caused by Tsunami in Between Pondicherry and Portonova, East Coast of India

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Abstract

Waves caused as a result of earthquakes occurring at the sea bottom are known as tsunami. Tamilnadu coastal region in South India is also one amongst the tsunami affected regions of the world. In the present study, the region between Pondicherry and Portonova has been given much attention to evaluate the impact of tsunami over beaches. Slope of the coastal region has been reduced and nearly flattened. The berm sediments have been washed away. From north (Pondicherry) to south (Portonova), it clearly exhibits the effect by increased death toll, destruction and modification in the landforms. The stony waste dump in Pondicherry and Ponniyar – Gadilam river mouth in Cuddalore region reduced the impact of tsunami. The single giant wave altered the coastal landforms by means of destructing the cliff and flattening the beach. Imprints like swash marks and adhesion ripples are noted in the Silver beach of Cuddalore. The study reveals that this giant wave has destroyed older expressions made by ordinary wave action over hundreds of years and left its imprints over them.

Key-words : tsunami, coastal landforms, beach, Tamilnadu coast.

1. Introduction

A series of gigantic waves triggered in a body of water by disturbance due to earthquake vertically displaces water column and leads to wall of water, hitting the shore with tremendous energy and leaving behind a trail of destructions. Such event has occurred on 26th December 2004, which is the one among the worst in the world has faced so far. Magnitude of 9 is the 5th largest earthquake ever recorded in the history (Gupta, 2005). This has created series of massive ocean waves and caused devastating inundation in south eastern coastline of India and eastern coastline of Sri Lanka. Since Sri Lanka acted as a barrier for this quake waves, coastal region in India from Point Calimer to Tuticorin becomes the shadow zone. The prime objective of the present study is to infer the impact of tsunami over morphological changes in beaches of central Tamilnadu coast.

2. Area of Study

Geomorphology of northern Tamilnadu coast, extending from Pulicat Lake in the north to Vedaranniam nose in the south, is unique in the world. The coastal zone is varying in its width from 10 m to as far as 100 m. It is vested with numerous deltas such as Palar, Ponniyar and Cauvery from north to south. The area of study forms a part of northern Tamilnadu coast, located in the East coast of India, bounded by Bay of Bengal. It extends between Pondicherry in the north and Portonova in the south between latitudes 12°0′ to 11°30′ N and longitude 79°15′ to 79°51′ E (Fig. 1).

3. Method

Extensive fieldwork was carried out to study and confirm the changes over different geomorphic features in

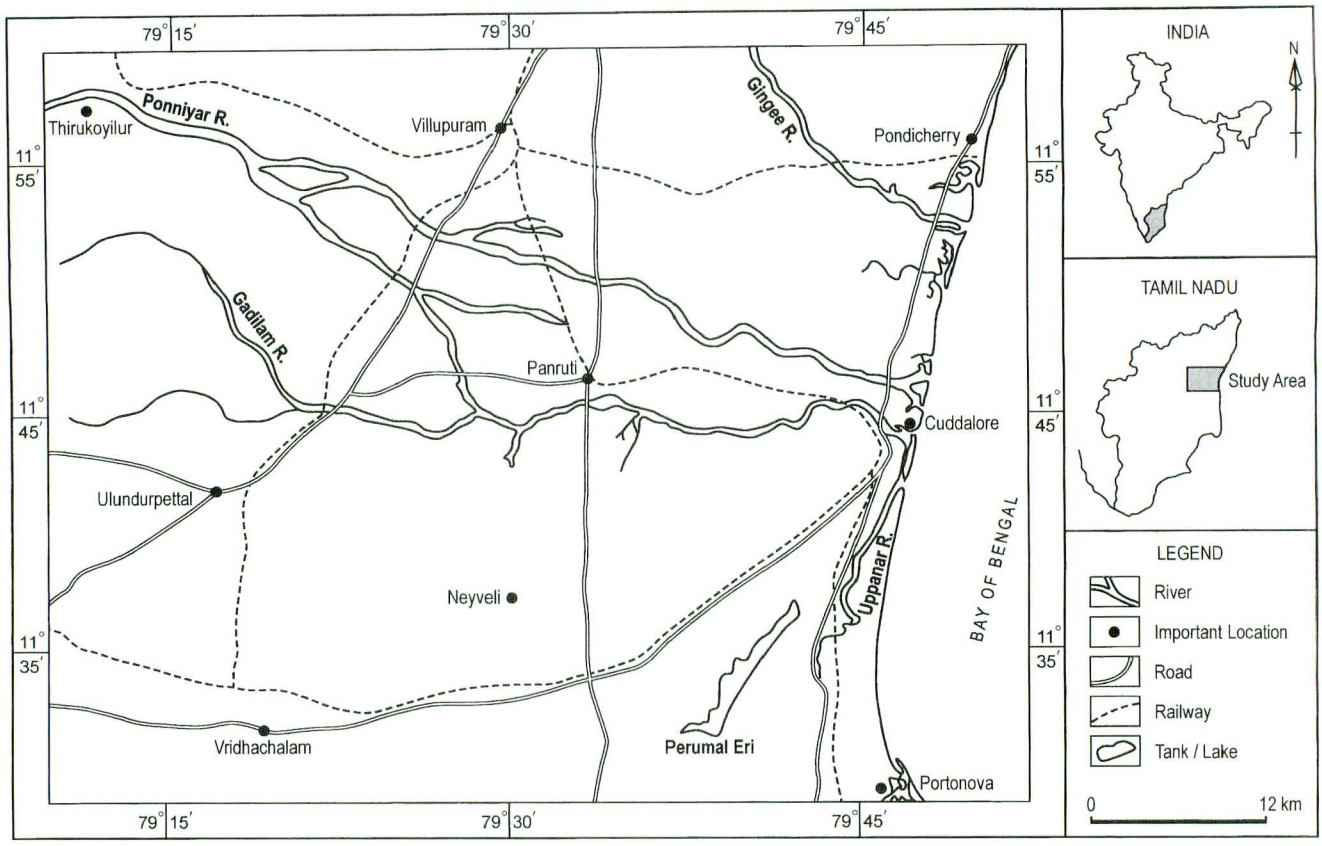

Fig. 1. Map showing the study area.

the entire area of study due to tsunami. Detailed mapping of different geomorphic features has been done on February 2004 (pre-tsunami). The field study to evaluate the impact of tsunami over beaches was carried out on 9th January 2005.

4. Tsunami and Its Impact

A tsunami moves silently, but rapidly across the ocean and raises unexpectedly as destructive high waves along shallow coastal water, causing widespread devastation overland along the coast. The East Indian coast in Tamilnadu is about 2000 km from the epicenter of the high magnitude earthquake, which triggered the tsunami. The wave appears to have hit the Cuddalore first, barely one and half hours after the event. That makes the tsunami that hit the Indian coast to be an extremely fast one with a speed of about 900 km/hr. It started out from Sumatra coast in Indonesia and affected countries in the Indian Ocean region, including India, Sri Lanka, and Thailand. It has claimed many lives. The death toll rate along the east coast of India is put at more than 10,000, the worst affected area being Nagapattinam and Cuddalore (Radhakrishna, 2005). In the area of study it has claimed more than 1000 lives, the worst affected regions being Devanampattinam (Cuddalore), Pudupettai and Portonova, and claiming death toll of more than 350 (Tsunami review meeting, 2005).

5. Results and Discussion

Wave energy is the major factor controlling the development of changes in the beach (Johnson, 1929). The destruction and construction of sedimentological features due to tsunami in the coastal region has modified the coastline configuration as well as geomorphic features of the area of study.

5.1 Pre-Tsunami Scenario

Land fringing the coast is made up of sands, deposited by stream and wind, and recycled and reorganized by the waves that develop the beach. A narrow stretch of sandy beach is observable all along the coastline of the area of study. Though beach accretion is found in its entire length, erosion is noticeably observed between Cuddalore and Pondicherry, indicated by low beach cliff. Hence, the coast has a very wide beach in certain sectors (Cuddalore) and narrows in certain sectors (Pondicherry). This kind of modification may happen due to natural morphodynamic

processes.

Though the nature and form of beaches are different in different sectors, two prominent types are noticed (Fig. 2). In spite of diurnal and seasonal changes in beach profile, the following two beach forms are constantly maintained.

Type 1: The following features of beaches are observed between Cuddalore and Portonova. The slope of the near shore zone is 5°, foreshore zone ranges between 5° and 10° and backshore zone is almost flat. The nearshore zone is submerged under sea water even during low tide. Aeolian activities are common in the backshore region which is rarely submerged during storm surge. Extending from the western end of backshore zone beach, berm, beach ridges, swales are present. In general, the beaches have gentle slope (Fig. 2A) without any cliffs, wave cut terraces, etc. and are also devoid of any river made features.

Type 2: The following features of beaches are observed between Pondicherry and Cuddalore. The break in slope between nearshore and foreshore zone is absent, leading to the formation of gently sloping shore zone. As a result, wider inter tidal zone is observed. A beach cliff (Fig. 2B), ranging in height from 0.5 m to 1.5 m, is significantly observed between foreshore zone and backshore zone.

In general, beaches of the area of study are composed of fine to medium sand. Shingles and pebbles are totally absent. The slope of the terrain is 5° to 10° due east. Apart from medium to fine sand, the beach material comprises shell fragments and pockets of opaque mineral rich sediments. The sand with shelly fragment in northern Pondicherry evidences wave dominance in this region.

5.2 Post-Tsunami Scenario

Incoming waves at beaches start becoming steeper after they touch the ground (above the wave base). Ultimately, they are over steepened, and break up in the breaker zone. It is followed by swash zone. During tsunami, the effective wave base reaches deeper parts of shoreface profile than during calm sea, and at ordinary waves. As the morphology of beach and grain size distribution is strongly controlled by wave action, beach has been drastically modified by the single giant wave motion.

The observation, made after tsunami, indicates that the entire coastal segment exhibits the type 1 of beach with more or less flat nature.

In Bommiyapalayam, cliffs are destructed and foreshore gales region become more or less flattened,

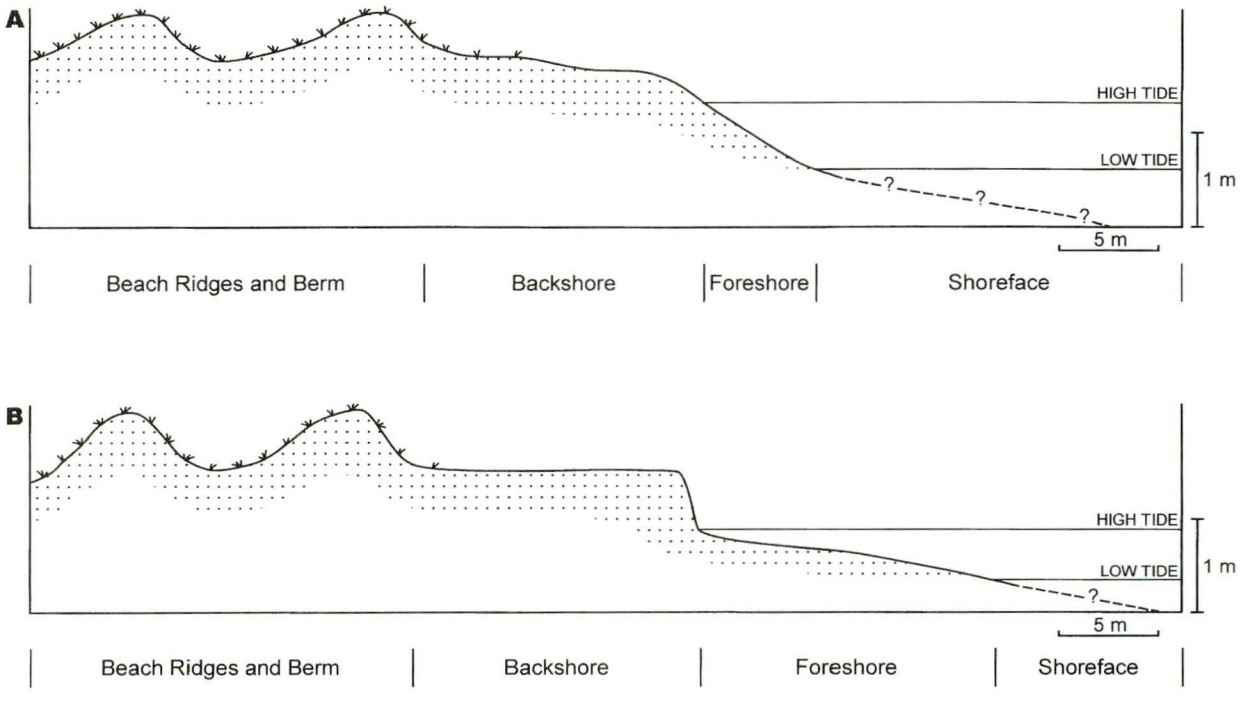

Fig. 2. Sketch showing two prominent types of beach profile.

without any morphological features (Plate 1, Figs. A and B). The pre- and post-tsunami photographs of Kottakuppam beach (Plate 1, Figs. C and D) depicts the erosive nature of tsunami wave by the amount of sediment washed off from berm and the present sea waves, occupying the pre-berm area. The uncovered coconut tree roots at Kottakuppam region are also evidences of the removal of sediments from the beach. By the action of giant wave in Veerampattinam region, the *Halodule* and *Cymodocea* (commonly grown over sands which accumulate and binds the sand) had been removed and had laid the sand bare (Plate 1, Figs. E and F). The rise and fall of tides cause characteristic sedimentary structures (Wunderlich, 1972). In Cuddalore, Silver beach displays characteristic features of very shallow water, and features associated with falling water level and intermittent sub-aerial emergence of sedimentation surface are found as seen by swash mark, adhesion ripples, various foam marks, rill marks and flat topped ripple (Plate 2, Fig. A). Tsunami has blown the beach slope and has made it more or less flattened, causing sea water to invade considerable portions of beach and also expanding its encroachment into the beach during high tide (Plate 2, Fig. B). Demolished concrete structures and ravaged homes (Plate 2, Fig. C) also manifest the energy of tsunami wave.

In Portonova region, sand bar has been submerged and advancement of shoreline over 30m has been noticed, it is clearly evidenced by the wave action at submerged sand bar region and at the present coast (Plate 2, Fig. D). The water level evaporate markers (Plate 2, Fig. E) in the houses, situated 250 m away from the coast at Pudupettai, indicates the duration, stages of retreat and amount of water expelled from sea. The ardour of the tsunami is also displayed by boats dislodged between the coniferous trees about 350 m away from the coast at Portonova (Plate 2, Fig. F).

The impact of tsunami over the type 2 beach (Pondicherry to Cuddalore) was less when compared to the type 1 (Cuddalore to Portonova). In the type 2 beach, the features like cliffed coast, stony waste dumped along the coastal regions of Pondicherry to reduce the wave erosion, and the presence of estuaries like Gingee river, Ariyankuppam river, Ponniyar, Gadilam and Uppanar played significant role in reducing the impact of tsunami. The northward location of the type 2 with respect to type 1 led to reduction in the impact of tsunami. Even though Cuddalore coast is the first affected portion in India, the Gadilam estuary played a vital role to protect this region from the impact of tsunami. The entire Silver beach (nearly 1 km) served as the Gadilam river mouth and engulfed the sea water as much as possible into its course. Had there been no such river mouths in Cuddalore region, this region should have been affected more and death toll might have been greater than Nagapattinam. In the type 1 beach, protective features like river mouth and cliffs etc. were absent, causing this terrain more vulnerable to tsunami action by its gentle slope without significant vegetative cover other than Pichavaram mangrove forest in Portonova region buffering the impact of tsunami. The impact of tsunami was also comparatively high since it was southward compared to the type 2. Combinations of these factors led this region as worst affected one in between Pondicherry and Portonova. The higher death tolls reported coastal village is the Pudupettai in the type 1 beach of the area of study.

6. Conclusions

On the basis of pre-tsunami scenario, the study area has been divided in to northern erosional coastal segment (which is retrograding–Pondicherry to Cuddalore) and, southern depositional coastal segment (which is prograding–Cuddalore to Portonova). Recent observations made after tsunami effect indicate that the entire beach have been disturbed and modified as a whole, rendering it very flat and also losing its entity. This leads to the inundation of coastline during high tide for considerable distances. The adverse lesson learned from tsunami emphasizes the necessity and the need for enforcing the coastal regulation zone (CRZ) act. Coastal forest development between the villages and CRZ along the coastal region for a distance of 500 m will reduce the energy of such natural damages. The immediate need for India is to generate tsunami warning system and communication facility and educating the people on the methods of overcoming the effects of such natural disaster.

Acknowledgements

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Plate 1.

Fig.A. Active cliff in Bommiyapalayam beach (pre-tsunami).

Fig.B. Cliff demolished by tsunami wave in Bommiyapalayam beach.

Fig.C. Beach in Kottakuppam (pre-tsunami).

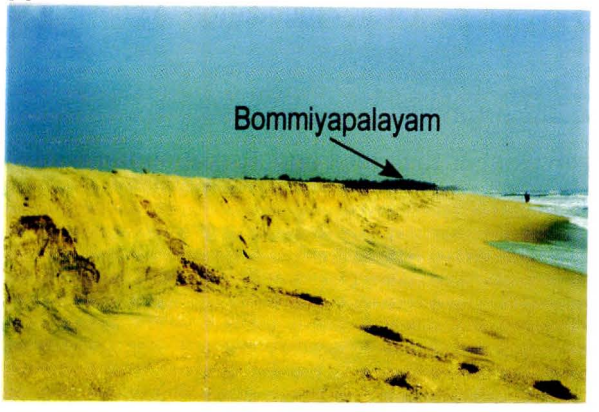
Fig.D. Beach sand washed off by tsunami wave in Kottakuppam.

Fig.E. *Ipemoera* in the beach sediments acts as sand binder in Veerampattinam (pre-tsunami).

Fig.F. *Ipemoera* in the beach sediments are eroded by tsunami wave in Veerampattinam (pre-tsunami).

Plate 1

A



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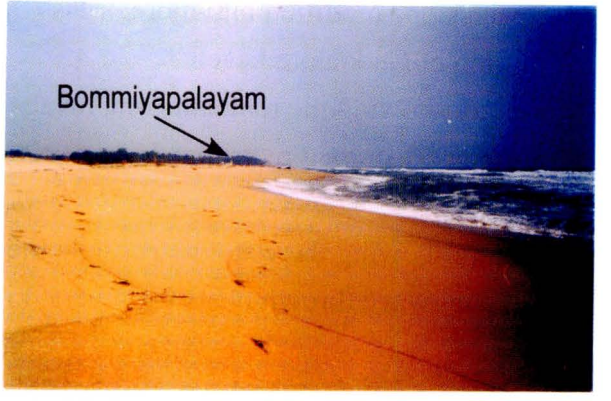

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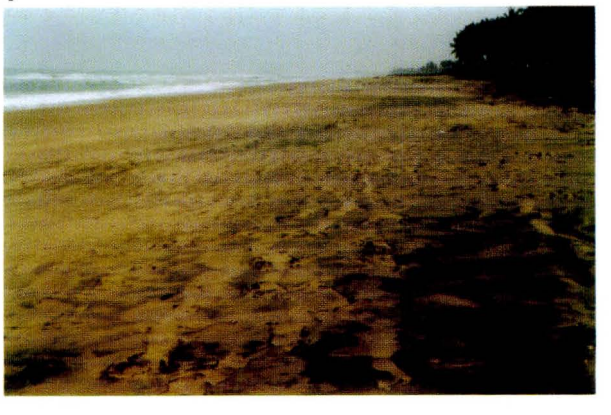


Plate 2.

Fig. A. Swash, rills and foam marks in Silver Beach of Cuddalore.

Fig. B. Beach slope modified into more or less flattened to cause sea water inundation to considerable portion of Cuddalore beach.

Fig. C. Picture showing the remnants of a ravaged home at Portonova.

Fig. D. Sand bar disturbed by tsunami wave. Note the waves near the coast and also at submerged sand bar.

Fig. E. Picture showing the water marks in home.

Fig. F. Tsunami wave thrown boats for several kilometers.

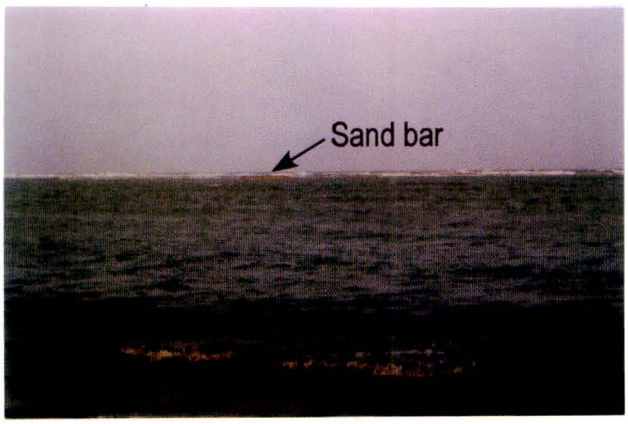
Plate 2

A

B

C

D



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