

# Shoreline Changes along the Poompuhar Tranquebar Region

Sundaresh, Jaya Kumar S, and Sanil Kumar V  
National Institute of Oceanography,  
Dona Paula, Goa  
Email: [sundares@nio.org](mailto:sundares@nio.org)

## Abstract

Poompuhar, a flourishing port in the beginning of the Christian era played a major role in maritime activities and cultural expansion in the history of India. The marine archaeological explorations around Poompuhar brought to light the remains of terracotta ring wells, brick structures, storage jars in the inter tidal zone and brick structures, stone structures, pottery from offshore explorations strongly support the habitation sites. There are several references suggesting the shift of shoreline at Poompuhar and Tranquebar, which may be one of the reasons of its submergence. The main process directly responsible for shoreline change is influenced by the waves. The studies on waves were used to estimate the long shore sediment transport, which indicates the predominant direction of transport is northerly from March to October and southerly from November to February. Cyclones during north-east monsoon would considerably increase the volume of sediment transport towards south with a short spell. It is noticed that for the occurrence of every cyclone there was a permanent loss of beach due to erosion. The global sea level is estimated to be 1 mm per year and may have resulted in 2 m net sea level rise in the last 2000 years. Since the near shore bathymetry gradient is gentle 1 m sea level rise may cover up to several hundred meters of coastline. The recent inundation during tsunami was up to 500m from the shore. The paper deals with the archaeological findings around Poompuhar and the impact of coastal processes on the shoreline change in the area, which was responsible for the submergence of ancient port town and other monuments in the region.

## Introduction

The ancient ports of the east and west coasts of India have played a dominant role in the transoceanic trade and commerce with Arab countries, Africa, Rome and Southeast Asian countries. The ports located on the Bay of Bengal, namely Tamralipti in West Bengal, Palur in Orissa, Kalingapatnam in Andhra Pradesh and Kaveripattinam in Tamil Nadu are noted not only for brisk maritime trade but also for the spread of the Indian culture in foreign land from the beginning of the Christian era up to the 11<sup>th</sup> century A.D. Many such port towns that existed on the coastal region got either vanished or submerged in the sea, may be due to coastal erosion, sea level changes, neo-tectonic activities etc. Several ancient literature across the country refer to submergence of the prosperous cities. The traditions, like submergence of the Golden City of Dwarka mentioned in Mahabharata, Sangam literature referring the submergence of Poompuhar and popular belief of submergence of Temples of Mahabalipuram, 'Kumari Kandam' traditions of Tamil Nadu etc., are well known as they are passed on from father to son as a local tradition. It may well be impossible to search their root or find proof as such of these beliefs. Nevertheless,

many archaeological explorations have been taken up. Though direct specific traditions and mythology have not been found, the artefacts found during such land excavations in different parts of the country support the presence of habitation.

Poompuhar, also known as Kaveripoompattinam is situated (Lat. 11° 08' 33" N and Long. 79° 51' 31" E) on the east coast of India (Figure 1). Several texts of Sangam literature (3<sup>rd</sup> century B.C. to 3<sup>rd</sup> century AD) such as Silappathikaram, Pattinappalai and Manimekhalai mention about the important port towns of Tamil Nadu including Poompuhar the port capital of early Cholas. Cilappatikaram mentions that the city was spread over an area of 4 Kavatham, approximate to 30 square miles with about 60,000 families in 30 villages (Damodaran, 1992).

The Manimekhalai further mentions that the Chola king had lost his son and in his great grief he forgot to celebrate the annual Indra festival (Nandakumar, 1989). This enraged the goddess Manimekhalai who caused the city to be swal-

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lowed by the sea. Though the reference is only to a supernatural incident, it may be taken as an echo of some actual sea erosion due to high tidal wave/storm surge that engulfed/lashed out the city.

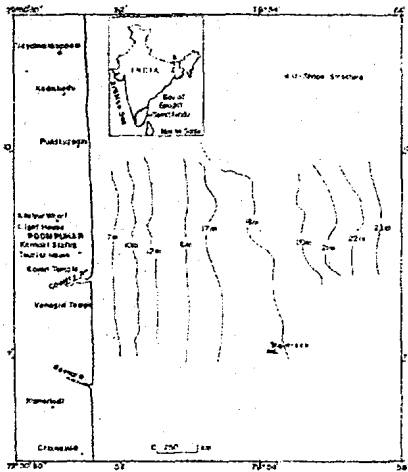


Fig. 1. Location and survey map of Poempuhar and surrounding sites.

The archaeological findings around Poempuhar are the copper coins (Soundararajan 1994), beads of semi-precious stones, amphora ( Rao 1965) and an I-shaped brick structure, (IAR 1962-63; Rao, 1965; Raman, 1968). Wharf at Kilaiyur, reservoir, (IAR 1962-63) and the terracotta ring wells are the habitational evidences down to Tranquebar on the south.

### Methodology

Onshore and inter tidal zone explorations were carried out to collect the information on coastal archaeology followed by offshore explorations, including both geophysical surveys and underwater diving (NIO technical report, 1997). Wave data available at NIO for Nagapattinam and Nagore was used to evaluate the wave climate and sediment transport rate.

### Results and Discussions

A brick structure of eleven courses having 1.2 m width, 1.2 m height and 4 m length, parallel to the coast (Pl. 51) and a terracotta ring well with three courses of 25 cm height, 4 cm thickness of rim with a diameter of 75 cm were exposed (Pl. 52) in the inter tidal zone at Poempuhar.

Four brick structures of 25 m in length, 3.4 m in width with the bricks of 22x13x6 cm aligned in a line were noticed about 60 m from the high water line at 1 m water depth opposite to present Kaveri temple.

Three terracotta ring wells of 75 cm diameter, 15cm height, and 6 cm thickness were exposed about 300 m south of Yellaiyamma temple at Vanagiri. A neatly paved floor of brick structure, probably floor of a house was exposed in inter tidal excavation (Pl. 53).

An 11<sup>th</sup> Century AD Yellaiyamma temple was collapsed and fallen in the inter tidal zone at Vanagiri. A terracotta ring well with a rings of 25 cm height, 5 cm rim thickness and 115 cm diameter surrounded with burnt bricks associated with megalithic black and red ware and other associated materials like beads of semi-precious stones such as agate, crystal carnelian and varieties of glass and a terracotta were noticed in a trench at beach site near Chinnavanagiri. The other important finds from here are inscribed Brahmi 'Ma' on a potsherd, an early Chola square coin (completely eroded) and the later Chola coins.

Tranquebar is situated about 15 km south of Poempuhar and has the habitation of late Chola period to till day. The Masilamani temple of the 10<sup>th</sup> century AD is under threat as the sea has almost destroyed more than 50% of the temple (Pl. 54) and is likely to engulf the entire temple in near future. The remains of Dutch fort have been submerged in the sea. The brick wells of Danish period were completely exposed in the inter-tidal zone. There are also evidences in Tranquebar about the destruction of modern houses due to the encroachment of sea (Sundaresh et al 1997). The coins of Chola, Dutch and Danish period were collected from inter tidal zone of Tranquebar. The entire Tranquebar was well protected by a fort wall including Masalamani temple and Dansberg museum with a sufficient distance from the shoreline as shown in the map prepared by the Danish rulers in the mid 17<sup>th</sup> century.

Under water explorations were conducted between grid size Tranquebar and Nayakankuppam for a distance of about 25 km with a small grids at Tranquebar and Poempuhar which revealed several isolated objects as

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rock boulders at a depth of 7-8 m and 11-13 m opposite to Masilamani temple (Vora 1987, Rao 1992, Rao 1991a). Further, south of Tranquebar, sonograms and echograms recorded the extension of submerged river valleys of Nandalur and Uppanar (Rao, 1991b). Off Poompuhar between the water depths of 5.5 to 10.5 m, presence of three major sites of interest namely, southern bank of river Cauvery, off Pudukkuppam and off Nayakankuppam were observed.

A few dressed stone blocks measuring 90 X 40 X 15 cm, a semi circular stone with a L-shape cut on its surface and many other irregular blocks of sandstone were noticed in 5 to 8 m water depth off Cauvery mouth. The other findings during airlifting operations are brickbats and early historic pottery of Black and Red ware, Red ware, Buff ware and Grey ware (NIO Technical Report 1995).

The airlifting operations at north of Poompuhar revealed a few dressed stone blocks in three general dimensions (30x20x5 cm, 65x40x10 cm and 60x35x10 cm) including the potsherds of Grey ware and huge storage jars at 1m below the sea bed. The echograms of the Sub-bottom profiler revealed a submerged paleochannel of the river Kaveri on the north of Poompuhar at 10 to 15 m water depth, with a width of 300 m to 500 m buried at 20 m below the sea bottom (NIO technical report 1997).

Three objects identified by geophysical surveys at 22-24 m water depth off Poompuhar (Vora 1987, Rao 1992, Rao 1991) were confirmed by diving. They are lying in north south direction. The first structure was located at a water depth of 23 m about 5 km off shore and is oval in shape. The total periphery of the object is 140 m. North-south length of the object is 40 m and east-west length is 20 m. The height of the object on the outer edge is 3 m while on the inner side maximum height is 1 m. The height of eastern arm is greater than that of the western arm. The width of the arm varies from 3 to 6 m. The centre of the object is covered with sediments and rock patches. About 40 m north of the above object, two smaller objects of the same material were noticed. These two objects are lying in east-west direction with a distance of 10 m. The circumference of each object is not more than 15

m and their height is about 2 m. They have a maximum height in the centre and edges are sloping. There are a number of wide cracks on the objects. A few blocks are of 2 m in length 1.5 m in breadth and 1 m in height. A few smaller blocks measure 100 X 60 X 20 cm (NIO Technical report 1995, 1997).

During marine archaeological explorations, a large number of ring wells, brick structures, storage jars and brick paved platforms were noticed in inter tidal zone. A ring well was excavated near Chinnavanagiri where habitation site is also preserved. The pottery from the site suggests that the ring well can be dated to 2<sup>nd</sup> century BC as one of the potsherds is inscribed in Brahmi 'Ma'. The other ring wells found at Vanagiri and Poompuhar are of the same period. Similar kind of ring wells found at Arikamedu and Vasavasamudram belong to the 2<sup>nd</sup> Century BC to the 3<sup>rd</sup> Century AD (Rao, et al., 1995). The brick structure exposed at Poompuhar can be dated to Sangam period. The size of the bricks used is 36x18x6 cm and closely corresponds to the bricks used in Buddha Vihar at Kaveripattinam.

Underwater exploration in shallow water revealed a few well-dressed stone blocks. One of them is a semi-circular in shape along with a number of eroded blocks. This evidence suggests that stones were also used for construction of buildings, but whether they were used for habitation or some other kind of building is still not confirmed. Sangam literature mentions that buildings were constructed of bricks. Airlift operation suggests that habitation site was buried at least 1 m below sediment. The ceramic evidences suggest that the habitation belongs to the early centuries of the Christian era. In the Bay of Bengal the high-energy zone can be considered up to a depth of 8-9 m. As this area is much more disturbed by high waves, currents and tides, it is very difficult to presume that some structures particularly of bricks that were mostly used in Sangam Period would have survived intact in the high-energy zone. It is only the stone structures, which are likely to give a clue to understand the plan.

The U-shaped structure at 23m water depths is a speculation. According to the views of S.R. Rao, T.C.S. Rao and Tamil literature Scholars at Tamil University,

Thanjavur (personal Communications), it may be a man made and probably a Buddhist structure as referred in Sangam literature supposed to be located at the mouth of the river Cauvery. This view gets support from the palaeochannel of the river Kaveri that is in the same direction, which can be connected to the wharf found in Kilayur and the structure found at 23 m water depth. Remote sensing studies also suggest that the palaeochannel of the river Kaveri is to the north of present Poompuhar (NIO Technical report, 1995).

### Coastal Processes

The coastline between Nagapattinam and Poompuhar is almost straight with an inclination of  $359^\circ$  to the north. The coastline is low and the beach material consists of sand sized particles. The sandy beach meets the sea without any prominent rock outcrops or thick vegetation in the foreshore. The beach gradient is gentle to moderate. The variation of monthly beach levels measured near Poompuhar museum indicates that the lowest level occurs in December and the highest level occurs in April. During the study period, the beach was subjected to seasonal changes with erosion during monsoon and accretion during fair weather. The beach was stable without any significant loss of material over the one-year cycle. It has to be stressed over here that no cyclone has occurred during the period of one-year study. Since there were no cyclones during the measurement period, the data collected provided normal estimates in the region by which the general processes can be understood.

The studies on waves were conducted in the region for a period of one year to understand the local phenomena responsible for the coastline changes. Based on the analysis of the wave records, the significant wave heights persisted between 0.5 and 1 m during March to October, and 1 to 2.1 m from November to February with the higher waves occurring during November. The zero crossing wave period predominantly varied between 3 and 8 s in November and December and between 3 and 5 s during the rest of the year. The wave direction (with respect to the north) mostly prevailed between  $60^\circ$  -  $120^\circ$  during November to February and  $90^\circ$  -  $120^\circ$  during the rest of the year. As the region is prone to cyclones and they generate high wave activity. The estimated deepwater significant wave

height for the 1977 cyclone, which hit Nagapattinam coast, is 7 m. The beach sand either gets deposited offshore or transported away from the vicinity of the region, which cannot be replenished after the seizure of the cyclone, thereby causing erosion of the coastline. These sediments get deposited near Vedaranniyam coast at the mouth of calm Palk Bay. Rapid land building activity in this region was observed by Ramasamy et al. (1998).

The measured wave characteristics reduced to breaker zone were used to estimate the long shore sediment transport. From the estimated transport rate, it is seen that the sediment transport is relatively low along the Poompuhar coastline as compared to the rest of Tamil Nadu coastline, north of Pondicherry during the study period. The monthly distribution of littoral transport rate indicates that the southwest monsoon waves have less significance effect compared to the northeast monsoon waves. The predominant direction of transport is northerly from March to October and southerly from November to February. Annual gross transport is found to be  $0.4 \times 10^6$  m<sup>3</sup>/year and the annual net transport is low ( $0.095 \times 10^6$  m<sup>3</sup>/year towards south). The sediment transport during the non-monsoon period is almost equal to the sediment transport during the monsoon period. The low net sediment transport substantiates the stability of the beach from the beach profile studies.

The explorations at Poompuhar and Tranquebar demonstrate that the sea has gradually encroached the land in greater extent since many years. It is worth mentioning here that shifting of Kannagi statue for about 150 m land ward from its original place after it was destroyed by the sea during 1994, was said to have been installed during 1973 about 200 m from the high water line which is a clear indication of advancement of sea. Similarly other monuments were also destroyed in the vicinity by the wave activity.

Several dams were constructed along the course of the river Kaveri for irrigation and hydroelectricity resulting the influx of sediment to the sea has been reduced to negligible amount. The erosion on sandy coastlines is due to less sediment supply from the rivers, especially where dams have been built for reser-

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voirs and also due to shifting of river mouths (Bird, 1984). Subsequently, the sea began to erode the coastline, leading to submergence of several ancient coastal structures of the Poompuhar (Sundaresh et al 1997). The response to a possible rise in sea level relative to the land and the possibility of increased storminess in coastal waters, also a long duration storms can erode the beach to a considerable extent (Caldwell, 1966). The Bay of Bengal is subjected to a large number of high intensity of cyclones compared to west coast of India. Cyclones are short-lived phenomena, capable of causing immense amounts of destruction where they cross the sea and hit the coastline. The cyclones of the east coast are well documented between 1891 and 1970, 42 major cyclones / depressions have been reported from the area. These factors vary in relative importance from sector to sector along sand coastlines. Beach systems are thus dynamic interactions between shore process and coastal sedimentation (Bird 1985).

The narrowness of the eastern continental shelf is also another responsible factor for the coastal erosion. This shelf is less than 50 km wide. Wave propagation over a narrow shelf results in low frictional loss of energy and thus expends much energy on the coastline, causing great coastal erosion. The removal of sand from the beaches results in destabilization and destruction of coastal structures.

The present inclination of coastline at Poompuhar ( $359^\circ$  w.r.t north) is found to be sensitively balanced since, any slight increase in approaching wave angles significantly increase the volume and also may alter the direction of sediment transport in this region. The volume of southerly drift during monsoon months, i.e. in November and December is large to nearly balance the northerly-drift taking place in another 8 months, i.e. from March to October. It is found that for the coastal orientation of  $360^\circ$  to north, i.e.  $1^\circ$  shift in the present orientation, the annual net transport would be opposite, in the southerly direction. Occurrence of cyclones would considerably increase the volume of sediment transport towards south within a short spell. It is noticed that for the occurrence of every cyclone, there was a permanent loss of beach due to erosion. Comparison with the Indian Naval hydrographic Charts (Nos. 3006 and 3007) surveyed during 1963 and 1993 indicates that 150 - 200 m wide coastal belt has been

eroded during the last 30 years and the erosion is still active along the Nagapattinam - Poompuhar shoreline (Jena et al, 2001).

There are specific evidences to indicate that Poompuhar coastline has changed significantly during last 300 years. A study near Tranquebar-Poompuhar indicates remains of a Dutch Fort in Tranquebar now lying in 2-3 m water depth. Based on the original 250 years old map Sundaresh, et al. (1997) have inferred that shoreline has advanced by about 300 m during last 250 years which in turn, indicates a rapidly advancing shoreline at the rate of about 1 m/year. Similarly, the presence of ring wells in the inter-tidal zone confirms retreat of shoreline. The hydrodynamic regime prevailing in the region may be the cause of this severe coastal erosion. In view of above it can be said that shoreline has receded significantly in last 2000 years or so off Poompuhar.

It is interesting to note here that a 12<sup>th</sup> century AD city known as Dunwick in Baltic Sea, Europe, is lying between 5 -16 m water depths as a result of coastal erosion. Besides these, the recent evidences from west coast of India (Nair et al 1997) and Florida (Locker et al 1996), in the Atlantic indicate episodic and on rapid sea level rise and fall of the sea level. The rates reported of 500 to 1000 years. These findings have now dispelled the notion that sea level is a stable and unchanging datum. The inference drawn from the above is that during a period of rising sea level the zone of erosion shifts landward and during a fall in sea level the zone of erosion shifts seaward, resulting in seaward progradation of land. An example of this is the location of ancient ports at Korkai and Algankulam in south Tamil Nadu coast far inland but which were patently designed and located to be on the shoreline.

From the above discussions, it can be attributed that coastal erosion followed by invasion of sea has played a major role in submergence of these structures and sea level changes might have played a contributory role.

### Conclusions

The archaeological evidences from inter tidal zone and offshore have indicated a possible time bracket for the settlement between the 3<sup>rd</sup> century BC and the 3<sup>rd</sup> cen-

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AD. Archaeological evidences have also provided data on the shoreline movements, which is about 300m receding of shoreline occurred in last 300 years at an average rate of one meter per year. If the same rate was continued for the last 2000 years then definitely ancient Poompuhar must have extended far offshore from the present coast. The relative sea level rise has undoubtedly been taking place on coasts where the land margin is subsiding.

The study on waves and sediment movement shows that the Poompuhar coastline is subjected to relatively low volume of transport. It is seen that the occurrence of prolonged high wave activity due to cyclone, during northeast monsoon may tend to change the annual net transport towards south. Under such circumstances, the large volume of southerly transport is likely to enter into the adjacent Palk Bay causing spits/shoals. Large accumulation of sand and emergence of such sand spits/islands in Palk Bay have been widely reported. As the Palk Bay is well protected for southerly waves, no mechanism is set to transport these deposited material towards north. This phenomenon appears to be the primary reason for the timely depletion of sediment supply to the littoral system and for the intermittent erosion along the Nagapattinam - Poompuhar coastal segment. Such processes would have prevailed right from the historical period, accelerating erosion in Poompuhar coast, which may continue till the coastline takes the shape/orientation to balance the littoral drift over an annual cycle.

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