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BENTHIC FORAMINIFERAL AND ITS ENVIRONMENTAL DEGRADATION STUDIES BETWEEN THE TSUNAMIGENIC SEDIMENTS OF MANDAPAM AND TUTICORIN, SOUTH EAST COAST OF INDIA

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ABSTRACT

The Gulf of Mannar is a transitional zone between the Arabian Sea and Indian Ocean proper and is connected with the Bay of Bengal through a shallow sill, the Palk Strait. The study area extends from Mandapam to Tuticorin on the southern coast of Tamil Nadu (India) over a distance of 120 km. It is bound in the northeast by Rameshwaram Island, in the east by the Bay of Bengal, in the west by the Eastern and Western Ghats, and in the south by Tuticorin. A total of 36 sediment samples were collected from the beach (6) and the offshore (30) area in the study region. The offshore samples were collected at six transects keeping the stations at Mandapam (5 nos), Valinokkam (5 nos), Vaippar (5 nos), Vembar (5 nos), Kallar, (5 nos) and Tuticorin (5 nos). Totally, 77 benthic foraminiferal species (Post-tsunami) and varieties belonging to 39 genera, 13 families, 10 superfamilies and 4 suborders have been reported and illustrated. The following species are widely distributed in the pre and post-tsunami samples namely S*piroloculina communis, Quinqueloculina elongatum, Q.lamarckiana, Q. seminulum, Triloculina trigonula, Cibicides lobatululs, Ammonia beccarii, A. dentata, A.tepida, Elphidium crispum* and *Assilina ammonoides*. Grain size studies shows the frequency curves vary from unimodal to bimodal in places of river discharge from the Vembar, Kallar, Vaippar and Tamiraparani, as a result of which an additional sub-population is deposited. At Mandapam and Tuticorin, the total species are increasing in the deeper depths whereas in Kallar there will be reverse trend which decreases with depth. Similarly, the living species also have the same trend at Vallinokkam. The scatter plot of salinity versus living species shows a positive correlation. The scatter plot of organic matter versus living species shows strong negative correlation and positive correlation with dead species showing a negative relation with the biomass. Further, the trend of organic matter vs. carbonate indicates that the littoral drift of sediments brought foraminifera from the inner shelf regions and has played a great role in the contribution of dead species, as well as microfossils. The present study indicated that the sediments were brought from the inner shelf.

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1. INTRODUCTION

Micropaleontology is a discipline well suited to the study of environments, environmental changes, and environmental monitoring of present day contaminated and polluted areas. Of which, foraminifers, almost exclusively marine, unicellular protists, generally consisting of a hard covering of calcium carbonate called a test, have extensively been used for studies related to paleoclimatic reconstruction, sediment transport, archaeology, etc.

After the 26th December 2004 earthquake, a major tsunami wave train traveled with tremendous velocity and transported large quantities of water and sediments, including microfossils. The present study used environmental characteristics and foraminifera distribution to determine the impact of tsunami sediments. The Gulf of Mannar receives input through a number of rivers and streams, of which the Tamiraparani followed by Vaipar River, are the major sources. The coastal area between Mandapam and Tuticorin that was studied was affected by recent tsunamis. The outcome of the tsunami sediment studies of this area based on micro fauna, particularly foraminifera, will give a clear picture about the impacts of tsunami and environmental degradation in this region.

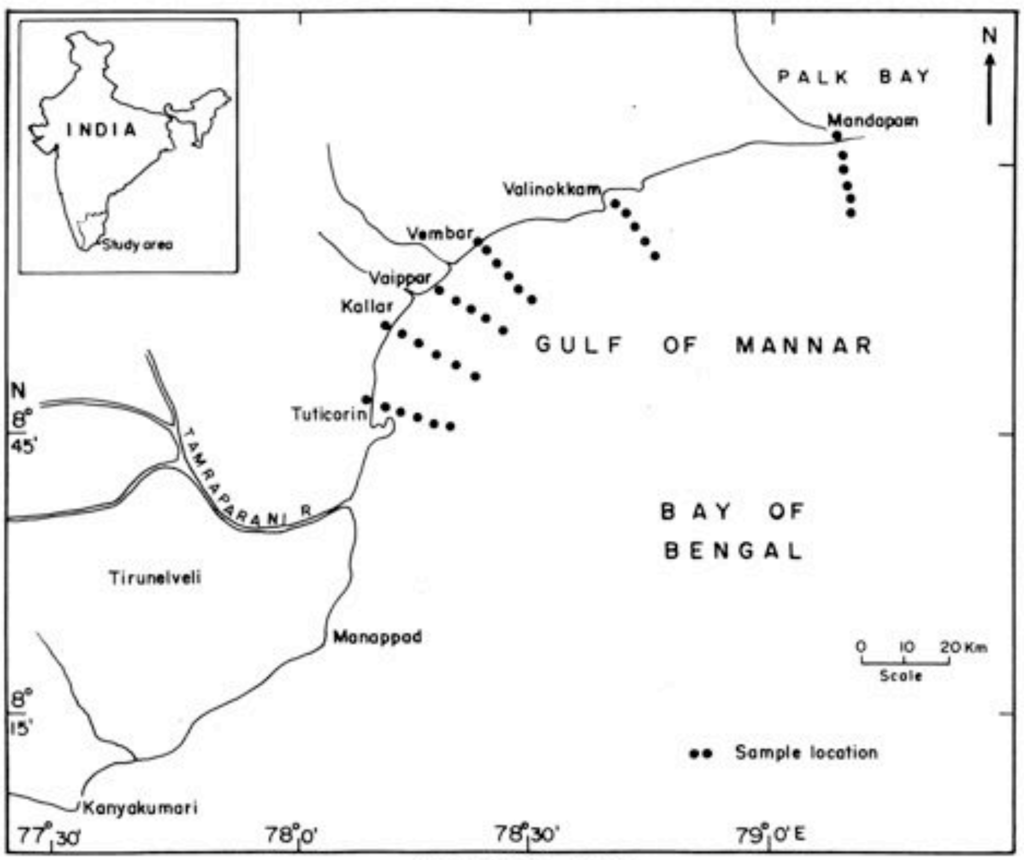

Fig.1 LOCATION MAP


Mandapam South – Pamban bridge **Marine terrace at south of Mandapam**


Marine calcareous sand stone at Valinokkam **Sand dunes at Kallar region**


Shurbs at Vaippar beach **Beach ridge at Vembar beach**

Fig. 2 Coastal landforms of the study region

2. STUDY AREA

The present study area is along the southern coastal tract of Tamilnadu. The coastal stretch between Mandapam and Tuticorin, in the southeastern part of the Tamilnadu State in India, extends over a distance of about 150 km in length. This area is located between 8º 45' to 9º 15' N 78º 35' to 79º 15' E covering the districts of Ramanathapuram and Tuticorin (Fig.1). The study area is situated on the northeastern side near Rameswaram Island, in the east of the Bay of Bengal, bounded in the south by the port of Tuticorin. The study area includes marine terraces, sand dunes, beach ridges, estuaries, floodplains, beaches, mangroves, peneplains, uplands, sea cliff, etc. (Fig.2). The coastal stretch of Tuticorin was extensively studied due to the presence of a major port. Between Tuticorin and Sippikulam, the beach is flat and narrow. The islands of Pandyan Tivu, Van Tivu, Kasuvari Tivu, Vilangu Shuli Tivu and Kariya Shuli Tivu are present within 5 km of the coastline along this segment and offer protection from wave action and erosion.

Three types of beaches are observed in the study area. They are rocky beaches, pocket beaches and sandy beaches. Rocky beaches exist at the Valinokkam and Terukkumukkaiyur coastal region, whereas sandy beaches can be found along Valinokkan, Bay, Keelmundal, Kannirajapuram, Vembar, Vaippar and the Tuticorin coastal areas. A pocket beach was observed near Narippaiyur. The beaches are normally gentle in slope and their width ranges from about 20 to 70 meters. In the Valinokkam, Vaippar and Tuticorin coastal region a well-defined beach ridge system has been recognized that is discontinuous and varies in length and width. The beach ridges are distributed a few kilometers away from the Tuticorin coastline. Spit formation was identified in Valinokkam and Tuticorin. The formation and distribution of spits suggest seaward progradation of the coast in the study area. The drainage pattern of the area is mainly controlled and influenced by the presence of perennial rivers like Gundar, Vembar, Vaippar and Kallar.

3. MATERIALS AND METHODS

Before sample collection, a base map in the scale 1: 50,000 was prepared using the toposheets (NO. 58L/13, 58L/1 and 58M/16). The fieldwork was done during the month of March 2006. Using a private motor launch, a unit volume of 100 ml of wet sediment sample taken from the top 1 cm of the substratum was preserved immediately in 10% neutralized formaldehyde. A total of 36 sediment samples were collected from beach (6) and Offshore (30) in the study region. The offshore samples were collected at six transects keeping the stations at Mandapam (5 nos), Valinokkam (5 no), Vaippar (5 nos), Vembar (5 nos), Kallar, (5 nos) and Tuticorin (5 nos). In the same locations, samples have already been collected by earlier workers (S.M.Hussain – Tuticorin region and Suresh Gandhi, Mandapam region, Rajesakhar – Manappad Region)) has been utilised for comparisons studies.

Global Positioning System (GPS) was used to locate the sample sites in the offshore region. At each station, bottom water samples were also collected and were preserved by adding 10 ml of chloroform. Temperature, pH and Eh were measured in the field immediately after the collection of each sample. In the present study, following Walton's (1952) technique, the sediment samples preserved in neutralized formalin were subjected to laboratory treatment. The preserved samples were washed over an ASTM 230 mesh sieve (0.063 mm) to remove the silt and clay. The sieve with the residue was kept for about an hour in a tray containing an aqueous solution of rose Bengal (1 g of rose Bengal dye in 1 liter of distilled water) ensuring that the residue on the sieve mesh was fully covered by the solution. Then, the material on the sieve was washed to remove the excess stain and dried. The foraminiferal tests were then separated from the residue by floatation method using carbon tetrachloride (Cushman, 1959). As a check, the residue after floatation was re-examined under a binocular stereo-microscope for the presence of any foraminiferal tests left unconcentrated. They were handpicked using `00' Windsor Newton sable hairbrush.

4. RESULTS AND DISCUSSION

4.1 Grain Size

In the present study 24 samples from 6 beach stations have been analyzed. Table. 1 shows the various textural parameters for beach samples (24) obtained through graphic and moment methods. In order to facilitate interpretation of statistical data in the study area, the different sub-population has been identified. In the Valinokkam zone, the frequency pattern point towards the presence of polymodal distribution having peaks at 1.5 φ, 2.25 φ and 2.75 φ. The coarser population of sediments is indicative of the influence of open sea conditions and strong winnowing action that in turn results in the removal of fines. It is supplemented by the presence of rocky beaches around the region. In the Vaippar zone of the study area, the frequency curves have peaks at 2.25 φ, 2.75 φ and 3.75 φ. The characteristic presence of two populations may be attributable to the role of multi sources, probably the contribution of oceanic as well as the rivers like Vembar, Vaippar and Kallar of the study area. Despite the prevalence of high-energy conditions here, the continuous presence of fine sediments may be ascribed to the prolific supply through the rivers as well as from the shelf. The Tuticorin zone also indicates a polymodal distribution. The dominance of coarse size grade in the total population indicates the high-energy conditions that result in the removal of fines. The presence of rocky beaches and convergence of wave pattern near Tamirabarani river mouth accentuate the coarsening of sediments.

The mean reflects the overall average grain size of the sediment as influenced by source of supply and environment of deposition. In the Mandapam zone mean values ranging form 1.48 φ to 1.84-φ indicating with medium sand. In the Valinokkam zone, mean value ranges from 1.46 φ to 1.95 φ indicating a prominent distribution of medium sand in the study area. The mean values demonstrate a gradational increase in the Terkumukkaiyur region of the zone. In the Vaippar zone, mean value fluctuates from 1.28 φ to 2.6 φ and it's characterized by medium sand and fine sand. The lack of winnowing action due to the protected nature of bay leads to the accumulation of the fine sediments. The mean values of Tuticorin zone ranges form 1.35 φ to 1.95 φ indicate the presence of medium sand. It indicates the northerly movement of Tamirabarani riverine sediments by littoral currents. In addition to this, the high-energy environments can also alter the nature of the sediments.

4.1.1 Standard Deviation

The Mandapam and Vallinokkam zones shows more or less similar sorting. The Valinokkam zone sorting value ranges from 0.32 φ to 0.69 φ indicates very well sorted to moderately well sorted nature. The sorting value in Vaippar and Kallar zone ranges from 0.25 φ to 0.80 φ. It indicates a very well sorted to moderately sorted nature. In the Tuticorin zone, sorting value varies from 0.34 φ to 0.62 φ. It indicates a very well sorted to moderately well sorted nature. In the Vaippar zone, the very well to moderately sorting nature may be due to the addition of sediments of different grain size from the reworking of beach ridges or by fluvial action and the prevalence of strong wave convergence throughout the year.

4.1.2 Skewness

The range of skewness values of Mandapam to Vembar, Vembar to Kallar and Kallar to Tuticorin are -0.39 to 0.95, -0.78 to 0.77 and -0.27 to 0.74, respectively. In general, based on the classification of Folk and Ward (1957) the skewness values of these beach sands vary from very negatively skewed to very positively skewed.

In the study region, the sediment skewness varies from near symmetrical to positively skewed. This is probably due to the presence of numerous coastal creeks In the Valinokkam zone, the sediments show coarse skewed to fine skewed (-0.39 to 0.95). It implies the prevalence of high and low energy environments in different wave directions, entailing a mixed distribution of coarse and fine sediments. In the Vaippar zone the sediments show a near symmetrical to negatively skewed nature, suggesting a high-energy environment. Due to washing and backwashing of waves, coarser sediments are retained and get entrapped amidst finer sediments. In the Tuticorin zone, the sediments show very negatively to very positively skewed nature indicative of the prevalence of mixed energy environment.

4.1.3 Kurtosis

The graphic kurtosis varies from 0.51 to 1.26 in the Valinokkam zone. In other words, the Valinokkam zone is very platykurtic to leptokurtic, whereas the Vaippar zone is very platykurtic to very leptokurtic and the Tuticorin zone is very platykurtic to very leptokurtic. The leptokurtic to platykurtic nature indicates multiple environment i.e., one derived from riverine/aeolian environment and the other primarily derived from marine environment. The moment kurtosis values are found to vary from 1.83 to 3.69, 1.65 to 5.46, and 1.60 to 3.68 in the Valinokkam, Vaippar and Tuticorin zones of the study area, respectively. In the Vaippar zone, a strong variation in the Kurtosis value reflects relict sediments along the beach.

4.2 Distribution and Ecology of Foraminifera

The widely utilized classification proposed by Loeblich and Tappan (1987) has been followed in the present study. A total of 77 benthic foraminiferal species (Post-tsunami) and varieties belonging to 39 genera, 13 families, 10 superfamilies and 4 suborders have been reported and illustrated. All the illustrated specimens have been deposited in the Department of Geology, University of Madras, Guindy Campus, Chennai – 600 025. The present study includes the results of the distribution of foraminiferal assemblages in the study area. The *Milionina* and *Rotalina* occupy the dominant place in the post tsunami samples of the study area.

4.2.1 Beach

Forty-nine species are identified from the analysis of 6 beach samples. Among them the species, *A.beccarri* shows a higher abundance in all the stations, barring one or two, followed by *A.dentata* and by *Q.seminulum* and *Elphidium crispum* in all the stations. In general, the beach sample shows that pre-tsunami species are lesser in amount compared to the post-tsunami species. In the study area due to tsunami, the distributions of species are slightly higher in number on the beaches.

4.2.2 Offshore

Out of the 76 taxa identified, only 18 represent the living crop at the time of post-tsunami sample collection. Among them, most of the species are sparingly distributed. The actual number and distribution of total and living foraminiferal species in the offshore region is shown in the Table.2. The significant variation in the distribution of total and living species assemblages may be due to sedimentation as well as due to the wave actions and tidal currents (Murray, 1973). Since the samples are collected after the tsunami, due to the wave actions, the living dead populations also varied in this region.

The general trend in modern shallow water foraminiferal assemblages is the increasing species diversity with increasing salinity gradients and environmental stability. The genus *Ammonia, Elphidium, Pararotalia, Quinqueloculina, Triloculina* and *Spiroloculina* are dominates the total assemblages in the study region. The following species are widely distributed in the pre and post-tsunami samples namely *Spiroloculina communis, Quinqueloculina elongatum, Q.lamarckiana, Q. seminulum, Triloculina trigonula, Cibicides lobatululs, Ammonia beccarii, A.dentata, A.tepida, Elphidium crispum* and *Assilina ammonoides*. The following species are found in lesser amount in all the stations, namely, *Elphidium discoidale, Rectobolivina raphanaus, Cribrononion simplex, Cymbaloporetta bradi, Eponoides rapandus, Spiroloculina aqua* and *S. inca.* Specimens of all species are abundant in the deeper depths.

4.3. Offshore – Pre- and Post- Tsunami

At Mandapam and Tuticorin, the total species increases in the deeper depths whereas in Kallar there is a reverse trend that decreased in deeper depths. The assemblage living species display the same trend at Vallinokkam.

The genus *Ammonia, Elphidium, Quinqueloculina, Triloculina* and *Spiroloculina* dominates the total assemblages followed by *Amphistegina, Globigerina* in the study region. The following species are widely distributed in the post-tsunami samples namely S*piroloculina communis, Quinqueloculina elongatum, Q.lamarckiana, Q. seminulum, Triloculina trigonula,* *Cibicides lobatululs, Ammonia beccarii, A. dentata, A.tepida, Elphidium crispum* and *Assilina ammonoides.*

4.3.1 Station-wise distribution of total and individual foraminiferal species

The distribution of total foraminiferal species according to the different stations shows an appreciable variation among the stations. At Mandapam and Tuticorin, an increasing trend in the total number of species is noticed in the deeper depths. The stations, Kallar and Vallinokkam show the similar trend but increasing trend is noticed from shallow to deeper depths, followed by a sudden decrease. The individual species distribution shows that diversity is greatest towards the shallow regions than the deeper. Even though, the individual species are more abundant in the shallow regions the total number of foraminiferal species are more abundant in the deeper regions with depths ranging form 8 to 12 m.

4.3.2 Station-wise total diversity of Living species

Total number of living foraminiferal species in the offshore region shows (fig.4) that an increase in the number of living foraminifera is observed in post-tsunami samples at the Tuticorin region at deeper depths than the other regions. The lowest diversity is noticed in the shallower depths at Vallinokkam and Kallar region and more or less a close similarity in the trend is noticed. Disturbance in the seabed resulted in low living diversity. Wherever the total species is high, the number of living species is increasing.

4.4. Ecology of the Foraminifera

The salinity measured during the present studies varies from 30.16 ‰ to 31.07 ‰. In all the stations, the salinity shows little variation due to mixing of water within the bay. Furthermore, the river mouth areas like Vaippar, Kallar, and Vembar, etc. display similar salinity. The scatter plot of salinity vs. living species shows a positive correlation (Fig. 3). At Tuticorin salinity values increased towards the deeper depths as did the number of living species. The correlation between depth vs. living species is positive. In the study region, the beach sands are coarser. In the offshore region, the sand is dominant over silt in most stations. Silty sand predominates in the deeper portion. Living foraminiferal populations are more abundant in the silt and silty sand region of the study area. At Vembar silt and silty sand are dominant.

4.4.1 Organic matter

In the study area, organic content ranges from 1.232% to 0.123% are noticed. In the near shore region the organic matter does not shows any variation. The scatter plot of organic matter of living species shows strong negative correlation (Fig.3) and positive correlation with dead species (Fig.3) shows a negative relation with the biomass. Further, the trend of organic matter vs. carbonate (Fig.3) suggests littoral drift of sediment brought from the inner shelf regions have played a significant role in the contribution of dead species as well as carbonate shells. The rise in total amount of living species in deeper portion at Tuticorin may be due to oxygenated conditions in that region

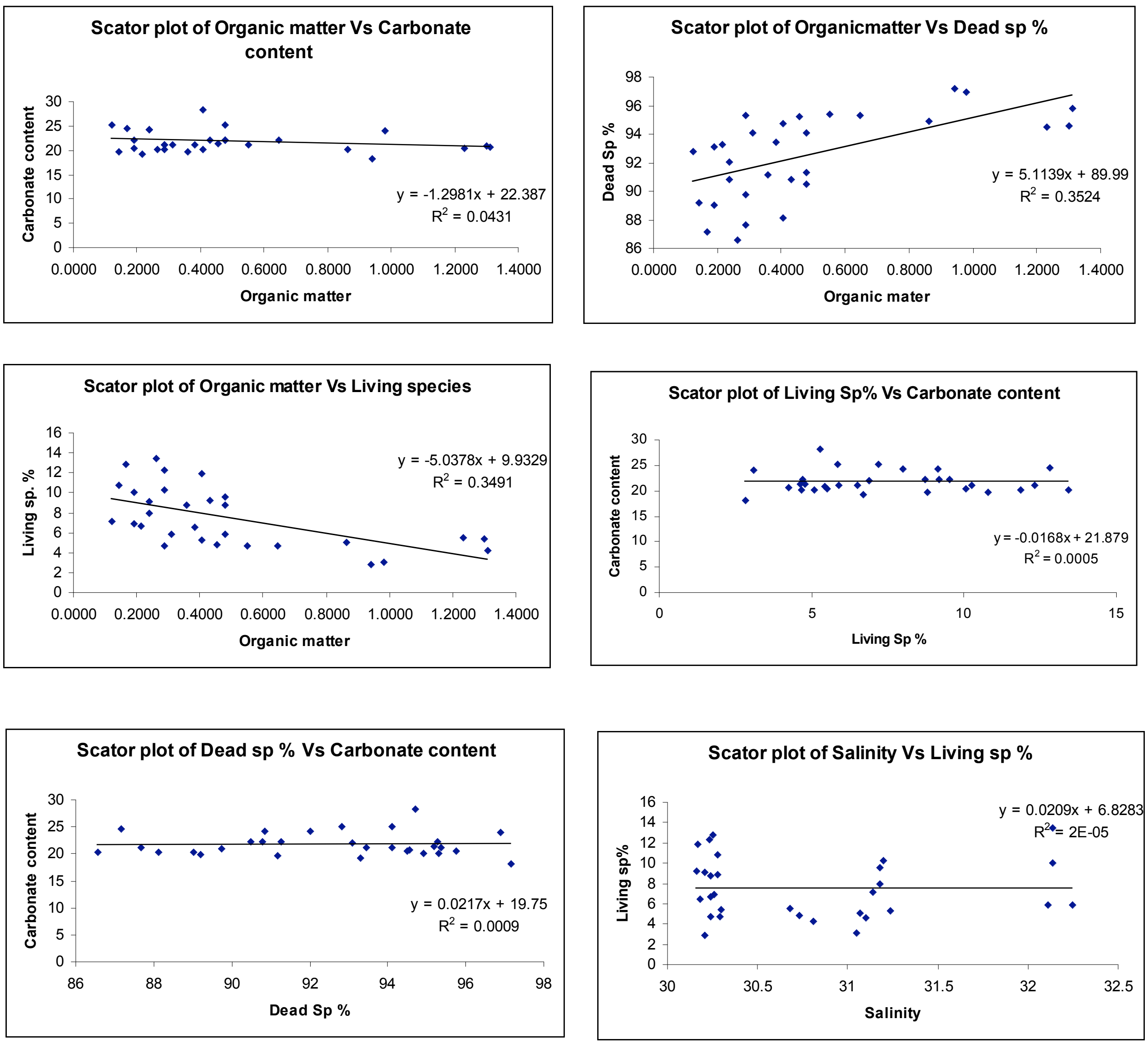

Fig.3. Scatter plots for the different environmental parameters

4.4.2 Calcium Carbonate

In the study area higher carbonate content in the shallow depths in all the stations is observed. In Kallar it is decreased in the deeper depths. The scatter plot of carbonate content vs. living species and organic matter shows the negative correlation (Fig.3) and positive correlations with dead species (Fig.3). It means that weak and strong relation is being maintained between carbonate and living dead species. But, now carbonates must have been the product originated from the other factors, probably the drifted shells from elsewhere or from the coral reef region in the in situ. It indicates that the carbonate present in this region is *in situ*.

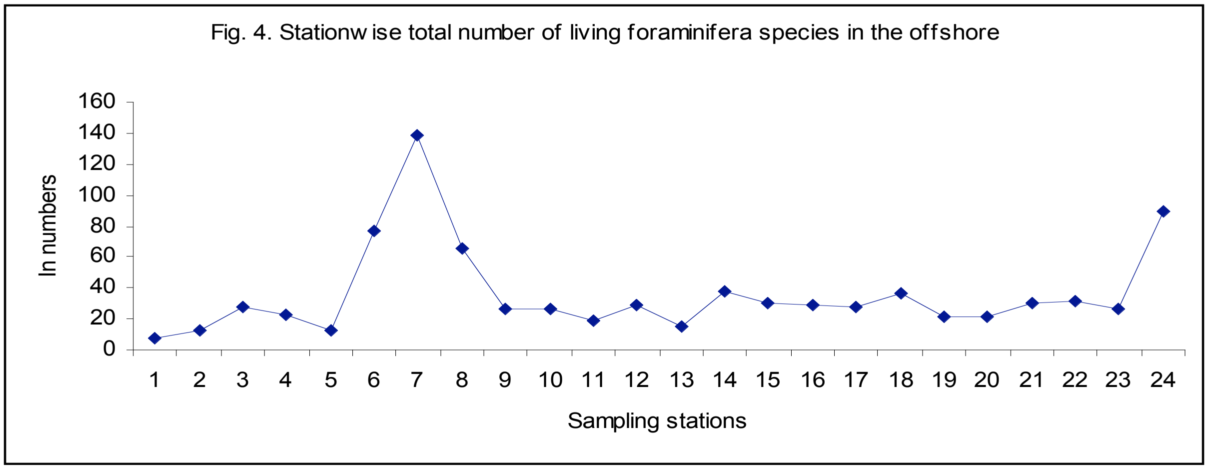

Fig.4. Station-wise total diversity of Living species

4.4.3 Morphological Deformities

In the present study, morphological abnormalities were observed in the species *Osangularia* and *Pararotalia* having abnormal and overgrowth apertures. The broken specimens were found in the beach, offshore and inland region. It may be due to the tidal actions, and strong current activity and industrial wastes at thermal power stations, and harbor, Tuticorin.

4.5. Comparisons with Pre-Tsunami

The comparison of post-tsunami and pre-tsunami data is possible due to earlier workers like S.M.Hussain and Rajesekhar and Suresh Gandhi (2000). The study reveals that in the offshore region at the shallow depths, the fossil enrichment is more in post tsunami sediments than the pre-tsunami samples. Due to the tsunami activities, large amount of sediment were transported from the deeper depths and deposited near the shore regions, hence higher species diversity is noticed near shore region. Table.3. shows the checklist of pre-tsunami and post-tsunami fossils.

The fieldwork carried out in the coastal belt, indicates that the topography has been smoothened as the tsunami overtopped the dune, ridges and transported the material into the low lying areas. It is difficult to estimate where the material is transported unless the dune material is lithologically different from the soil inland. Sand deposits over mudflats, and alluvial flats clearly reveal that a considerable amount of beach deposit have been transported inland. While the eroded features provide insight into the transport of the sediments, how much material has been brought from the deep sea and continental shelf is not clear. Clasts of clay and rare coral debris indicate that the tsunami brought sediments from the sea.

A considerable amount of sediments are transported into the sea via carved channels as much as 5 m wide and 30 m long during the tsunami drain back. So, it is evident that transportation from sea to land, transport of beach material to inland and transport back to the sea have taken place. The erosion appears to be more in the northern part of the area investigated; on the other hand deposition dominates over erosion in the southern part of the area, which is characterized by flat topography (Sanjay Gandhi, 2005).

The total distribution of foraminifera is higher at Mandapam and Tuticorin sector, than in Kallar and Vallinokam. The configuration of the beach may control the distribution of foraminifera species from offshore to the beach. The arcuate nature of the bay and wave energy conditions is the major controlling factors for the distribution of foraminifera.

The study area receives inputs from many small channels and rivers like Vembar, Vaippar, Kallar and Tamirabarani. The land areas through which these rivers and channels flow are well known for agricultural activities. Tsunami sediments entered through the rivers and were deposited inland. The total populations of foraminiferal species are very low in the beach region probably due to erosion. Living populations are also found to be low to moderate in number in the study area.

Several authors, (Yassini and Jones, 1995; Murray, 1991; Nigam et al., 1979; Haig, 1988) have studied and reported the distribution of foraminifera in various regions and concluded the distribution of species reflect different environments. Kamalakanan et al (2005) have studied the tsunami sediment from the Nagapattinam coast and inferred that the majority of foraminiferal species are inhabit coastal water and hence the sediment would have been removed from the near shore coastal water zone by tsunami waves and spread over the coastal line. Rao et al., (2005) have studied the tsunami laid sediments along the North Chennai coast and suggested that the fossils distributed in these areas have been transported from the inner shelf region, probably at depths less than 30 m. From the overall studies of foraminiferal distribution in this region, it may be inferred that the species distribution in the offshore region is mainly derived from the inner shelf region. Due to tsunami activities the offshore species are deposited in the beach, accompanied by transport of beach material to inland and transport back to the sea.

5. CONCLUSIONS

The study of a composite cosmopolitan fauna of 76 species belonging to 39 genera, 24 families, 16 super families and 5 suborders from the samples collected from post-tsunami beaches and offshore samples is reported here. Grain size studies shows the frequency curves vary from unimodal to bimodal in the proximity of river discharge from the Vembar, Kallar, Vaippar and Tamiraparani. The offshore region of Mandapam and Tuticorin receives higher species diversity than the Kallar in post tsunami samples. In general, the distribution of pre-tsunami fossils is less than the post-tsunami distribution. This may be due to the impact of tsunami action. Furthermore, salinity and carbonate content are the controlling factors for the distribution of foraminifera in this region. A thorough review of literature of foraminiferal research from the Indian subcontinent reveals that the foraminiferal species distributed in this region were brought from the deeper depths particularly form the inner shelf region due to tsunamigenic activities. It will be essential to track the source of sediment in the deeper part by carrying out a detailed investigation on the microfossil studies.

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LIST OF TABLES (Tables divided because of size)

Table.1 RESUTLS OF GRAIN SIZE ANALYSIS FOR BEACH SAMPLES

Stations	s.no	ME-Q	MSD-Q	MCD-Q	MSK	MKU	MED-Q	M-Q	SD-Q	SK	KU	FP-Q
		Moment methods						Graphic method				
MANDAPAM												
BERM	1	1.83	0.48	-0.33	-0.03	1.2	1.87	1.86	0.45	0.48	0.48	-0.99
HIGHTIDE	2	1.84	0.43	1.66	0.17	1.14	1.8	1.8	0.4	0.49	0.44	-0.98
MIDTIDE	3	125	0.29	-0.38	0.03	1.12	1.49	1.8	0.28	0.12	0.54	0.98
LOWTIDE	4	1.45	0.26	2.75	0.84	1.74	1.48	1.4	0.25	0.15	0.82	0.97
VALINOKKAM												
BERM	5	1.87	0.45	-0.33	-0.03	1.1	1.83	1.81	0.42	0.44	0.45	-0.98
HIGHTIDE	6	1.84	0.43	1.66	0.17	1.14	1.8	1.8	0.4	0.49	0.44	-0.98
MIDTIDE	7	1.45	0.28	-0.34	-0.03	1.08	1.43	1.4	0.269	0.19	0.44	0.99
LOWTIDE	8	1.44	0.24	2.71	0.85	1.7	1.42	1.41	0.22	0.13	0.79	0.95
VEMBAR												
BERM	9	2.11	0.54	0.48	0.9	1.13	2.1	2.08	0.59	0.15	0.79	0.96
HIGHTIDE	10	2.06	0.59	-0.94	-0.14	1.4	2.04	2.03	0.65	0.27	0.5	-0.98
MIDTIDE	11	2	0.57	0.48	0.71	2.39	2	1.98	0.55	0.24	1.41	1.02
LOWTIDE	12	1.94	0.32	0.64	0.06	1.12	1.93	1.91	0.32	0.3	0.45	-0.98
VAIPAR												
BERM	13	2.1	0.78	-0.67	-0.16	1.16	2.08	2.05	0.74	-0.37	0.42	0.99
HIGHTIDE	14	2.05	0.74	0.73	0.1	1.25	2.04	2.01	0.72	0.3	0.46	1.03
MIDTIDE	15	2.02	0.69	0.2	0.02	1.18	2.01	1.99	0.69	0.27	0.46	-0.98
LOWTIDE	16	1.92	0.51	-0.42	-0.28	1.26	1.92	1.9	0.5	-0.92	0.49	-0.98
KALAR												
BERM	17	2.01	0.62	0.61	0.77	1.88	2	1.99	0.6	0.76	0.62	0.99
HIGHTIDE	18	1.57	0.43	0.67	0.61	2.36	1.57	1.5	0.43	0.21	0.75	0.24
MIDTIDE	19	1.69	0.39	0.23	0.71	2.24	1.63	1.61	0.33	0.33	1.19	-0.98
LOWTIDE	20	1.58	0.27	0.59	0.71	1.88	1.56	1.53	0.22	0.61	0.45	0.99
TUTICORIN												
BERM	21	1.67	0.58	0.85	0.23	2.11	1.66	1.64	0.53	0.94	0.8	0.96
HIGHTIDE	22	1.69	0.53	0.11	0.39	2.32	1.69	1.63	0.5	0.65	0.71	0.96
MIDTIDE	23	1.64	0.34	0.25	0.02	2.81	1.64	1.62	0.34	0.84	0.79	0.96
LOWTIDE	24	1.62	0.31	0.92	0.38	2.21	1.62	1.6	0.3	0.45	0.73	0.96

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Table.2. Distribution of total and living foraminiferal species between Mandapam and Tuticorin (offshore)

Sl.No	Station Numbers	Mandapam										Valinokkam									
	Depth in mts	1m		2m		4m		5m		5.5m		2m		3m		4 m		4.5m		5m	
	Name of Species	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
1	*Ammobaculites exiguus*					0	2	0	1	0	3	0	1								
2	*Textularia agglutinans*			0	1			0	2					0	1	0	2				
3	*Textularia conica*											0	1								
4	*Vertebralina striata*			0	2	0	1	0	2	0	3	0	2	0	1	0	4	1	4	1	3
5	*Edentostomina cultrata*	0	1	0	2													0	1	0	1
6	*Adelosina laevigata*	0	2	0	7	0		0	8	0	12										
7	*Spiroloculina angusta*			0	2	0	1														
8	*Spiroloculina affixa*	0	1	0																	
9	*Spiroloculina communis*	0	4	0	3	0	1	1	14	1	10					0	2	0	1	0	2
10	*Spiroloculina costifera*					0	1	0	1												
11	*Spiroloculina depressa*	0	1	0	2	0	1	0	2	0	1										
12	*Spiroloculina orbis*					0	2	0	1	0	1			0	1						
13	*Spiroloculina sp1*	0	1									0	1								
14	*Spiroloculina sp2*	0	1																		
15	*Massilina secans tropicalis*					0	2	0	2	0	1										
16	*Vertebralina striata*					0	1	0	1							0	2	0	1		
17	*Quinqueloculina agglutinans*			0	2	0	4	1	12	0	7										
18	*Quinqueloculina bicostata*	0	2	1	5	0	1		8	0	2										
19	*Quinqueloculina costata*	0	1	0	3			0	3												
20	*Quinqueloculina elegans*			0	2	0	1	0	5	0	1										
21	*Quinqueloculina lamarckiana*	0	2	1	5	2	12	1	7	0	5	0	2	0	2	0	3	0	2	0	1
22	*Quinqueloculina polygona*	0	3	0	2	0	4	0	8	0	7										
23	*Quinqueloculina seminulum*	0	12	2	12	1	8	0	12	0	5	0	2	0	4	0	4	0	6	0	1
24	*Quinqueloculina elongatum*			0	3	0	2	0	1			0	4	0	1	0	1				
25	*Quinqueloculina tropicalis*			0	8	0	6	0	3			0	3								
26	*Quinqueloculina sp 1*																				
27	*Quinqueloculina sp 2*																				
28	*Miliolinella circularis*			0	2	0	2	0	1			0	1	0	1						
29	*Triloculina oblonga*																				
30	*Triloculina insignis*	0	2	0	2									0	2	0	1				
31	*Triloculina schreiberiana*	0	1	0	5																
32	*Triloculina terquemiana*	0	1	0	2																
33	*Triloculina tricarinata*	0	8	1	18	0	16	0	3			0	2								
34	*Triloculina trigonula*	0	2	0	18	1	23	2	32	1	29	0	3	0	4	0	4	0	2	0	1
35	*Hauerina bradyi*					0	1	0	0	0	1										
36	*Articulina pacifica*	0	2	0	1																
37	*Rupertianella rupertiana*	0	1	0	3	0	4	0	4	0	1			0	2	0	2				
38	*Sorites marginalis*					0	2	0	3	0	1										
39	*Peneroplis planatus*							0	1	0	1										
40	*Lagena striata*									0	2									0	2
41	*Bolivina nobilis*							0	1	1	5									0	1
42	*Brizalina striatula*							0	1												

43	*Cancris auriculus*					0	2	0	2												
44	*Eponides repandus*					0	2	0	1												
45	*Rosalina globularis*	0	8	2	7	1	9	1	11	2	12			0	4	0	2	2	5	2	4
46	*Discorbinella bertheloti*			0	2																
47	*Cibicides lobatulus*	0	2	2	12	0	2	0	4									0	1	0	1
48	Cassidulina laevgata							0	1												
49	*Cymbaloporetta brodyi*	0	1															0	1		
50	*Amphistegina lessonii*					0	1	0	1									0	2	0	1
51	*Amphistegina radiata*					0	12	2	24	1	17								0	1	0
52	*Nonionellina labradorica*	0	3	0	4	0	2														
53	*Nonionoides boueanum*	0	2																		
54	*Nonionoides elongatum*			0	5			0	3												
55	*Peneroplis planatus*			0	1							0	1	0	2						
56	*Pararotalia calcar*	0	22	2	17	1	28	1	18			0	7	0	5	2	18	1	24	2	17
57	*Pararotalia nipponica*	2	28	6	68	12	150	25	164	12	102	0	12	2	41	1	24	2	14	2	14
58	*Ammonia beccarii*	3	68	6	92	21	290	4	28	12	159	1	18	2	16	2	154	2	174	1	79
59	*Ammonia deviata*	1	12	0	4	0	3	0	4	0	14	1	8	0	10	2	18	2	24	2	17
60	*Ammonia tepida*	1	10	0	2	0	2	0	4	0	8	2	24	2	112	7	141	2	54	1	75
61	*Asterorotalia inflata*															0	1	0	2		
62	*Asterorotalia trispinosa*					0	4	0	2												
63	*Pseudorotalia schroeteriana*			0	3	0	1							0	2						
64	*Edentostomina cultrata*					0	2														
65	*Elphidium advenum*	0	2					0	4			0	2								
66	*Elphidium craticulatum*					0	2					0	2								
67	*Elphidium crispum*	0	0	1	14	2	14	0	1	0	4	0	4	0	11	2	15	2	14	1	21
68	*Elphidium discoidale*	0	4	0	2	0	1	0	2	0	1	1	2	0	1	0	1	0	2	0	4
69	*Elphidium incertum*	0	3									0	3	1	5	0	3	0	2	0	4
70	*E.excavatum*					0	1	0	1	0	1					0	1	0	1		
71	*E.macellum*					0	1	0	1	0	1					0	4	0	1		
72	*Elphidium sp1*																				
73	*Elphidium sp2*																				
74	*Parrellina hispidula*	0	1	0	1							0	1								
75	*Rectobolivina Raphanus*			0	3			0	1	0	1			0	2	0	1				
76	*Assilina ammonoides*			0	3	1	5	4	26	2	12							0	2	0	1
77	*Osangularia venusta*	0	12	0	17	2	26	1	48	2	62	2	141	12	120	2	17	21	147	5	75
	TOTAL	7	**226**	24	**369**	44	**657**	43	**458**	34	**88**	7	**247**	19	**350**	18	**425**	35	**487**	18	**327**
	Number of Genus	*2*	*16*	*7*	*25*	*8*	*25*	*10*	*28*	*9*	*11*	*3*	*13*	*4*	*15*	*4*	*19*	*6*	*12*	*5*	*13*
	Individual species	*4*	*34*	*10*	*41*	*10*	*45*	*12*	*48*	*9*	*32*	*5*	*24*	*5*	*24*	*6*	*28*	*8*	*24*	*10*	*21*

43	*Cancris auriculus*										
44	*Eponides repandus*										
45	*Rosalina globularis*	0	2	1	3	0	4	0	2	0	3
46	*Discorbinella bertheloti*	0	2	0	1						
47	*Cibicides lobatulus*			0	3					0	2
48	Cassidulina laevigata										
49	*Cymbaloporetta bradyi*										
50	*Amphistegina lessonii*	1									
51	*Amphistegina radiata*	0	6	0	9			0	1	1	8
52	*Nonionellina labradorica*		3	0	2			0	1	0	2
53	*Nonionoides boueanum*		2	0	3	0	3	0	2	1	4
54	*Nonionoides elongatum*		48	5	22	4	24	4	47	14	41
55	*Pyneropsis planatus*										
56	*Pararotalia calcar*										
57	*Pararotalia nipponica*	0	24	0	12	1	6			0	2
58	*Ammonia beccarii*	7	20	6	26	2	12			2	18
59	*Ammonia dentata*	3	38	5	33	4	34	3	54	3	34
60	*Ammonia tepida*	4	48	6	32	6	41	2	78	4	54
61	*Asterorotalia inflata*			0	6	0	4			1	6
62	*Asterorotalia trispinosa*										
63	*Pseudorotalia schroeteriana*	0	1	0	2						
64	*Edentostomina cultrata*										
65	*Elphidium advenum*										
66	*Elphidium craticulatum*										
67	*Elphidium crispum*			0	1	0	2			0	1
68	*Elphidium discoidale*										
69	*Elphidium incertum*										
70	*E.excavatum*										
71	*E.macellum*										
72	*Elphidium sp1*	0	2	0	1						
73	*Elphidium sp2*										
74	*Parrellina hispidula*					1	5			0	3
75	*Rectobolivina Raphanus*			0	2						
76	*Assilina ammonoides*	0	1	0	1	1	8				
77	*Osangularia venusta*	5	14	1	15	0	14	0	12	0	15
	TOTAL	21	263	28	236	22	204	11	233	27	219
	Number of Genus	*4*	*7*	*7*	*24*	*8*	*14*	*4*	*13*	*6*	*15*
	Individual species	*6*	*26*	*9*	*38*	*10*	*31*	*5*	*16*	*9*	*24*

43	*Cancris auriculus*										
44	*Eponides repandus*										
45	*Rosalina globularis*	0	2	1	5	0	4	0	2	0	3
46	*Discorbinella bertheloti*	0	2	0	1						
47	*Cibicides lobatulus*			0	3					0	2
48	Cassidulina laevigata										
49	*Cymbaloporetta bradyi*										
50	*Amphistegina lessonii*	1									
51	*Amphistegina radiata*	0	6	0	9			0	1	1	8
52	*Nonionellina labradorica*		3	0	2			0	1	0	2
53	*Nonionoides boueanum*		2	0	3	0	3	0	2	1	4
54	*Nonionoides elongatum*		48	5	22	4	24	4	47	14	41
55	*Pyrneropsis planatus*										
56	*Pararotalia calcar*										
57	*Pararotalia nipponica*	0	24	0	12	1	6			0	2
58	*Ammonia beccarii*	7	20	6	26	2	12			2	18
59	*Ammonia dentata*	3	38	5	33	4	34	3	54	3	34
60	*Ammonia tepida*	4	48	6	32	6	41	2	78	4	54
61	*Asterorotalia inflata*			0	6	0	4			1	6
62	*Asterorotalia trispinosa*										
63	*Pseudorotalia schroeteriana*	0	1	0	2						
64	*Edentostomina cultrata*										
65	*Elphidium advenum*										
66	*Elphidium craticulatum*										
67	*Elphidium crispum*			0	1	0	2			0	1
68	*Elphidium discoidale*										
69	*Elphidium incertum*										
70	*E.excavatum*										
71	*E.macellum*										
72	*Elphidium sp1*	0	2	0	1						
73	*Elphidium sp2*										
74	*Parrellina hispidula*					1	5			0	1
75	*Rectobolivina Raphanus*			0	2						
76	*Assilina ammonoides*	0	1	0	1	1	8				
77	*Osangularia venusta*	5	14	1	15	0	14	0	12	0	15
	TOTAL	21	263	28	236	22	204	11	233	27	219
	Number of Genus	*4*	*7*	*7*	*24*	*8*	*14*	*4*	*13*	*6*	*15*
	Individual species	*6*	*26*	*9*	*38*	*10*	*31*	*5*	*16*	*9*	*24*

	Table.7.1 Distribution of living and total foraminifera between Mandapam and Tuticorin (Offshore)																				
#	Station Numbers	Vaippar										Kallar									
	Depth in mts	2m		3m		4m		5m		7m		2m		4m		6m		7m		7.5m	
	Name of Species	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T
1	*Ammobaculites exiguus*	0	1	0	2	0	1	0	2	0	1										
2	*Textularia agglutinans*					0	3	0	3			0	2	0	1	0	4	0	1		
3	*Textularia conica*			0	2		4														
4	*Vertebralina striata*	0	2			0	2	0	1			0	2	0	1						
5	*Edentostomina cultrata*	0	1									0	2	0	2	0	1			0	1
6	*Adelosina laevigata*	0	1	0	1	0	2	0	1	0	3					0	3	0	2		
7	*Spiroloculina angusa*	0	1	0	2	0	1														
8	*Spiroloculina affixa*	0	1							0	1										
9	*Spiroloculina communis*	1	2	0	8	1	6	0	5	1	9	0	3	0	2	1	5				
10	*Spiroloculina costifera*			0	4	0	6			0	3							0	1	0	1
11	*Spiroloculina depressa*			0	1	0	2														
12	*Spiroloculina orbis*			0	1	0	2	1	2												
13	*Spiroloculina sp 1*	0	2																		
14	*Spiroloculina sp 2*																				
15	*Massilina secans tropicalis*	0	2	0	1	0	1														
16	*Vertebralina striata*																				
17	*Quinqueloculina agglutinans*	0	2	0	1	0	2	1	2	0	1	0	2			0	2				
18	*Quinqueloculina bicostata*											0	4	0	3	0	2				
19	*Quinqueloculina costata*																				
20	*Quinqueloculina elegans*																				
21	*Quinqueloculina lamarckiana*	0	2	0	2	0	1			0	2	0	4	1	6		3	0	2	1	3
22	*Quinqueloculina polygona*	0	1			0	2			0	1	1	6	1	4		2	0	1		
23	*Quinqueloculina seminulum*	0	4	2	8	0	2	1	8	0	2	0	3	0	2	0	1	0	8		
24	*Quinqueloculina elongatum*	0	4	0	2	0	1			0	2										
25	*Quinqueloculina tropicalis*	0	2	0	1	1	4			0	4										
26	*Quinqueloculina sp 1*	0	1																		
27	*Quinqueloculina sp 2*																				
28	*Miliolinella circularis*	0	1	0	2	0	1			0	1	0	2	0	1	0	2				
29	*Triloculina oblonga*																				
30	*Triloculina insignis*	0	2	0	2	0	1														
31	*Triloculina schreiberiana*	0	1	1	9																
32	*Triloculina terquemiana*					0	2														
33	*Triloculina tricarinata*	0	2	1	7	0	8	0	1	2	12	2	12	2	14	0	8	1	11		
34	*Triloculina trigonula*	1	8	2	12	2	16	0	1	2	28	1	8	0	5	0	4	0	8		
35	*Hauerina bradyi*																				
36	*Articulina pacifica*																				
37	*Rupertianella rupertiana*	0	1							0	4	0	5	0	1			0	1		
38	*Sorites marginalis*	0	1																		
39	*Peneroplis planatus*																				
40	*Lagena striata*					0	1			0	2			0	2	0	1	0	4		
	Bolivina mobilis																				
41	*Brizalina striatula*																				
42	*Cancris auriculus*																				
43	*Eponides repandus*					0	2			0	1										

44	*Rosalina globularis*	0	2									0	6	0	17	0	5	0	2		
45	*Discorbinella bertheloti*					0	2														
46	*Cibicides lobatulus*	0	1	0	2	0	2			0	4	0	1	0	1			0	2		
47	Cassidulina laevigata																				
48	*Cymbaloporetta bradyi*	0	1																		
	Amphistegina lessonii																				
49	*Amphistegina radiata*	2	12	2	24	0	2			2	10		3	0	4	0	8	0	5		
50	*Nonionellina labradorica*	0	1	0	2	1	2					1	11	0	1						
51	*Nonionoides boueanum*	0	2	0	3									0	2	0	1				
52	*Nonionoides elongatum*			2	12	1	4			0	3	3	16	2	12	0	3	0	7		
	Peneroplis planatus																				
54	*Pararotalia calcar*	0	2																		
55	*Pararotalia nipponica*	0	3	0	2								8	0	4						
56	*Ammonia beccarii*	1	20	7	91	21	187	18	210	18	108	3	28	12	137	11	108	14	122	15	101
57	*Ammonia dentata*	1	6	2	12	0	4	0	1	1	7	2	14	4	24	4	35	3	24	2	18
58	*Ammonia tepida*	3	11	1	4	0	3					2	26	8	65	4	32	3	28		
59	*Asterorotalia inflata*	1	2	0	2	0	4	0	1	1	3	0	6	0	7	1	7	0	2		
60	*Asterorotalia trispinosa*					0	2			0	1										
61	*Pseudorotalia schroeteriana*			0	2	0	2					0	2								
62	*Cribrononion simplex*			0	1	0	2														
63	*Elphidium advenum*			0	3							0	2	0	1						
64	*Elphidium craticulatum*			0	3	0	2														
65	*Elphidium crispum*	1	8	1	7	1	7	0	1	2	10	0	14	2	28	2	19	2	25	2	14
66	*Elphidium discoidale*	1	5	1	4	0	2					0	4	0	3	0	3	0	1		
67	*Elphidium incertum*	0	3	0	1							0	2	0	1	0	1				
68	*E.excavatum*																				
69	*E.macellum*																				
70	*Elphidium sp 1*			0	1																
71	*Elphidium sp 2*	0	1																		
72	*Parrellina hispidula*	0	1	0	1							0	2	0	8	1	6	0	4		
73	*Rectobolivina raphana*			0	2					0	1										
74	*Assilina ammonoides*					0	4	0	3	0	2	0	2	0	2	0	3	0	2	0	1
75	*Quinqueloculina seminula*	12										2	124	4	248	2	286	2	257	3	334
	TOTAL	12	126	22	239	28	306	21	241	29	226	17	322	36	613	26	555	25	520	25	492
	Number of Genus	*6*	*20*	*6*	*17*	*6*	*18*	*3*	*18*	*6*	*17*	*5*	*19*	*6*	*18*	*6*	*16*	*4*	*13*	*5*	*8*
	Individual species	*9*	*40*	*11*	*37*	*7*	*39*	*4*	*15*	*8*	*30*	*9*	*31*	*9*	*31*	*8*	*27*	*6*	*16*	*6*	*16*

Table.7.1 Distribution of living and total foraminifera between Mandapam and Tuticorin (Offshore)

S	Station Numbers	Tuticorin									
	Depth in mts	2m		3m		4m		5m		6m	
	Name of Species	L	T	L	T	L	T			L	T
1	*Ammobaculites exiguus*										
2	*Textularia agglutinans*							0	4	0	5
3	*Textularia conica*							0	2	0	4
4	*Vertebralina striata*					0	1	0	2	0	1
5	*Edentostomina cultrata*										
6	*Adelosina laevigata*					0	9				
7	*Spiroloculina angusta*					0	3			0	4
8	*Spiroloculina affixa*										
9	*Spiroloculina communis*	0	4	0	12	1	6			0	8
10	*Spiroloculina costifera*	0	1	0	2	0	2	0	1	0	3
11	*Spiroloculina depressa*			0	2	0	1				
12	*Spiroloculina orbis*			0	3	0	4	0	1	1	24
13	*Spiroloculina sp 1*										
14	*Spiroloculina sp 2*			0	1						
15	*Massilina secans tropicalis*										
16	*Vertebralina striata*										
17	*Quinqueloculina agglutinans*			0	3	0	3	0	5	0	2
18	*Quinqueloculina bicostata*			0	6	1	7			1	12
19	*Quinqueloculina costata*										
20	*Quinqueloculina elegans*					0	2			0	2
21	*Quinqueloculina lamarckiana*	3	56	2	47	0	4	1	8		
22	*Quinqueloculina polygona*					0	2	0	4	0	2
23	*Quinqueloculina seminulum*			0	2	0	2	0	1	1	12
24	*Quinqueloculina elongatum*										
25	*Quinqueloculina tropicalis*			0	7						
26	*Quinqueloculina sp 1*										
27	*Quinqueloculina sp 2*										
28	*Miliolinella circularis*										
29	*Triloculina oblonga*							0	1	0	1
30	*Triloculina insignis*	0	3	0	4	0	2	0	1	0	1
31	*Triloculina schreiberiana*	0	6	0	5	0	3	0	1	0	1
32	*Triloculina terquemiana*	0	4	0	20	0	8	0	7	0	2
33	*Triloculina tricarinata*					0	4	1	5	0	5
34	*Triloculina trigonula*	1	5	2	19	2	6	2	8	0	10
35	*Hauerina bradyi*	0	2	0	2	0	4	0	1	0	1
36	*Articulina pacifica*	0	2	0	1						
37	*Rupertianella rupertiana*	0	3					0	1		
38	*Sorites marginalis*	0	1					0	2		
39	*Peneroplis planatus*			0	1	0	2				
40	*Lagena striata*									0	1
	Bolivina nobilis										
41	*Brizalina striatula*										
42	*Cancris auriculus*					0	1				

43	*Eponides repandus*					0	2				
44	*Rosalina globularis*										
45	*Discorbinella bertheloti*			0	1	0	2				
46	*Cibicides lobatulus*	0	2	1	4	0	2	0	4	1	8
47	Cassidulina laevigata										
48	*Cymbaloporetta bradyi*										
	Amphistegina lessonii										
49	*Amphistegina radiata*	0	1	0	2	0	3			0	5
50	*Nonionellina labradorica*										
51	*Nonionoides bouseanum*					0	3			0	2
52	*Nonionoides elongatum*	0	1	0	1						
	Peneroplis planatus										
54	*Pararotalia calcar*	0	12	2	15	5	45	2	14	3	28
55	*Pararotalia nipponica*	1	34	3	47	2	12	2	18	2	14
56	*Ammonia beccarii*	3	18	0	2	1	4	5	58	11	42
57	*Ammonia dentata*	0	2	1	8	8	48	2	18	20	98
58	*Ammonia tepida*	0	4	0	8	1	12	5	17	0	2
59	*Asterorotalia inflata*	2	26	0	3	1	4	0	1	12	58
60	*Asterorotalia trispinosa*					0	2	0	4	0	2
61	*Pseudorotalia schroeteriana*										
62	*Cribrononion simplex*				1	0	2				
63	*Elphidium advenum*	1	12	3	14	1	12			0	3
64	*Elphidium craticulatum*	1	8	0	8	0	2			0	1
65	*Elphidium crispum*	1	4	0	4	2	5	0	4	0	5
66	*Elphidium discoidale*		2			0	1				
67	*Elphidium incertum*					0	2				
68	*E.excavatum*										
69	*E.macellum*							0	1	0	2
70	*Elphidium sp 1*										
71	*Elphidium sp 2*										
72	*Parrellina hispidula*					0	1			0	2
73	*Rectobolivina Raphanus*										
74	*Assilina ammonoides*	0	4	0	15	0	12	1	12	1	12
75	*Operculina venosa*	0	4	1	11	2	14	2	18	1	15
	TOTAL	13	**221**	15	**281**	27	**268**	**23**	**224**	54	**402**
	Number of Genus	*11*	*12*	*11*	*22*	***8***	*20*	***6***	*16*	***8***	*18*
	Individual species	*17*	*27*	*23*	*33*	***11***	*42*	***10***	*30*	***11***	*37*

	Post tsunami species		Pre-tsunami species
41	*Bolivina nobilis*	41	*Siphonina philippinensis*
42	*Brizalina striatula*	42	*Sorites marginalis*
43	*Cancris auriculus*	43	*Spirolina arietinus*
44	*Eponides repandus*	44	*Spiroloculina communis*
45	*Rosalina globularis*	45	*S. costifera*
46	*Discorbinella bertheloti*	46	*Textularia agglutinans*
47	*Cibicides lobatulus*	47	*T.aura*
48	*Cassidulina laevgata*	48	*T.conica*
49	*Cymbaloporetta bradyi*	49	*T.pseudotrochus*
50	*Amphistegina lessonii*	50	*Triloculina oblonga*
51	*Amphistegina radiata*	51	*T.schreberiana*
52	*Nonionellina labradorica*	52	*T.terquemiana*
53	*Nonionoides boueanum*	53	*T.tricarinata*
54	*Nonionoides elongatum*	54	*T.trigonuia*
55	*Peneroplis planatus*	55	*Uvigerina hispido-costana*
56	*Pararotalia calcar*	56	*Vertebralina striata*
57	*Pararotalia nipponica*	57	*Globigerina bulloides*
58	*Ammonia beccarii*	58	*Globigerinoides trilobus*
59	*Ammonia dentata*	59	*Globorotalia mennardii*
60	*Ammonia tepida*	60	*A.dentata*
61	*Asterorotalia inflata*	61	*E.hispidulum*
62	*Asterorotalia trispinosa*	62	*F.labradoricum*
63	*Pseudorotalia schroeteriana*	63	*Glabratella australensis*
64	*Edentostomina cultrata*	64	*Globigerinodes trilobus*
65	*Elphidium advenum*	65	*Haplophragmoides emaciatum*
66	*Elphidium craticulatum*	66	*Miliolinella circularis*
67	*Elphidium crispum*	67	*orbulina universa*
68	*Elphidium discoidale*	68	*pseudomassilina macilenta*
69	*Elphidium incertum*	69	*Q.bicostata*
70	*E.excavatum*	70	*R.virgula*
71	*E.macellum*	71	*Reussella spinulosa*
72	*Elphidium.sp1*	72	*Rupertianella rupertiana*
73	*Elphidium.sp2*	73	*Sorites orbiculus*
74	*Parrellina hispidula*	74	*S.orbis*
75	*Rectobolivina Raphanus*	75	*Triloculina terquemiana*
76	*Assilina ammonoides*	76	*Assilina ammonoides*
77	*Osangularia venusta*	77	*Osangularia venusta*

Table. 3. Comparison of Pre-tsunami and Post- tsunami foraminiferal species in the study area

Post tsunami species		Pre-tsunami species
Ammobaculites exiguus	1	*Alveolinella quoyi*
Textularia agglutinans	2	*Ammonia beccarii*
Textularia conica	3	*A.beccarii var.tepida*
Vertebralina striata	4	*Amphistegina lessonii*
Edentostomina cultrata	5	*Buliminella millettii*
Adelosina laevigata	6	*Cassidulina laevgata*
Spiroloculina aequa	7	*Chrysalidinella dimorpha*
Spiroloculina affixa	8	*Cibicides lobatulus*
Spiroloculina communis	9	*C.refulgens*
Spiroloculina costifera	10	*Elphidium crispum*
Spiroloculina depressa	11	*E.crispum var.crassa*
Spiroloculina orbis	12	*E.excavatum*
Spiroloculina sp1	13	*E.incertum*
Spiroloculina sp2	14	*E.macellum*
Massilina secans tropicalis	15	*Fissurina bod jonegoroensis*
Vertebralina striata	16	*Florilus boueanus*
Quinqueloculina agglutinans	17	*F.grateloupi*
Quinqueloculina bicostata	18	*Hauerina bradyi*
Quinqueloculina costata	19	*H.fragilissima*
Quinqueloculina elegans	20	*H.involuta*
Quinqueloculina lamarckiana	21	*Heterostegina suborbcularis*
Quinqueloculina polygona	22	*Lagena striata*
Quinqueloculina seminulum	23	*Operculina ammoides*
Quinqueloculina elongatum	24	*Opercullinella cumingii*
Quinqueloculina tropicalis	25	*O. venosus*
Quinqueloculina sp 1	26	*Osangulariria vemata*
Quinqueloculina sp 2	27	*Peneroplis planatus*
Miliolinella circularis	28	*Planorbulinalla mediterranensis*
Triloculina oblonga	29	*Planorbulinella larvata*
Triloculina insignis	30	*Poroeponides lateralis*
Triloculina schreiberiana	31	*Pseudotriloculina rupertiana*
Triloculina terquemiana	32	*Pyrgo subsphaertica*
Triloculina tricarinata	33	*Quinqueloculina agglutinans*
Triloculina trigonula	34	*Q.inca*
Hauerina bradyi	35	*Q.lamarckiana*
Articulina pacifica	36	*Q.polygona*
Rupertianella rupertiana	37	*Q.pseudoreticulata*
Sorites marginalis	38	*Q.undulose-costata*
Peneroplis planatus	39	*Rectobolivina-raphanus*
Lagena striata	40	*Sigmavirgulina tortuosa*