Distribution of Benthic Foraminiferal Assemblages in the Surface Sediments of the Manakudy Estuary, Kanyakumari District, Southeast Coast of India

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Abstract: The main aim of the study is to investigate foraminifera distribution from recent sediments of the Manakudy estuary in Kanyakumari district. In this connection, 10 samples were collected from the Manakudy estuary at a distance of about 27-30 m approximately. The distribution of benthic foraminiferal studies in the surface sediment samples of Manakudy estuary leads to the recognition of 12 species belonging to 6 genera, 4 families, 3 superfamilies, and 1 suborder of the order Foraminiferida. The seven species viz. *Ammonia beccarii, Ammonia tepida, Ammonia dentata, Elphidium crispum, Quinqueloculina agglutinans, Quinqueloculina lamarckiana and Quinqueloculina seminulum* were dominant out of the twelve species in the study area. The sedimentological parameters such as calcium carbonate, organic matter, and sand/silt/clay were estimated using standard procedures. The maximum number of foraminifera species was found in stations 1 and 3. The sandy substrate is more favourable for the Foraminiferal assemblages in the study area. From the present study, it is observed that the recorded assemblages of foraminifera are the characteristics of a tropical shallow outer shelf environment.
Keywords: Benthic Foraminifera, surface sediments, Manakudy estuary, Tamil Nadu.

Introduction

Manakudy estuary is located at 8°088´N latitude and 77°486´E longitude in Kanyakumari district, Tamil Nadu. It is formed by the river Pazhayar at Manakudy. This estuary is bar-built and it covers an area of about 150 ha and extends over 5 km, the estuarine mouth is dominated by sand. Foraminifera are the world-wide tested protozoa, living almost in all aquatic environments including marine, brackish or fresh water. They are the most diverse group of the modern oceans as living shelled microorganisms and in the rocks of Phanerozoic times as fossils. Stable isotopes extracted from the tests of foraminifera have provided data about sea temperatures through the Mesozoic and Cenozoic periods. They provide extremely useful indicators in the petroleum and correlation between oil field data. They are an excellent tool for determining the age of sediments. The foraminifera found in the sediments are of all ages ranging from Cambrian to recent. They made their first appearance in Cambrian and were comparatively rare till the Carboniferous, but they became prominent and of great geological importance during Upper Carboniferous and Permian. Foraminifers are very good indicator of paleo-climate. The main aim of the study is to investigate foraminifera distribution from recent sediments and determination of their depositional environment at the Manakudy estuary in Kanyakumari district.

Study area

The study area i.e., Manakudy estuary covers an area of about 150 ha and extends over 5 km in length (Fig. 1). The area lies between latitude 8° 5′ 30″and longitude 77° 29′ 10″ respectively. Manakudy is the second-largest estuary in the Kanyakumari district (Fig. 2). The Manakudy estuary is associated with the river Pazhayar originating from the southern Western Ghats and flowing through Nagercoil, Suchindrum, and North Thamaraikulam. The river Pazhayar originated from the Mahendragiri peak of the Western Ghats. It passes through the Kanyakumari district in the southeast direction and confluences with the Arabian Sea through the Manakudy estuary. The river has 11 check dams for irrigational purposes, and the lowermost check dam is the Mission dam located near Thamaraikulam about 3.5 km away from the bar mouth. The Pazhayar River has many tributaries. The major tributaries are Thodariyar, Ulakkai River, Alanthuraiyar, Koyuodai, and Poigaiyar. The Manakudy is a sand-bar-built estuary that remains landlocked during most of the year and it connects the sea only during the rainy season.

Methodology

A total of ten surface sediment samples were collected from the estuary at a distance of approximately 27-30 m. The samples for the present study were collected on 10th Oct 2021 (Table 1). All the sediment samples were analysed through standard micropaleontological techniques and identified the species following (Loeblich and Tappan, 1988; Murray, 1971, 1991) and the world foraminiferal database. Calcium carbonate in the sediments samples was determined based on the procedure of Loring and Rantala (1992) and the organic matter in the sediments was determined by adopting the standard procedure of Gaudette et al. (1974). Sand, silt, and clay percentages were calculated using the wet sieving and pipette method in accordance with the procedure adopted

by Krumbein and Pettijohn (1938). A Trilinear plot was prepared using Trefethen (1950) textural nomenclature, which has been used to describe the sediments in the present study.

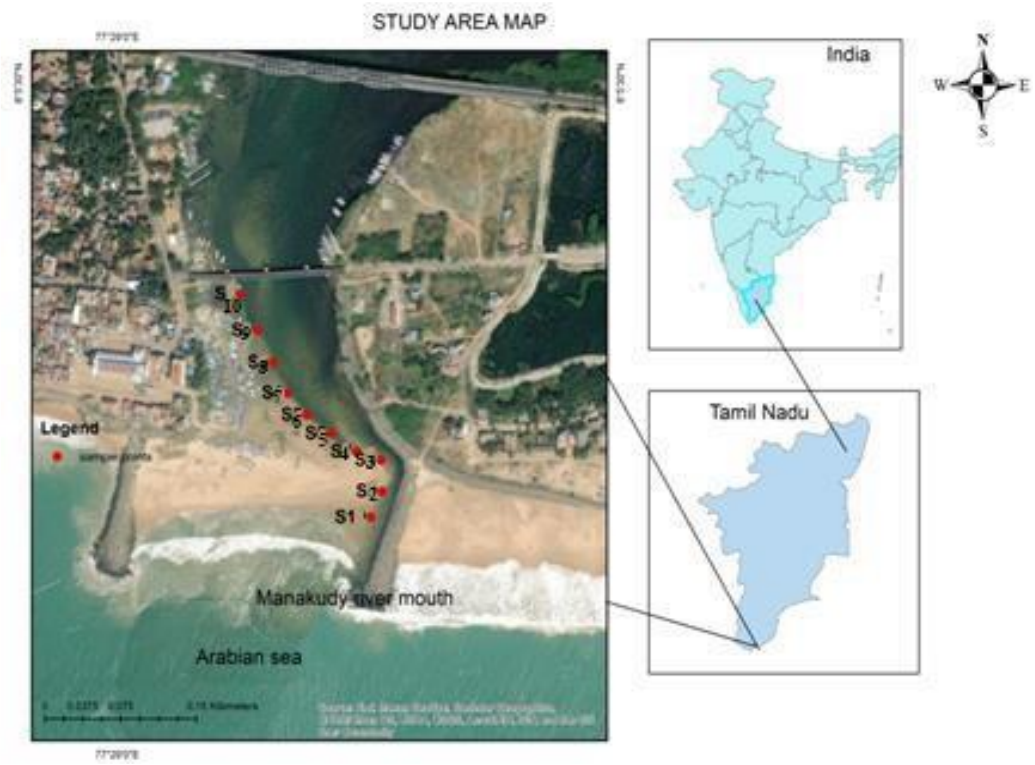

Fig. 1. Location map of the study area.

Table 1. Location of the sample points.

Sample no	Latitude	Longitude
1	8° 5′ 21″	77° 29′ 04″
2	8° 5′ 22″	77° 29′ 04″
3	8° 5′ 22″	77° 29′ 04″
4	8° 5′ 22″	77° 29′ 05″
5	8° 5′ 22″	77° 29′ 05″
6	8° 5′ 22″	77° 29′ 05″
7	8° 5′ 22″	77° 29′ 03
8	8° 5′ 22″	77° 29′ 03″
9	8° 5′ 22″	77° 29′ 02″
10	8° 5′ 22″	77° 29′ 02″

Fig. 2. Field Photograph shows an overview of the Manakudy estuary.

Results and Discussion

Spatial distribution

The study on the distribution of benthic foraminifera in the surface sediment samples of the Manakudy estuary led to the recognition of 12 species belonging to 6 genera, 4 families, 3 superfamilies and 1 suborder of the order Foraminiferida. The distribution is shown in Table 4.

Textural parameters

Silty and muddy substrates are often rich in organic debris and the small pore spaces contain bacterial blooms. Such substrates are attractive and conducive for foraminiferal species and support large populations.

Ramanathan (1969) describe the foraminifera from the Vellar estuary and compared them with the nature of the sediment in sand-silt-clay substrates. Sandy sediments with silt and dominating clay represent the highest foraminiferal numbers. Ganapathy and Satyavati (1958) demonstrate a close correlation between sedimentary texture and the distribution of foraminifera.

Sand-silt-clay ratio

Sand, silt, and clay percentages were estimated according to the procedure proposed by Krumbein and Pettijohn (1938). Table 2 shows the percentages of sand, silt, and clay. The favorable substrate for the distribution of foraminifera in the Manakudy estuary is sand. Due to the high energy of the tides and waves, the substrate is more sandy at stations near the mouth and becomes more silty in the upper estuary. The amount of sand recorded in the study area ranges from 91-97%, the clay percentage is 0-0.2 and the silt is 5.4-8.2%. The trilinear plot of sand/silt/clay values were plotted using Trefethens (1950) indicating that most of the sediments are sandy, and it was shown in Figure 3.

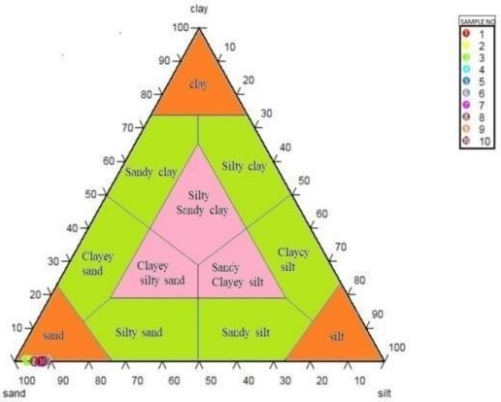

Fig. 3. Trefethen (1950) Trilinear plot.

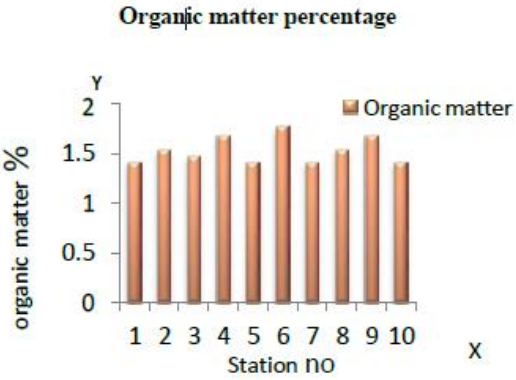

Fig. 4. Plot shows the spatial distribution of organic matter.

Organic matter

In the present study, the organic matter content has been determined for all the samples collected from the estuary. The organic matter values range from 1.41%- 1.77%. The percentage of organic matter is shown in Table 2 and Figure 4. The total foraminiferal number increase with a decrease in organic matter. While OM exhibits a steady increase trend from the mouth to the higher estuary (sheltered habitat and increased riverine OM intake). Sediment texture plays an important role in controlling the organic matter content. The main sources of organic matter in the estuaries are mangrove vegetation, benthic vegetation, riverine transport, freshwater, and marine phytoplankton accumulation (Ranjan et al., 2010).

Table 2. Percentages of calcium carbonate, organic matter, sand/silt/clay.

Station	$CaCO_3$	OM	Sand	Silt	Clay
1	28.5	1.41	92.6	7.2	0.2
2	27.5	1.54	94.6	5.4	0
3	29.5	1.47	96.6	3.2	0.2
4	27.5	1.68	91.4	8.2	0.4
5	28.5	1.41	92.8	7.2	0
6	28	1.77	91.4	8.2	0.4
7	27	1.41	93.2	6.6	0.2
8	25	1.54	94.5	5.4	0.1
9	27	1.68	92.1	7.7	0.2
10	26.5	1.41	92.3	7.5	0.2
Average	**27.5**	**1.53**	**93.1**	**6.66**	**0.19**
Minimum	**25**	**1.41**	**91.4**	**3.2**	**0**
Maximum	**29.5**	**1.77**	**96.6**	**8.2**	**0.4**

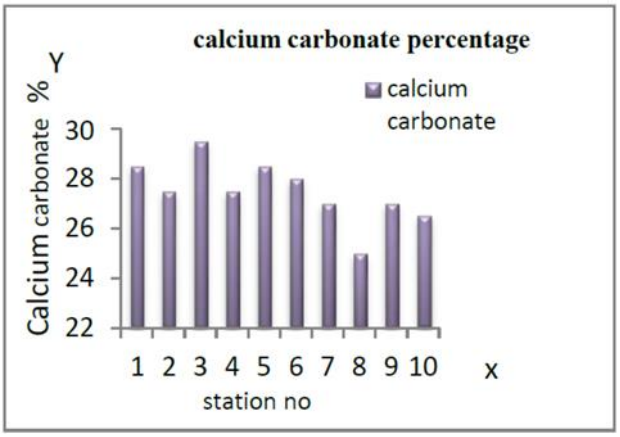

Fig. 5. Graph shows the calcium carbonate %.

Calcium carbonate

In the present study, the calcium carbonate percentages are varying from 25-29.5%. Nearshore station 3 contains more carbonate content, and the presence of broken shell fragments mixed with the sand is expected to increase

the calcium carbonate content in the estuary. The maximum value of calcium carbonate was reported to be a high order of about 30. $CaCO_3$ shows a decreasing tendency from the mouth to the upper estuary. The calcium carbonate percentage is shown in (Table 2, Fig. 5).

Correlation Matrix

Correlation between sedimentological parameters and TFN has been carried out to find out the inter-relationship between them. The correlation coefficient values indicating +1 or -1 between the values reveal that there exist a strong correlation and the values at zero indicate no relationship between them. The Pearson correlation matrices for the samples are computed and shown in (Table 3) Sedimentary characteristics were significantly correlated with the TFN. The TFN is positively correlated with $CaCO_3$, sand, and silt and negatively correlate with organic matter and clay. The correlation matrix shows that calcium carbonate, sand, and clay are the favorable environmental conditions for the distribution of foraminifera in Manakudy estuary with the r values of about 0.85, 0.39, and 0.01 respectively. Sand is negatively correlated with organic matter which attributes the presence of organic debris independent of the deposition or erosion of sand. Organic matter is positively correlated with silt and clay can be related to the terrigenous nature of the sediments. This indicates that sediment grain size is an important factor in the distribution of foraminifera.

Table 3. Correlation coefficient matrix.

$CaCO_3$	OM	Sand	Silt	Clay	TFN
$CaCO_3$	1				
OM	-0.11	1			
Sand	0.17	-0.41	1		
Silt	0.10	0.60	-0.52	1	
Clay	-0.18	0.37	-1.00	0.46	1
TFN	0.85	-0.23	0.39	0.01	-0.41	1

Table 4. Distribution of Foraminifera.

	Station Number									
Species Name	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Q. agglutinans	2			1	1					1
Q. lamarckiana	20	9	28	10	25	18	11	5	8	10
Q.seminulum	25	10	22	15	10	9	15		9	
M. circularis	16		15	11	15	11				
T. tricarinata	10		12		5	4	9			2
A. beccarii	68	55	72	35	40	58	30	28	25	29
A.dentata	52	48	45	23	25	30	28	22	20	20
A.tepida	45	28	30	25	23	20	19	10	10	8
E. crispum	15	20	22	13	15	19	9	8	10	8
E. macellum	5	9	12		4	5			1	2
E. reticulatum	4		5		1	2				
Amphistegena radiata	10		12		4	6		3		1
Total no of species	272	179	275	122	164	186	132	84	92	91
Total no of individuals	12	7	11	7	12	11	8	7	7	9

Discussion

The distribution of benthic foraminiferal studies in the surface sediment samples of the Manakudy estuary (Table 4). This study leads to the recognition of 12 species belonging to 6 genera, 4 families, 3 superfamilies, and 1 suborder of the order Foraminiferida. Of the Twelve species identified from the Manakudy estuary, seven species were dominant. Percentages of the total foraminiferal distribution in the study area reveal that the species *Ammonia beccarii, Ammonia tepida, Ammonia dentata, Elphidium crispum, Quinqueloculina agglutinans, Quinqueloculina lamarckiana and Quinqueloculina seminulum* were dominant in the area. *Ammonia* is considered one of the most abundant genera worldwide and it occurs in shallow marine intertidal as well as brackish water. The study area is dominated by calcareous materials. *Elphidium* is also a cosmopolitan species. *Elphidium crispum* is found in the sandy environment and was capable of tolerating lower salinity. It is a shallow-water species. *Quinqueloculina* can survive in an oxygenated environment.

Conclusions

For the study of Foraminiferal fauna, the sediment samples were collected from the Manakudy estuary at a distance of about 27-30 m approximately. The collected samples were subjected to various sedimentological, geochemical, and micropaleontological studies. It is observed that the recognition of 12 species belongs to 6 genera, 4 families, 3 superfamilies, and 1 suborder of the order Foraminiferida of which seven species were dominant. The percentage of the total species in the study area reveals that the species *Ammonia beccarii, Ammonia tepida, Ammonia dentata, Elphidium crispum, Quinqueloculina agglutinans, Quinqueloculina lamarckiana and Quinqueloculina seminulum* were dominant in the study area.

The low organic matter content and higher values of calcium carbonate in the estuary favor the maximum population and distribution of Foraminifera. The sand/silt/clay ratios were estimated and only sandy subtract is more dominant in the study area. From the recorded assemblages of Foraminifera, seven species were dominant. They are *Ammonia beccarii, Ammonia tepida, Ammonia dentata, Elphidium crispum, Quinqueloculina agglutinans, Quinqueloculina lamarckiana and Quinqueloculina seminulum*. The most favorable for the distribution of foraminifera is sand. The study of benthic foraminiferal assemblages in the surface sediments of the Manakudy estuary reveals that $CaCO_3$ and sandy subtract are the most favorable parameters for the distribution of Foraminifera in the Study area. Finally, it is concluded that the recorded assemblages of Foraminifera are characteristics of tropical shallow outer shelf environments.

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