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Recent Benthic Foraminifera and its ecological condition along the surface samples of Pichavaram and Muthupet Mangroves, Tamil Nadu, East Coast of India

M.Suresh Gandhi[1*], K.Jisha[1] and N.Rajeshwara Rao[2]

[1]Department of Geology, University of Madras, Guindy Campus, Chennai, India, India
[2]Department of Applied Geology, University of Madras, Guindy Campus, Chennai – 25, India
Corresponding author

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A B S T R A C T

Totally 12 surface sediment were collected, in order to study the assemblages of foraminifera from the Pichavaram and Muthupet Lagoon, Tamil Nadu. The depths of sample collection in the area ranges from 0.5 m to 1.8 m. Standard procedures adopted for the evaluation of different environmental parameters are incorporate. Pichavaram mangroves located 15 km north-east of Chidambaram, Cuddalore district, Tamil Nadu within latitudes 11º 20' to 11º 30' N and Longitudes 79º 45' to 79º 50' E. Totally, six surface sediment samples were collected at Pitchavaram at water depths ranging from 1.0 – 1.5. Similarly at Muthupet Mangroves, 6 surface sediment samples were collected.

Introduction

Mangrove ecosystem is very much useful for sea level variation studies, ecological studies, etc. Recently the application of benthic foraminifera has emerged as an excellent environmental monitoring tool for present day contaminated and polluted areas. Benthic foraminifera have been widely used for environmental reconstructions for over a century. Phleger and Walton (1950) characterized the foraminiferal assemblages over the surface of salt marshes relating the faunal occurrences with ecological parameters.

Microfossils are fossils generally not larger than four millimeters, and commonly smaller than one millimeter, the study of which requires the use of light or electron microscopy. Being exclusively marine, expect a few species, highly abundant in deep-sea sediments/rocks, very sensitive to even minute change in environment foraminifera have wide applications in stratigraphic correlation, higher resolution biostratigraphy, oil exploration, environmental and paleoenvironmental interpretations.

Foraminifera have been successful inhabitants of every aquatic environment from deep oceans to brackish water, lagoons, estuaries and even rarely in freshwater streams, lakes etc. The aim of this study was to identify and record the foraminifera inhabiting a modern Pitchavaram and Muthupet mangrove swamp and associated environments.

Study area

The study areas are the mangrove swamp region in the south east coast of Tamil Nadu, Pichavaram and Muthupet. The mangrove forest at Pichavaram is situated in the extensive Cauvery delta, approximately 230 km (145 miles) to the south of Madras (Chennai) in the Cuddalore district of Tamil Nadu.

The forest itself is bounded by two rivers, to the north the Vellar, and to the south the larger Coleroon (Kollidam), a distributary of the Cauvery. The main expanse of the mangrove forest extends intermittently for some six-seven km from north to south and three-four km from east to west, and is fed directly by the small Upper River.The geology of the area is dominated by Quaternary sediments.

Muthupet mangrove forest is located at the southern end of the Cauvery delta, covering an area of approximately 13,500 ha of which only 4% is occupied by well-grown mangroves. The rivers Paminiyar, Koraiyar, Kilaithankiyar, Marakkakoraiyar and other tributaries of the river Cauvery flow through Muthupet and adjacent villages. At the tail end, they form a lagoon before meeting the sea. The northern and western borders of the lagoon are occupied by muddy silt ground which is devoid of mangroves. The salinity is the major environmental factor, controlling zonation of Muthupet mangrove forest.

Experimental

As a prelude to sample collection a base map was prepared using toposheets (1:50,000) from survey of India Toposheets. All the prominent and permanent objects, rivers, tanks, roads and elevation were marked in the base map. In order to study the distribution of recent benthic Foraminiferain the mangrove swamps, surface sediment samples were collected from the Pichavaram and Muthupet lagoon, with the help of a motor launch. The locations of surface samples are recorded using GPS. Twelve surface samples were collected from the mangrove swamps. All the sediment samples were subjected to standard micropaleontological techniques (Leoblich and Tappan, 1987, Murray, 1991), so as to record the occurrence of foraminifera. . Calcium carbonate, organic and organic matter in the sediment samples were determined by adopting a methodology suggested by Piper (1947), Gaudette et al (1974), Walkey- Black method (1947), adopted and modified from M L Jackson (1954) respectively. Sand, silt and clay percentages were calculated using a combination of sieving and pipette procedure, the later in accordance with Krumbein and Pettijhon (1938). Trilinear plots were prepared and description has been given based on Trefethen's(1950) textural nomenclature.

The handpicked faunal specimens from each sample (25 ml of wet sediment) were transferred to 24-chambered micropaleontological slides and mounted over a thin layer of tragacanth gum according to the family, genus and species, wherever possible. The different genera and species were identified; type specimens of each species were selected and transferred to round punch microfaunal slides with cover slips. Later, they were mounted on brass

stubs (1 cm in diameter) using a double-sided adhesive carbon tape and coated with palladium for about 90 to 120 seconds (JEOL: JFC) ion sputtering device) to render the surface of the foraminiferal tests conductive for scanning. To obtain lucid illustrations, microphotographs of different views of all the foraminiferal species present were taken using a Scanning Electron Microscope (JEOL JSM-6360). All the foraminifera species described and illustrated here are deposited in the Department of Geology, University of Madras, Chennai.

Result and Discussion

Classification of foraminifera

The classification proposed by Loeblich and Tappan (1987) has been followed in the present study through which 25 species belonging to 14 generaare identified (table.1). The study of foraminifera began as an investigation into their taxonomy and the purely descriptive phase of foraminiferal studies is gradually giving way to ecological investigations. The identification of the species recorded in this study is based on comparison with the Catalogue of Foraminifera by Ellis and Messina (1940 onwards, innumerable publications and several researchers from all over the world) and specimens reposited in the Department of Geology , University of Madras, Chennai 600 025, India.

Ecological Parameters

Ecology is the study of the reciprocal between organisms and their surroundings; the influence of the environment of the physiological activity of the organisms and vice versa. It thus embraces the study of the environmental limits in which a species exists (Boltovskoy and Wright, 1976).

The distribution and abundance of living foraminifera are controlled by a number of natural factors which include sediment substrate, calcium carbonate, organic matter and geochemistry of the sediment.

According to Albani and Johnson (1975) the composition of a living assemblage affects environmental conditions which exist at the time of sample collection. . In order to find out whether the organic matter and calcium carbonate contents of the sediments and the nature of substrate reflect the environmental conditions of foraminifera, an effort has been made to determine the same in all the sediment samples collected from the Pichavaram and Muthupet mangrove area.

Organic matter

The organic matter content in the sediments of Surface samples ranges from 0.618 to 1.854 % (table 1&Fig.3). The lowest value was recorded in station no.P5 at a depth of 0.5 m and the highest value in station no P6 at a depth of 1.7m.In the study region, the organic matter are higher in the samples no P1, P2,P3 P4, P6, M2 and M4 this is due to the decay of plants. The sites with dense mangrove vegetation showed higher sediment carbon content as compared to the sites with degraded vegetation or estuarine sites thus indicating mangrove plants to be the dominant source of organic matter to the sediments. The observed lower organic matter content can be attributed to the resuspension of organic matter to the water column due to tidal activity.

Calcium carbonate

In the present area, it has been found that the calcium carbonate percentage in the surface sediments of Pichavaram and Muthupet mangrove area varies from 1.5 % to 8 %(Table1).

Fig.1 Location map of the study area (Pichavaram region)

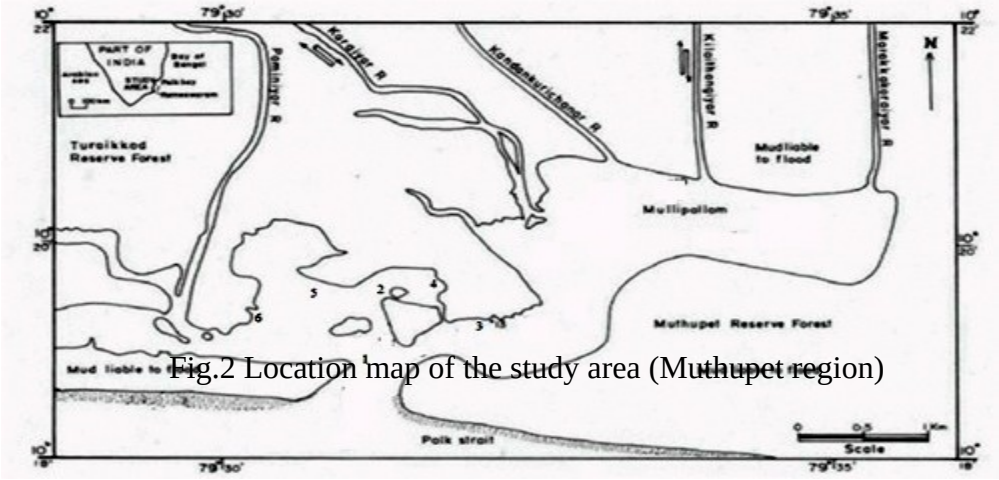

Fig.2 Location map of the study area (Muthupet region)

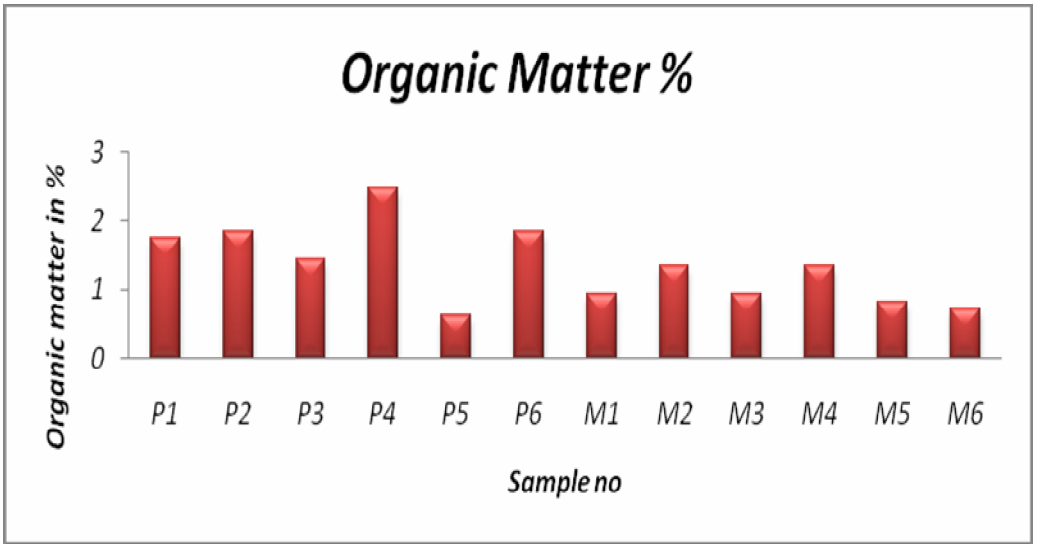

Fig.2 Showing the percentage of organic matter

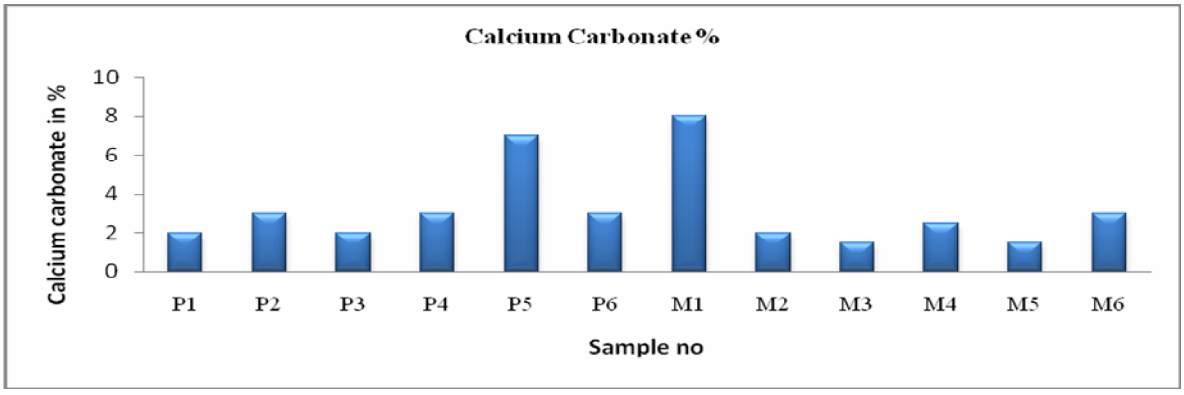

Fig.4 Showing the percentage of calcium carbonate

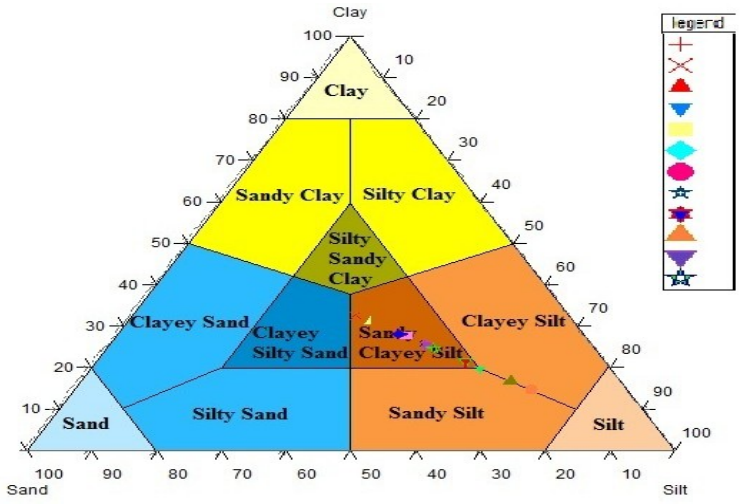

Fig.5 Trilinear plots of Sand Silt Clay ratio of Pichavaram and Muthupet Lagoon

Table.1 Estimated values of Organic matter, Calcium Carbonate and Sand Silt Clay Percentages

SAMPLE NO.	$CaCO_3$%	OM%	Sand %	Silt %	Clay %
P1	2	1.751	26.512	43.124	30.364
P2	3	1.854	38.512	40.522	20.966
P3	2	1.442	36.002	42.258	21.74
P4	3	2.472	19.74	59.602	20.658
P5	7	0.618	24.938	40.178	34.884
P6	3	1.854	36.552	56.442	7.006
M1	8	0.927	15.75	75.00	9.25
M2	2	1.339	24.126	44.56	31.314
M3	1.5	0.927	21.78	41.72	36.5
M4	2.5	1.339	16.582	64.24	19.178
M5	1.5	0.824	21.96	57.96	20.08
M6	3	0.721	19.74	40.58	39.68
Average Value	3.2	1.339	25.183	50.515	24.302
Minimum Value	1.5	0.618	15.75	40.178	7.006
Maximum Value	8	1.854	38.512	75.00	39.68

Table.2 Showing distribution of foraminifera in the study area

SPECIES	p1	p2	p3	p4	p5	p6	mp1	mp2	mp3	mp4	mp5	mp6
Ammonia Beccari	230	225	58	120	126	135	224	304	95	906	775	690
A.tepida	52	35	45	65	58	36	46	64	30	106	55	75
P.nippoika		2					66					5
Rosalina globularis	1		5			6						
Astrorotalia.trispinosa	1	3	2	4	1	5		12	6	10	5	3
Cibicedis.lobatus	3			5			12					1
Elphidium sp	15			19								5
E.advenum		3				6	6					
E.Cripsum	1	5	3				22		2		2	
Parrellina hispidula	3		1			1					2	
Bolivina nobilus			3	2			3		2			
Cancrisauricula		2					2					
Q.perkari	1			3			6					
Q.seminulam	25			6		2	48	6	3		5	2
Q.oblonga	4			2			4		2		2	
Q.lamarkina	6		3			2	25	2				
Q.tropicalis	3						2					
Q.elongata				2						1	1	
Spiroloculina communis	12	1	2	3		4	4	16	3			
Nonionoides elongatum	3			4				6				7
N.boueanum	1	3	7	5		2	5					
Nonionellina labradorica	6	2	5	3								
Ammobaculites exiguus	8	2	4	5	6	2						
Textularia agglutinans	5	4	6		4							
Textularia porrecta	4	2		3		1						
Total	384	289	144	251	195	202	475	410	143	1023	847	788
Total no of individuals	20	13	13	16	5	12	15	7	8	4	8	8

The highest value was recorded in station no M1 and lowest value in M3 & M5 and (fig .4).When megascopicaly checked, higher orders of broken shells are noticed. Due to the salinity influence the species assemblages are high. This is also a reason for the higher rate of calcium carbonate. The presence of broken shells mixed up in the sand in this area is also expected to cause a rise in the carbonate content.

The low value of calcium carbonate in this region is mainly due to the non-deposition of broken debris in that region due to the tidal action.

Substrate

Silty and muddy substrates are often rich in organic debris and the small pore spaced contains bacterial blooms. Such substrates are, therefore, attractive to the foraminiera

species and support large populations. The larger pore space of sands and gravel contain fewer nutrients and, therefore, support less diverse population. A number of studies have revealed a close correlation between the natures of sediments especially the texture (sand-silt-clay ratio) and the foraminiferal population.

The relative abundance of sand, silt and clay in the sediments of surface has been estimated (Table.1). The determined values are plotted on trilinear diagrams (Fig.). Trefethen's (1950) textural nomenclature has been used to describe the sediment types of the present area. Taking into consideration the 12 possible sediment types of Trefethen (*op. cit.*), the substrate of the Pichavaram and Muthupet mangrove's surface samples consists of sandy clayey silt and clayey silt.

Distribution of Foraminifera

A total of 25 foraminiferal taxa belonging to 14 genera, 11 families, 9 super families, and 5 suborders have been identified (Table.2). Of which, the following species are widely distributed in this region namely, *A. becarri, A. tepida, A. trispinosa, E. cripsum, Q. seminulam, S. communis, and N.boueanum.* Furthermore based on foraminiferal distribution, it is observed that the following species are very rare and low in abundance namely *Cancris auricula, Q.elongata*, and Q.tropicalisdue to heavy influx of freshwater in the estuarine area. Our findings also supported by Kameshwara Rao and Balasubramanium (1996).

The variation in the total abundance of foraminifera in this region is mainly due the substrate as well as tidal current action. Further, due to the low salinity and freshwater influx from different rivers may control the foraminifer's abundance in this region.

The following species are dominated in the study region namely *A,becarri, A.tepida, E. crispum, A. trispinosa,Q. seminulam, S. communis, and N.boueanum.*. This assemblage is characteristic of modern-day inter-tidal and estuarine environments (Reddy and Reddy, 1982; Yeruku Naidu and SubbaRao, 1988). The overall dominance of *A. beccarii*, which is a cosmopolitan species is considered to be highly tolerant to different ecosystems. The fine sediment accumulated at the bottom of mangrove swamps which also contains organic matter, favours the occurrence of stress-tolerant genera in this region namely Ammonia, Elphidium and other heterotrophic genera such as Quinqueloculina etc.

The low organic matters in Pichavaram at inter- and a shallow sub-tidal and mud flat environment away from the mangrove swamp is observed. It is also supported by Ramanathan et al., 2011, who have suggested that particularly mangrove derived OM is either diluted due to mixing with OM enriched in δ 13 C org and δ 15 N org , or there is considerable change in the isotopic composition associated with OM degradation during early diagenetic changes. It is found to be a zone of unstable substratum having number of minor channels conduiting the fast moving currents and here the settling of organic carbon may not feasible. Moreover, it is observed to be a station with sheltered environment allowing the deposition of only fine sediments, pushed aside to the calm environment. The low energy condition is also accounted by the positive skewness prevailing in this station. The Muthupet Lagoon substrate is predominantly mud, typically ,95% in the collected samples. The lagoon is connected to the Palk Strait by a wide mouth located in the southern part of the mangroves. Twenty-five years ago, the

mouth was ,2.5 km wide and 2.0–2.5 m deep; it is now hardly 1-km wide and not even 1-m deep. Seawater enters the lagoon only through a narrow channel of ,100–200-m width (Rao et al., 2013. Selvam and others (2003) observed that no sand was being deposited at the mouth of the lagoon; instead, only fine silt brought from the sea was accumulating. Owing to its extreme shallowness, Muthupet Lagoon is highly influenced by wind turbulence that almost continuously churns the bottom sediments; the fine clay is, therefore, incessantly kept under suspension, giving the lagoon a ‘‘brown carpet’’ appearance. Moreover, because of the shallowness, wind-induced currents dominate tidal currents (ICMAM, 2005). Our findings also corroboted with Rao et al (2013) who have reported that no significant temporal or spatial variations in pH, dissolved oxygen (DO), or calcium carbonate (CaCO3) content either between sample sites or between sample sets. They observed a slight general decrease in salinity and organic matter content towards the landward part of the lagoon. Suresh Gandhi and Rajamanickam (2004) investigated four different environments from the Palk Strait, Bay of Bengal, and found Asterorotalia only off Kodiyakkarai where the followwing ecological conditions were recorded: 5–7-m water depth, 0.64% organic matter, rather high carbonate content (19%), salinity 33.7%, silty-sand sub strate, and low algal content.

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