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Comparative study on foraminifera of east and west coast of India

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Abstract

The oceanographic conditions of west and east coasts of India provide variations in ecological conditions. Hence, the present study was undertaken to assess the geographic distribution and diversity of foraminifera (Protista) of west and east Coasts of India to gain insights in to ecological conditions that effect their distribution. The intertidal sediment samples, collected for a period of two years from October 2004 to September 2006 were analysed for foraminiferal diversity and sediment characteristics by standard methods. Relatively high densities (west coast -156 to 19,400 g^{-1}, east coast – 37-214 g^{-1}) and diversities were observed at all the sites of the West (74 species) compared to the east coast (57 species). Thirty three species were common to both the coasts. Forty one and 24 species were found to be unique to west and east coast, respectively. Foraminifera of west and east coasts form distinct clusters as revealed by Bray-Curtis cluster analysis, indicating distinctly different foraminiferal assemblages. The geographical and oceanographic conditions thus seem to influence a differential diversity of forams.

Key words

Intertidal, Foraminifera, Diversity, West and East Coasts

Introduction

Foraminifera (Protista) are good ecological indicators. They are the most widely used fossil organisms for biostratigraphy, age dating and correlation of sediments and palaeoenvironmental interpretation (Murray, 2006). Extant species help in understanding various ecological features. Their mineralized tests provide records of palaeotemperatures, glaciation and other palaeogeographic features. Both stable isotopic (carbon, oxygen etc) and elemental (magnesium, calcium etc) analysis of foraminiferal shells strengthen the use of foraminifera as proxy in climate research (Katz *et al*., 2010). Good preservation and fossilization potential of foraminifera have been used extremely in pollution studies all over the world (Saraswat *et al*., 2004; Ernst *et al.,* 2006, Sabean *et al.,* 2009). They also provide useful information in hydrocarbon exploration (Giwa *et al.,* 2006), understanding the occurrence of Tsunamis (Gadi and Rajashekhar, 2007; Dahanayake and Kulasena, 2008). Foraminifera (forams) are abundant in tropical conditions and their significance in monitoring coastal environment has been emphasized by Scott *et al.* (2001). Forams have been described by many researchers as useful indicators for reconstructing sea-level changes from coastal sediments (Horton and Edwards, 2005; Massey *et al*., 2006). Thus forams have contributed to understanding ecology, palaeoclimate and oceanography.

Bathymetric, geological and hydrological differences of west and east coasts of India are expected to provide variations in ecological conditions influencing foraminiferal distribution and diversity. The study by Kathal *et al.* (2000) using Q mode cluster analysis showed that only 26 out of 160 species studied were common to west and east coasts of India. Studies have been carried out on foraminiferal diversity, distribution and assemblages to various ecological conditions of West coast of India (Gandhi *et al.,* 2002). The west coast of India was found to support high diversity and density of foraminiferal species (Nigam and Khare, 1999) which can be due to the intense upwelling associated with the southwest monsoon. The marked difference in hydrographic regimes and productivity patterns of east coast due to the weak upwelling associated with northeast monsoon results in lower foraminiferal species diversity (Kaladhar *et al.,* 1990; Majumdar *et al.,* 1999).

The available literature on foraminiferal affinities of west and east coast of India in relation to ecological conditions is scanty. The west and east coasts differ in many aspects and hence, the present study was undertaken to assess the diversity of foraminifera of west and east coast of India by studying their assemblages from 9 sites on the west and 8 sites on the east coasts of India. Their affinities and similarities were assessed by Bray-Curtis Analysis. Such a study permits correlation of marine ecological conditions to foram assemblage.

Materials and Methods

Study area : The study sites along the west coast (Fig. 1) were Okha (Gujrat), Juhu (Maharashtra), Malvan (Maharashtra), Calngute (Goa), Majorda (Goa), Ankola (Karnataka), Murudeshwar (Karnataka), Kozhikode (Kerala), Kochi (Kerala). Along the east coast following sites were surveyed – Nagapattinam (Tamil Nadu), Chennai (Tamil Nadu); Vishakhapattinam (Andhra Pradesh), Bheemunipattinam (Andhra Pradesh), Puri (Orissa), Paradip (West Bengal), Digha (West Bengal) and Sunderbans (Gujarat).

From all the above mentioned sites of west and east coasts of India (from five stations at each site with an interval of 1km), intertidal sediment samples were collected at an interval of six months for a period of two years, from October 2004 to September 2006. Thus, 180 samples on the west coast and 160 samples on the east coast were collected over a period of 2 years. The samples (10 g) were collected from at a distance of 2 m from the lower water line, to a depth of 6 inches of sediment. The samples were analysed for foraminiferal diversity and sediment characteristics. Foraminiferal species were identified and classified by following Loeblich and Tappan (1987) and Devi and Rajashekhar (2009). To obtain lucid illustrations and assist in identification, representative species of foraminifera were observed using scanning electron microscope (JEOL JSM – 5800VL) at National Institute of Oceanography, Goa. Various biodiversity indices (Shannon- Weiner Index, Simpson's dominance, Evenness and Morisita-Horn Index) were calculated (Magurran, 1983). Bray- Curtis Cluster analysis was also carried out using Past ® software. Sediment characteristics such as texture (Carver, 1971; Lindholm, 1987), organic matter (Trivedy and Goel, 1986) and calcium carbonate (Loring and Rantala, 1992) were estimated. In textural study, sand-silt-clay percentages were determined from a combination of sieving and pipette analysis. The readily oxidisable organic carbon content was determined by modified Walkley-Black method (Trivedy and Goel,1986).

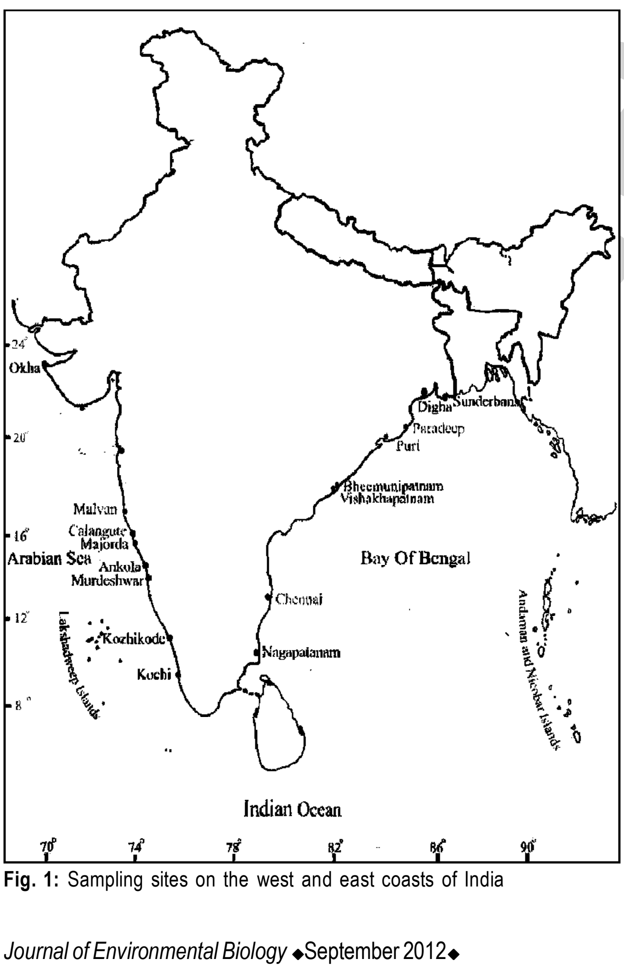

Fig. 1: Sampling sites on the west and east coasts of India

Results and Discussion

Foraminiferal diversity : Considerable differences in foraminiferal assemblages were observed in west and east coasts of India. High densities and diversities were observed in all the sites of the west as compared to the east coast of India. Tables 1 and 2 show the densities of dominant species of west and east coasts of India. Density of foraminiferal species was expressed as Total foraminiferal number (TFN g^{-1}). TFN of west coast varied between 156 to 19,400 g^{-1} (Table 3) whereas TFN g^{-1} of east coast ranged from 37 to 214 g^{-1} (Table 4). Thus the density in the west coast is higher by a factor ranging from 5 to 91 times as compared to east coast. In the present study, a total of 98 species of foraminifera were recorded from west and east coasts of India. Out of which 74 species of foraminifera, belonging to 39 genera, 27 families and 7 suborders were recorded from the intertidal sediments of West coast and 57 species of foraminifera were observed from the sediment samples of east coast. They belonged to 32 genera, 23 families and 5 suborders. Thirty three species were common to both the coasts of India. Forty one and 24 species were found to be unique to west and east coast of India, respectively. Site specific variations in density were observed and Murdeshwar and Juhu on the westcoast were found to have the highest TFN g^{-1} and Cherai beach (Kochi) had the least. Similarly, lowest and highest numbers of species were observed at Nagapattinam and Vishakapatnam respectively. The diversity of forams was however not related to TFN g^{-1}. The densities of the ten most dominant species are provided in Table 1 and 2. The sites of foram collection on the west or east coast do not have identical dominance of species. For example *Quniquiloculina semilunum* and *Asterorotalia trispinosa* that are among the ten most dominant species of the east coast are not found on the west coast.

Spiroloculina communis, Globigerina bulloides, Bolivina striatula, Nonion elongatum, *Nonion boueanum*, *Nonion scaphum, Ammonia beccarii*, *Ammonia tepida*, *Ammonia dentata* and

Table- 1: Density (number gm^{-1}) of dominant species of Inter-tidal Foraminifera of west coast of India

Sr.No.	Species	Sites								
		Okha	Juhu	Malvan	Calan gute	Majorda	Ankola	Murude shwar	Kozhi	Kochi
1.	*Ammonia beccarii* (Linne)	-	6100	295	80	65	530	2550	363	33
2.	*Nonion scaphum* (Fichtel and Moll)	150	750	30	70	35	185	4600	-	-
3.	*Nonion boueanum* (d'Orbigny)	275	850	195	45	45	410	3200	160	-
4.	*Rotalidium annectans* (Parker and Jones)	400	600	220	1530	1125	-	850	-	07
5.	*Nonion elongatum* (d'Orbigny)	-	550	140	55	-	-	2250	-	-
6.	*Ammonia tepida* Cushman	-	2400	30	20	-	-	100	80	-
7.	*Ammonia dentata* (Parker and Jones)	-	950	20	25	-	90	200	57	07
8.	*Spiroloculina aequa* Cushman	-	-	-	-	30	-	-	-	-
9.	*Bolivina striatula* Cushman	135	550	25	15	-	20	200	-	-
10.	*Elphidium discoidale* (d'Orbigny)	185	350	10	20	30	30	250	43	-

Table- 2: Density (number gm^{-1}) of dominant species of Inter-tidal Foraminifera of east coast of India

Sr.No.	Species	Sites							
		Nagapa ttinam	Chennai	Visakha-patnam	Bheemu-nipatnam	Puri	Parad wip	Digha	Sunderbans
1.	*Quinqueloculina seminulum* (Linne)	02	02	03	03	-	02	02	04
2.	*Triloculina trigonula* (Lamarck)	01	-	04	-	01	03	03	04
3.	*Globigerinoides ruber* (d'Orbigny)	-	-	05	-	-	02	-	-
4.	*Nonion boueanum* (d'Orbigny)	06	05	-	-	-	11	-	29
5.	*Nonion scaphum* (Fichtel and Moll)	03	04	04	06	02	09	08	46
6.	*Ammonia beccarii* (Linne)	08	09	09	11	08	13	12	51
7..	*Ammonia tepida Cushman*	-	-	04	02	13	-	05	-
8.	*Ammonia dentata* (Parker and Jones)	04	04	-	04	02	05	-	32
9.	*Asterorotalia trispinosa* (Thalmann)	03	02	04	03	-	04	03	07
10.	*Elphidium discoidale* (d'Orbigny)	-	-	04	05	03	05	03	07

Table- 3: Diversity characteristics of Inter-tidal Foraminifera of west coast of India

Attributes	Okha	Juhu	Malvan	Calangute	Ankola	Murudeshwar	Kozhikode	Kochi
Total Foraminifera (Number g^{-1} sediment)	2575	18,900	1,185	2,130	1,620	19,400	1,280	156
Species richness	24	29	26	29	23	36	21	16
Shannon diversity (H')	2.789	2.658	2.389	1.446	2.161	2.642	2.583	2.314
Simpson's dominance	0.075	0.140	0.142	0.521	0.195	0.121	0.120	0.130
Evenness	0.878	0.790	0.733	0.429	0.682	0.737	0.848	0.835

Table- 4: Diversity characteristics of Inter-tidal Foraminifera of east coast of India

Attributes	Nagapattinam	Chennai	Visakha patnam	Bheemuni patnam	Puri	Paradeep	Digha	Sunderbans
Total Foraminifera (Number g^{-1} sediment)	37	46	96	58	46	73	51	214
Species richness (Number g^{-1})	14	20	29	19	15	21	17	21
Shannon diversity (H')	2.393	2.730	3.250	2.705	2.358	2.682	2.496	2.262
Simpson's dominance	0.113	0.085	0.044	0.084	0.135	0.092	0.112	0.150
Evenness	0.907	0.911	0.965	0.919	0.871	0.881	0.881	0.743

Table- 5: Organic matter and calcium carbonate content in the sediments of west and east coast of India.

West coast characteristics	**Okha**	**Juhu**	**Malvan**	**Calangute**	**Ankola**	**Murudeshwar**	**Kozhikode**	**Kochi**
Organic matter (%)	0.456	0.746	0.192	0.301	0.329	0.889	0.398	0.231
Calcium carbonate (%)	12.648	7.661	6.849	11.184	6.984	8.132	4.889	2.396
East coast characteristics	**Nagapattinam**	**Chennai**	**Visakhapatnam**	**Bhimunipatnam**	**Puri**	**Paradwip**	**Digha**	**Sunderbans**
Organic matter (%)	0.202	0.234	0.426	0.248	0.276	0.473	0.347	0.797
Calcium carbonate (%)	1.210	1.750	2.248	1.467	1.698	3.006	2.019	3.027

Table- 6: Correlation between foraminiferal diversity and sediment characteristics of west and east coasts of India.

		Total sand	**Coarse sand**	**Medium sand**	**Fine sand**	**Silt**	**Clay**	**Organic matter**	**Calcium carbonate**	**TFN**	**Species richness**
West coast	**TFN**	-0.936**	-0.145	-0.760*	-0.156	0.788*	0.841**	0.958**	0.803*	1.000	
	Species richness	-0.377	0.090	-0.834*	-0.012	0.127	0.158	0.468	0.564	0.623	1.000
East coast	**TFN**	-0.755*	-0.339	-0.850**	0.834*	0.851**	0.809*	0.865**	0.189	1.000	
	Species richness	-0.486	-0.392	-0.603	0.695	0.663	0.579	0.705	0.026	0.868**	1.000

TFN: Total foraminiferal number; ** Correlation is significant at (±0.834 critical value) the 0.01 level (two-tail); * Correlation is significant at (±0.707critical value) the 0.05 level (two-tail)

Rotalidium annectans were dominant species on the west coast. *Bolivina striatula*, *Nonion boueanum*, *Nonion scaphum*, *Ammonia beccarri*, *Ammonia dentata*, *Asterorotalia trispinosa*, and *Elphidium discoidale* were found to be the dominant species of east coast. But their abundance was less in comparison with that of west coast. Four planktonic species, *Globigerina bulloides, Globigerinoides ruber*, *Globigerinoides sacculifer and Orbulina universa* were observed on the west coast. Except *Globigerinoides sacculifer*, other three species of planktonic foraminifera were found in the samples of east coast.

Shannon diversity values of west coast varied from 1.446 to 2.658. Shannon diversity values of east coast varied between 2.262 to 3.250. The values of Simpson's dominance of west coast and east coast varied from 0.120 to 0.521 and 0.044 to 0.150 respectively. The observed values of Evenness of west coast ranged from 0.429 to 0.848. The values of Evenness of east coast varied from 0.743 to 0.965 (Tables 3, 4). Morisita Horn index similarity for pooled data of west and east coast of India was 0.535.

Bray – Curtis cluster analysis was performed to assess the similarity of foraminiferal assemblages. It is evident from the dendrogram (Fig. 2) that the sites of west coast form a distinct cluster except Kochi. Cherai beach of Kochi has unique status assemblage of foraminifera. The other sites of west coast like Juhu beach of Mumbai and Murudeshwar; Malvan, Ankola and Kozhikode and Calangute and Majorda of west coast form sub clusters. Similarly all the sites of east coast form a separate cluster indicating distantly different assemblage.

Sediment characteristics : Silt was observed only at two sites on west coast i.e. Murudeshwar (7.349 %) and Juhu beach of Mumbai (8.630%). The silt of east coast varied between 0.275 to 6.134%. Clay was found at two sites on west coast i.e. Murudeshwar (2.174%) and Juhu beach of Mumbai (3.966%). Even on the east coast, only in two sediment samples the clay was recorded i.e. Digha (1.399%) and Bali Island of Suderbans (17.121%). Sediment samples of west coast showed organic matter ranging from 0.192 to 0.889%.

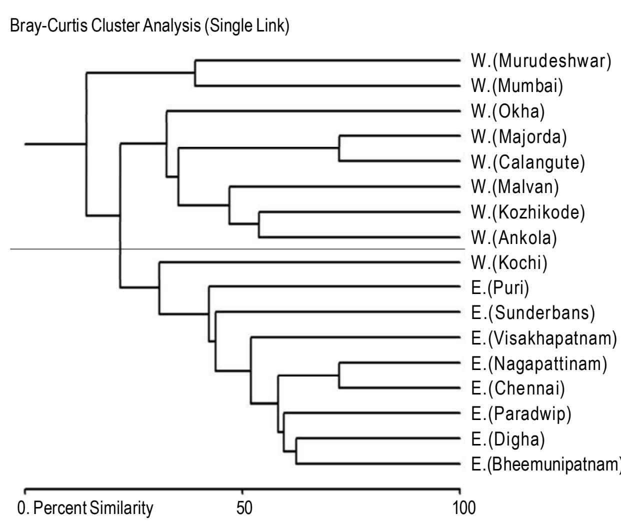

Fig. 2 : Bray-Curtis cluster analysis dendrogram showing the similarity between different sites of west coast and east coast of India. (W: Site on West coast, E: Site on east coast). Solid horizontal line distinguishes the two clusters of the east and west coast.

The organic matter of the east coast varied from 0.202 to 0.797%. Calcium carbonate content of west and east coasts' samples ranged from 2.396 to 23.352% and 1.210 to 3.027% respectively (Table 5).

Even though Arabian Sea and the Bay of Bengal are located on the same latitude and come under southWest monsoon regime, Arabian Sea is highly productive than Bay of Bengal. Four to five times higher concentration of chlorophyll a and 8 fold increase in primary productivity were found in the Arabian Sea (Kumar *et al*., 2002). This is due to lesser river discharge into Arabian Sea. Intense upwelling during south west monsoon (Bauer *et al*., 1991; Prakash and Ramesh, 2007) brings nutrients from deeper water to euphotic zone in Arabian Sea. In the Bay of Bengal, the upper 30 m of water column had very less amount of nitrate and silicate. A stratified surface layer prevents mixing of nutrients from deeper water to upper layers in Bay of Bengal (Kumar *et al*., 2002) due to the greater influx of river water (3,000 $km^3 yr^{-1}$) into Bay of Bengal (Rajamani *et al*., 2006). In the present study, higher ranges of organic matter and calcium carbonate were observed in the sediment samples of west coast (Table 5). Factors such as greater availability of nutrients, high primary productivity, high organic matter and calcium carbonate content, lesser river discharge and higher salinity of Arabian Sea as evident from the present study are responsible for greater abundance and diversity of foraminiferal populations on the west coast of India. The greater influx of river water highly stratified isothermal layer in the upper 30 m water column and lower salinity of Bay of Bengal might be the causes for low diversity and abundance of foraminifera on the east coast in the present study. It is evident from various diversity measures that there is significant difference in the TFN, Species richness and Shannon diversity (H') between the west and east coast of India. Higher Simpson's dominance values indicate that the number of dominant species is more on the west coast. The higher Evenness values show that there is greater uniformity in the distribution of foraminiferal species on the east coast. It is evident from dendrogram (Fig. 2) that the 9 sites of west and 8 sites of east coasts form two distinct clusters. The sites, Juhu beach of Mumbai and Murudeshwar; Malvan, Ankola and Kozhikode and Calangute and Majorda of west coast form sub clusters. The unique status of Cherai beach of Kochi on the west coast can be attributed to less number of species.

Various sediment characteristics affect the distribution and diversity of foraminifera. Fine sand, clay, organic matter and calcium carbonate of the sediments are the important determining factors of abundance and species richness of foraminifera. Several authors reported that sediments rich in fine sand and clay have higher density and diversity of foraminifera than the coarse grain sands (Jennings and Nelson 1992; Kumar *et al*., 1996). In the present study, very high abundance and diversity of foraminifera found at Murudeshwar and Juhu beach of Mumbai are correlated to the presence of high amount of fine sand and clay in the sediment composition. Organic matter plays an important role in controlling the distribution of foraminifera (Murray, 2009). In the present study, it was observed that the shore sediments of east coast were coarser and the concentration of organic matter was low. Foraminiferal abundance and diversity were also less on the east coast. Calcium carbonate also influences the distribution of foraminifera. In the present study also, a direct relationship was observed between the calcium content and abundance and diversity of foraminifera. The species belonging to suborders Miliolina and Rotaliina were abundant on the west coast where calcium content was more. The sediment samples of east coast had lesser amount of calcium carbonate. This might be one of the causes for lesser abundance of the suborders Miliolina and Rotaliina on the East coast as compared to west coast. It is evident from the correlation matrices that the factors, fine sand, clay, organic matter and calcium carbonate play an important positive role in controlling the diversity and distribution of foraminifera along the west and east coasts of India (Table 6). The present comparative study of foraminiferal diversity of west and east coasts of India, confirms that the foraminiferal species belong to two distinct assemblages.

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References

Carver, R.E.: Procedure in sedimentary petrology. Wiley Inter Science, New York, pp.637 (1971).

Dahanayake, K. and N. Kulasena: Geological evidence for Paleo-Tsunamis in Sri Lanka. *Sci. Tsunami Haz.,* **27**, 54 (2008)

Devi, G.S. and K.P. Rajashekhar: Intertidal foraminifera of Indian coast – a scanning electronmicrograph– illustrated catalogue. *J. Threatened Taxa*., **1**, 17-36, (2009).

Ernst, S.R., J. Morvan, E. Geslin, A. Le Bihan and F.J. Jorissen: Benthic foraminifera response to experimentally induced Erika oil pollution. *Marine Micropaleontology*, **61**, 76-93(2006).

Gadi, S.D. and K.P. Rajashekhar: Changes in intertidal foraminifera following tsunami induction of Indian coast. *Indian J. Marine Sci*., **36**, 35-42 (2007)

Gandhi, M.S., G.V. Rajamanickam and R. Nigam: Taxonomy and distribution of benthic foraminifera from the sediments off Palk Strait, Tamil Nadu, east coast of India. *J. Palaeontol. Soc. India*, **47,** 47-64 (2002).

Giwa, G.O., A.C. Oyede and E.A. Okosun: Advances in the application of biostratigraphy to petroleum exploration and production. Search and Discovery Article (2006).

Horton, B.P. and R.J. Edwards: The application of local and regional transfer function: Implications for sea level studies. *Marine Micropaleontology*, **36**, 205-223 (2005)

Jennings, A.E. and A.R. Nelson Foraminiferal assemblage zones in Oregon tidal marshes - relation to marsh floral zones and sea-level. *J. Foram. Res.,* **22,** 13-29 (1992)

Kaladhar, R., S. Kamalakaran, K.U. Varma and B.V. Rao: Recent foraminifera from nearshore shelf, south of Vishakhapatnam,east coast of India. *Indian J. Marine Sci.*, **19**, 71-73 (1990)

Kathal, P.K., S.N. Bhalla and R. Nigam: Foramgeographical affinities of the west and east coasts of India: An approach through cluster analysis and comparison of taxonomical, environmental and ecological parameters of recent foraminiferal thanatotopes. *Oil and Natural Gas Corporation of India Bull*., **37,** 65-75. (2000)

Katz, M.E., B.S. Cramer, A. Franzese, B. Honisch, K.G. Miller, Y. Rosenthal and J.D. Wright: Traditional and emerging geochemical proxies in foraminifera. J. *Foraminiferal Res.,* **40**, 165-192 **(**2010)

Kumar, S.P., P.M. Muraleedharan, T.G. Prasad, M. Gauns, N. Ramaiah, S.N. de Souza, S. Sardesai and M. Madhupratap: Why is the Bay of Bengal less productive during summer monsoon compared to the Arabian Sea? *Geophy*. *Res*. *Lett*., **29,** 881-884 (2002).

Kumar, V., V. Manivanan and V. Ragothaman: Spatial and temporal variations in foraminiferal abundance and their relation to substrale characteristics in the Palk Bay, off Rameshwaram, Tamil Nadu. *Proceedings of XV Indian Colloquium Micropaleontologyand Stratigraphy*, pp. 393-402. (1996)

Lindholm, R.C.: A practical approach to sedimentology. London, Allen and Unwin Publication, pp1-276 (1987)

Loeblich, A.R. Jr. and H. Tappan: Foraminiferal genera and their classification. New York, Von Nostrand Rinhold, pp1-970 (1987)

Loring, D.H. and R.T. T. Rantala: Manual for the geochemical analysis of marine sediments and suspended particulate matter. *Ear. Sci. Rev*., **32,** 235-283 (1992).

Magurran, A.E.: Ecological diversity and its measurement. Princeton University Press, Princeton, N J, pp.197 (1983).

Majumdar, S., A. Choundhury and T.Y. Naidu: Recent benthic foraminifera from the near shore inner shelf off Digha, North-East of India. *J. Biol. Sci*., **5,** 1-8 (1999)

Massey, A.C., W.R. Gehrels, D.J. Charman and S.V. White. An intertidal foraminifera based transfer function foe reconstructing Holocene Sea level change in southwest England. *J. Foraminifera Res*., **36**, 215-232 (2006)

Murray, J.W.: Ecology and applications of benthic foraminifera. Cambridge University Press, p. 278 (2006)

Nigam, R. and N. Khare: Spatial and temporal distribution of foraminifera in sediments off the central west coast of India and use of their morphologies for the reconstruction of palaeomonsoonal precipitation. *Micropal.,* **45,** 285-303. (1999)

Prakash, S. and R. Ramesh: Is the Arabian Sea getting more productive? *Curr. Sci*., **92,** 667-669 (2007)

Rajamani, V., U.C. Mohanty, R. Ramesh, G.S. Bhat, P.N. Vinayachandran, D. Sengupta, P. Kumar and R.K. Kolli: Linking indian rivers vs Bay of Bengal monsoon activity. *Curr. Sci*., **90,** 12-13 (2006).

Sabean, J.A.R., D.B. Scott, K. Lee and A.D. Venosa: Monitoring oil spill bioremediation using marsh foraminifera as indicators. *Marine Poll. Bull.,* **59**, 352-361(2009)

Saraswat, R., S.R. Kurtarkar, A. Mazumder and R. Nigam: Foraminifers as indicators of marine pollution: A culture experiment with *Rosalina leei. Marine Poll. Bull.,* **48**, 91–96 (2004).

Scott, D.B., F.S. Medioli and C.T. Schafer: Monitoring of coastal environments using Foraminifera and Thecamoebial indicators. Cambridge University Press, pp.176 (2001)

Trivedy, R.K. and P.K. Goel: The chemical and biological methods for water pollution studies. Environmental Publication, Karad, India, pp. 104-248 (1986)

Venkataraman, K. and M. Wafar: Coastal and marine biodiversity of India. *Indian J. Mar. Sci*., **34,** 57-55. (2005)