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Community Structure of Benthic Foraminifera in the Adimalathura Estuary, Southwest coast of India

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Original Article

Abstract

Foraminifera are successful inhabitants of every aquatic environment from deep oceans to brackish water lagoons, estuaries, and even rarely in freshwater habitats. Sediment samples collected from 3 stations in the Adimalathura Estuary (between latitudes $8^0$0'-$8^0$24'N and longitudes $77^0$01'–$77^0$03'E) exposed to pollution from domestic wastes and coconut husk retting were analysed for a period of one year on monthly basis to study the assemblages of foraminifera. The study has shown that *Elphidium advenumis* to be the most dominant and most widely distributed foraminifera species of the estuary. *Textularia agglutinans*, *Rotalia becarii* and *Elphidium crispum* are the other abundant species of the fauna. The fauna in general is dominated by the species of Nonionidae followed by Rotalidae. The Shannon-Wiener diversity index (H') annually ranged from 0 to 1.9225, the Margalef species richness index (d) from 0 to 1.1696, Pielou's equitability index (e) from 0 to 0.9543 and Simpson's index of dominance (C) from 0.1822 to 1. The index values in general were least during the southwest monsoon which coincided with a fall in the density of benthic foraminifera.

Keywords*: Benthic foraminifera, Species diversity, Estuary, Southwest coast of India*

Introduction

Benthic organisms are very sensitive to habitat disturbances, including organic enrichment of the sediment and contamination of the sediment by toxic substances. Any change in the estuarine environment leaves its print on the benthic community inhabiting the sediment biome. The vast majority of the coastal environments have been affected by the adverse effect of coastal contamination from land based sources. The discharge of excessive amount of human wastes to coastal area is one of the most wide spread pollution problems faced by the coastal zone. A fluctuation in organic input is considered to be one of the principal causes of faunal change in estuarine and near shore benthic environment.

Foraminifera are among the most abundant and scientifically important group of organisms. They are an important component of benthic communities in the open ocean, along the coast and in estuaries, where they form sometimes a dominant taxon, both in terms of abundance and species diversity. Their taxonomic diversity gives them the potential for diverse biological responses to various pollutants and to stay as index species for monitoring pollution from diverse sources. The application of benthic foraminifera has emerged

as an excellent environment monitoring tool for polluted aquatic ecosystems. Over the years, various characteristics of foraminifera have been applied for ecotoxicology and pollution monitoring. Rapid changes in abundance of foraminifera were considered as indicators of stressed environment by many researchers (Rao and Rao, 1976; Alve, 1995; Yanko *et al.*, 1999; Nigam, 2005). There are relatively few studies on benthic foraminifera of estuarine habitats.

An outstanding feature of the Kerala coast is the continuous chain of lagoons or estuaries lying along the coastal region and separated from the Arabian Sea by low belt of sand. These extensive estuarine water bodies are getting increasingly polluted as a result of persistent anthropogenic activities. Adimalathura Estuary is a small brackish water biotope between latitudes $8^0 0'$ -$8^0 24'$N and longitudes $77^0 01'$–$77^0 03'$E on the southern part of Kerala in Thiruvananthapuram district, on the southwest coast of India. This small brackish water biotope receive untreated domestic wastes from the thickly populated human settlement around and foul water from the near-by coconut husk retting grounds almost on a continuous basis. Some baseline data on water quality and benthic community is available from the Adimalathura Estuary (Anila Kumary *et al.*, 2007; Anila Kumary, 2014, 2016, 2017), whereas absolutely no information on the foraminiferal assemblages from this area is recorded. The present study was undertaken with the objectives to (1) prepare a check list of the benthic foraminifera species in the Adimalathura Estuary and (2) measure species diversity, richness, dominance and evenness using diversity indices.

Material and methods

Samples of sediment were collected using a hand operated steel corer (5.5 cm inner diameter and 25 cm long) at monthly intervals from three selected stations in the Adimalathura Estuary, station I located in the upper reaches, Station II in the middle reaches and Station III in the lower reaches, close to the bar mouth of the estuary(Fig.1). Totally 108 undisturbed core samples were collected manually and transferred to clean polythene bags and were preserved immediately in 10% neutralized formaldehyde solution. The isolation and extraction of benthic organisms were carried out by flotation decantation method (Holme and McIntyre, 1971). To identify the specimens, the samples fixed in neutralized formaldehyde solution were stained with Rose Bengal and the foraminifera specimens were sorted out. The specimens were identified under compound microscope (Olympus CX41 under higher magnification of 1000x) and classified following Loeblich and Tappan (1987). From the species composition at each station the descriptive measures of diversity indices were worked out following the expressions

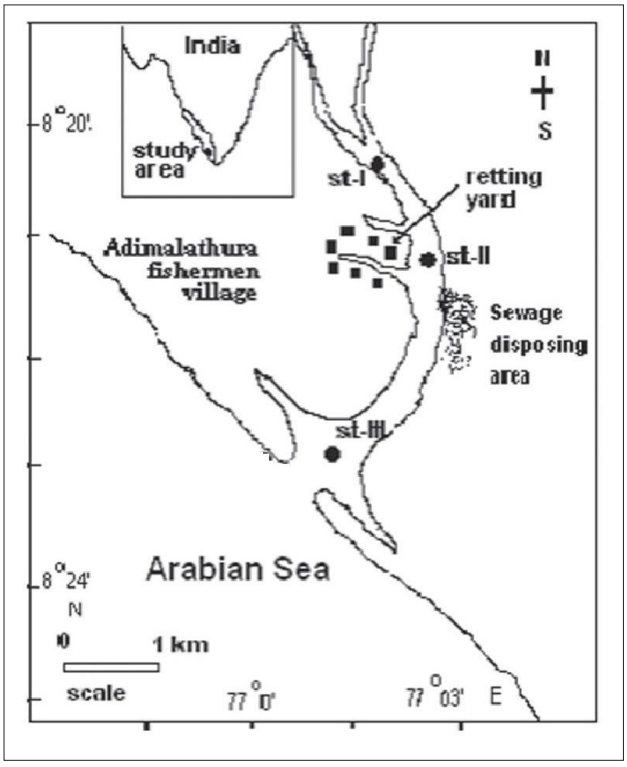

Fig. 1. Map showing the Adimalathura Estuary and location of stations

Index of species diversity (Shannon and Weaver, 1963) $H' = -\sum (ni/N) \log (ni/N)$

Index of Dominance (Simpson, 1949) $C = \sum (ni/N)^2$
Species richness index (Margalef, 1958) $d = S-1/ \log N$
Species evenness index (Pielou's, 1966) $e = H'/ \log s$
Where, ni = importance value of each species
N = total of importance values
S = number of species

Results and discussion

The study revealed the occurrence of 14 species of foraminifera belonging to 8 genera from the families Lituolidae, Textulariidae, Rotalidae, Nonionidae and Globigerinidae. The fauna in general was dominated by the species of Nonionidae followed by Rotalidae. Among these the foraminifera species widely distributed in the estuary are *Elphidium advenum* and *Textularia agglutinans*. This assemblage is characteristic of present-day intertidal and estuarine environment (Reddy and Reddy, 1982; Suresh Gandhi *et al.*, 2014). It was also observed that the foraminiferal species such as *Textularia cuneiformis, Nonion scaphum* and *Globigerina dubia* were very rare and low in abundance. Species such as *Textularia cuneiformis, Rotalia becarii*, *Nonion boueanum*, *Nonion scaphum*, *Globigerina dubia* and *Orbulina universa* were characteristic of the downstream station with high marine influence. Occurrence of foraminifera

species and their percentage contribution at the three stations of the estuary is given in Table 1.

Table I. Composition (% of species density) of foraminifera at the different stations of Adimalathura Estuary

Species	Station I	Station II	Station III
Ammobaculites taylorensis	0	6.2	0
Ammobaculites catenulatus	8.82	0.36	0
Textularia agglutinans	27.55	28.57	8.69
Textularia polustris	4.18	1.07	0.49
Textularia sagittula	0	1.58	0.68
Textularia cuneiformis	0	0	0.64
Ammonia becarii	1.21	1.17	0
Rotalia becarii	0	0	17.39
Elphidium advenum	59.43	54.16	60.62
Elphidium crispum	0	8.06	4.67
Nonion boueanum	0	0	4.16
Nonion scaphum	0	0	0.13
Globigerina dubia	0	0	0.78
Orbulina universa	0	0	1.91

The total density as well as diversity of foraminifera was generally low in the study area. The peak standing stock was 2422/ m^2 and there was considerable station to station variability in abundance and diversity. Foraminiferal density and species richness at the different stations are presented in Table 2. Upstream station was poorly populated while the downstream section of the estuary had a large population together with better species richness. The variation in total abundance of foraminifera in the Adimalathura Estuary is mainly due to the substrate as well as tidal current action. It was found that the bar mouth of the estuary is a zone of unstable substratum which uproots benthic foraminifera from the habitat. However, comparatively high density and diversity of foraminifera were recorded in the lower reaches of the estuary with sandy bottom. Further, low salinity due to freshwater influx may also have a control over the foraminiferal abundance in the estuary. Reduced number of species were noted in the upper fresh water zone and in the middle reaches of estuary.

Changes in the species composition in a community are capable of providing a more sensitive and clear measure of pollution disturbances. Some sensitive species decrease in relative importance, some tolerant species remain unaffected

Table 2. Density (mean) of total foraminifera (No/m^2) and the species richness (No. of species) at the different stations of Adimalathura estuary

Season	Station I		Station II		Station III	
	No/m^2	Number of species	No/m^2	Number of species	No/m^2	Number of species
Premonsoon	344	4	488	7	862	10
Monsoon	257	3	359	5	426	8
Postmonsoon	442	5	622	8	1422	10
Annual	348	5	490	8	904	11

and some which may benefit from the changed conditions increase (Warwick, 1988). Species diversity indices measure the way in which the individuals of an ecological community are distributed. Species diversity is at a minimum when all the individuals belong to the same species and maximum when the individuals belong to different species. The index of Shannon and Weaver (H') used to evaluate the diversity of foraminifera species in the Adimalathura Estuary varied from 0 (Station I) during June to 1.9225 (station III) during September. Monthly variations in the species diversity of benthic foraminifera at the three stations of the Adimalathura Estuary are presented in Fig. 2. All the three stations had maximum species diversity during the post monsoon season coinciding with higher density of total foraminifera. Foraminiferal zonatons are, in general, related to factors such as river runoff, currents, environmental stability and bio-geo chemical process (Denny and Sen Gupta, 1993; Elakkia and Manivannan, 2013).The monsoon period was generally characterised by poor density and low diversity. The shift in this community structure was probably caused by heavy rain and flood water discharge which might have flushed out the surface layers of sediment.

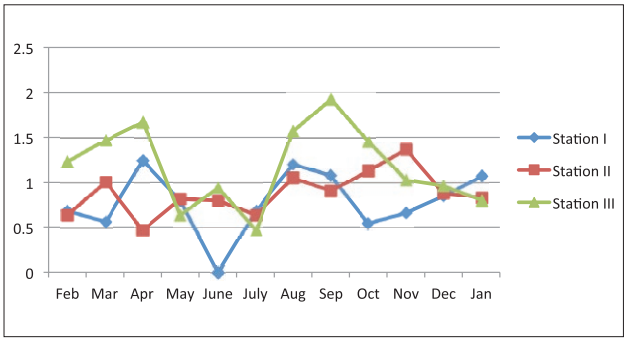

Fig.2 Monthly variations in species diversity index (H') of foraminifera

Species richness is the ratio between the total number of species and the total number of individuals and the index of species richness increase with the occurrence of several species. Higher values of species richness occur due to the occurrence of several species without allowing one or two species to dominate the community completely. Species richness in the estuary was maximum (1.1696) during September (Station III) along with the maximum value of H'. Lowest value of species richness (0) was during June at station I (Fig. 3).

A major component of community diversity is the evenness or equitability in the apportionment of the individuals among species. Species evenness describes how equally the various species are distributed in the community. High evenness index occurs when the large numbers of species

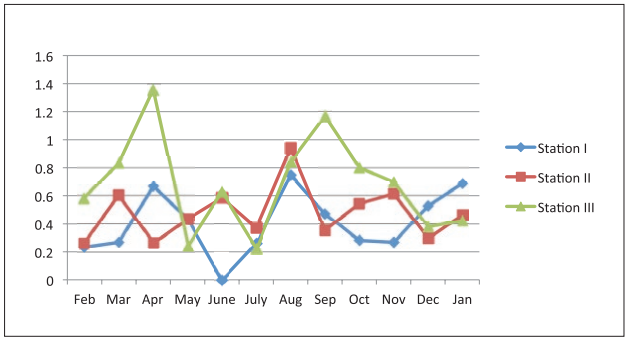

Fig.3 Monthly variations in species richness index of foraminifera

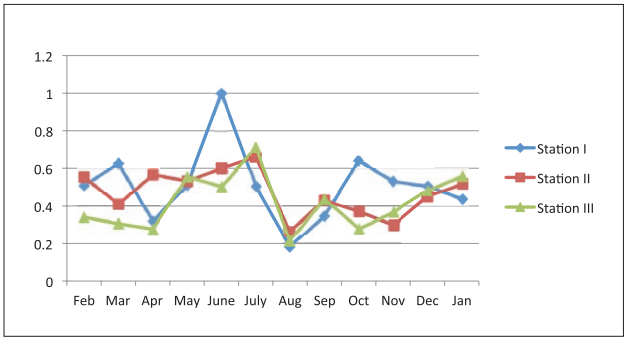

Fig.5 Monthly variations in species dominance index of foraminifera

in a community are virtually equal in abundance. The evenness of distribution among species may be the result of competition under optimum conditions (Patrick, 1971). Evenness index of foraminifera in the Adimalathura Estuary was least (0) during June at station I due to the complete dominance *Elphidium advenum* and the highest (0.9879) during September at station III (Fig. 4). The distribution of foraminiferal community was more even during the post monsoon season at all stations in the estuary.

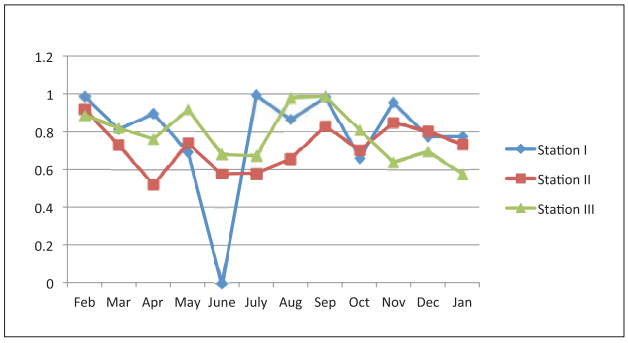

Fig.4 Monthly variations in species evenness index of foraminifera

Communities have species or species groups which largely control the energy flow and strongly affect the environment of all other species which are known as ecological dominants. The degree to which dominance is concentrated at one, several or many species can be expressed by the index of dominance (Simpson, 1949) which sums up the importance of each species in relation to the community as a whole. Dominance index is used to identify the main species in a community (Rosenberg, 1975). Among the different stations in the Adimalathura Estuary peak dominance index was during June (1.00) at station I with the complete dominance of *Elphidium advenum* and during July at stations II and III due to the clear dominance of *Elphidium advenum* over the other component species (Fig. 5).

Estuarine ecosystems are generally characterized by low species diversity because of various factors such as bathymetry, sediment texture, physicochemical characteristics of sediment as well as water and pollution (Pielou, 1975).The number of species present and the diversity indices were less at the upstream station with muddier deposits at the bottom whereas comparatively high density and diversity of foraminifera were recorded in the lower reaches of the estuary with sandy bottom. Foraminifera are very sensitive to any kind of pollution in the ambient environment. Anthropogenic stress may lead to alterations in the community structure of benthic foraminifera, which include changes in its density and diversity, high abundance of opportunistic species, barren areas, test deformations and the changes of test chemistry (Yanko *et al.*, 1988; Murray, 2006; Ferraro *et al.*, 2006; Nigam *et al.*, 2006). The impact of anthropogenic stress on benthic foraminifera community depends, however, on the type of stress, and its supply rate. The better dominance index prevailed at the intermediate station (Station II) could be attributed to the modification in the community structure consequent to changes in the organic load in to the estuary at the station.

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