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Meiobenthic diversity and abundance along Arthunkal coast in Kerala, southwest coast of India

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Original Article

Abstract
Meiobenthos are key indicators of aquatic environmental pollution and stress and can be used as effective tools in biomonitoring programs to assess the overall health of oceans. The present paper highlights the dynamics of meiobenthic assemblages in relation to environmental variables along the coast of Arthunkal in Kerala, India from February 2013 to January 2014. Meiobenthic composition consisted of fifteen taxa in which nematodes (85.02%), foraminiferans (25.38%), ciliates (10.92%), copepods (6.66%) and polychaetes (7.47%) dominated. Diversity indices indicate moderate pollution and uneven distribution. PCA analysis revealed the relation between environmental variables like bottom water temperature, pH, dissolved oxygen, silicate-silicon, sediment organic carbon, texture and meiobenthic distribution. Nematodes, foraminiferans and polychaetes were found to be abundant in sediments with a temperature of 29.60±0.55°C, organic matter 2.108±1.60%, pH 8.25±0.36 and silty texture while copepods preferred a sandy habitat. The study also revealed the presence of biomonitors signalling the need for conservation and management of the bioresources of Arthunkal.

Keywords: *Arthunkal coast, meiobenthos, diversity indices, hydrological variables, conservation.*

Introduction

Coastal habitat deterioration is mainly due to unregulated anthropogenic activities which lead to loss of biodiversity and ecological integrity. Monitoring of coastal and marine environment is one of the key tools in scientific management of marine and coastal resources. Meiobenthic assemblages are sensitive indicators which reflect the general health of benthic habitat and are also involved in bioturbation and stimulation of bacterial metabolism that forms a link between detritus and higher trophic levels (Hongayo *et al.,* 2013). Sediment contamination poses one of the most serious forms of environmental degradation within marine ecosystems and disruption of benthic function through environmental degradation causing redirection and loss of benthic trophic transfer potential to microbial pathways (Diaz and Rosenberg, 2008). Meiobenthos has so far been studied mainly in the context of the formation of sediments and ecotoxicology in marine environments (Soltwedel, 2000).

Studies on meiobenthic assemblages in relation to environmental variables in marine realms is scanty and most studies are limited to taxonomic documentation along the Indian coast (Damodaran, 1972; Sajan and Damodaran, 2007; Sajan *et al.,* 2010; Ansari *et al*., 2013). Investigation on nematode abundance and oxygen flux in the Arabian Sea was carried out by Cook, 2000. Priyalakshmi and Menon (2014) studied the ecology of interstitial faunal assemblage from the beaches along the coast of Kerala, India.

Arthunkal is a coastal hamlet in Alleppey, Kerala. It is a major Christian pilgrimage centre and exposed to massive foot traffic coupled with organic waste disposal. The present paper explores the diversity of the meiobenthos off the coast of Arthunkal. An attempt has also been made to correlate the impact of anthropogenic stress on the faunal communities.

Material and methods

The study was carried out along the coast of Arthunkal (9°39'19''N & 76°17'23''E) in Kerala, India during the year 2013-14. Samples were taken seasonally (pre-monsoon, monsoon, and post-monsoon) from five stations (station I, II, III, IV and V) representing depths of 5 m, 10 m, 15 m, 20 m and 30 m from the shoreline along one transect (Fig 1). Samples were collected using a Van veen grab having a mouth area of 0.1m^2. A 10 cm long graduated stainless steel corer with an inner diameter of 2.5 cm was used to sub sample meiobenthos from the grab. Three undisturbed sediment samples each were immediately transferred into polythene vials. The samples were anaesthetized with 7% $MgCl_2$ and preserved in buffered 4% formalin. 0.1% Rose Bengal was added to the sample for efficient extraction of the fauna and was separated by suspension decantation method (Wieser, 1960).

Bottom water samples were collected using a Nessler's bottom water sampler. Temperature was determined using a thermometer having an accuracy of 0.5°C, hydrogen ion concentration by a digital pH pen, salinity with a water analyser (systronics-model-371), dissolved oxygen by Winkler's method (Winkler, 1883) and water nutrients such as nitrate-nitrogen, nitrite-nitrogen, phosphate-phosphorous and silicate-silicon were analysed spectrophotometrically (Strickland and Parsons, 1972 and Grasshoff, 1983).

Bottom sediment (approximately 250 gm) was collected from each station for the analysis of geo chemical variables. Temperature was analysed using a thermometer and pH with a digital pH pen. Organic carbon was determined using wet oxidation method (El-Wakeel and Riley, 1957) and sediment texture was determined by pipette analysis (Krumbien and Pettijohn, 1938).

Biodiversity indices- Margalef's index (d) (Margalef, 1968), Shannon Weiner index (H') (Shannon and Weaver, 1949), Pielou's evenness index (J') (Pielou, 1966) and Simpsons' index (λ') (Simpson, 1949) were used in the calculation of taxa richness, general diversity and evenness. ANOVA (three-way) was used to compare the variation in the physical, chemical and biological data between stations and seasons while Principal Component Analysis (PCA) was used to explain

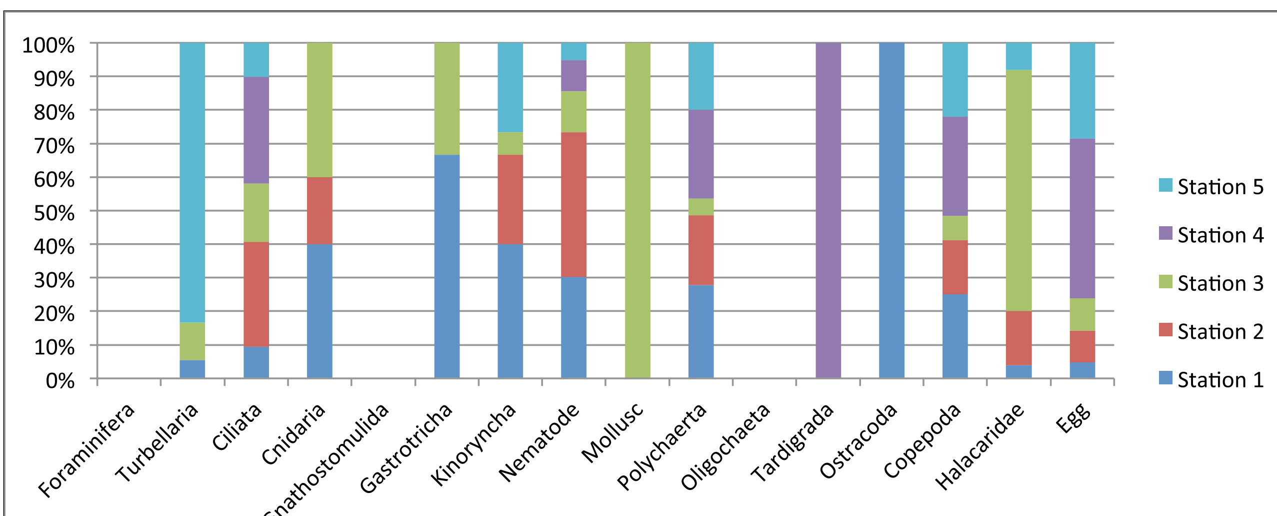

Fig. 1.Variation in the percentage contribution of meiobenthos during pre monsoon.

the environmental variables influencing the changes in meiofaunal assemblages using SPSS ver. 20.

Results

Meiobenthic Dynamics

Faunal composition of meiobenthos obtained from the study sites consisted of fifteen taxa viz. foraminifera, turbellaria, ciliata, cnidaria, gnathostomulida, gastrotricha, kinoryncha, nematode, mollusca, polychaeta, oligocheata, tardigrada, ostracoda, copepoda and halacaridae (Table 1, Figs 1-3). Faunal abundance was maximum during pre-monsoon with nematodes recording maximum abundance (85.02%) at station II followed by foraminifera (25.38%) at station I and ciliate (10.92%) at station IV. Copepods (6.66%) and halacarids (4.83%) were dominant at station IV during post -monsoon while polychaetes were abundant at station IV (7.47%) during pre-monsoon.

Diversity indices (Table 2) viz; Margalef's index (d), Shannon's index (H'), Pielou's evenness (J') and Simpson index (λ') revealed maximum values at station V (H'=1.5, J'=0.683 and λ'=0.691) whereas lower values were observed at station II (H'=0.611, J'=0.278 and λ'=0.269) during pre-monsoon. Margalef'sindex showed higher values at station III (d=1.78) during pre-monsoon and lower values at station III (d=0.935) during monsoon.

Hydrological variables

The season wise variation of hydrological variables of the bottom water is given in Table 3. Temperature ranged from 31.5° C at station IV during post-monsoon to 21°C at station V

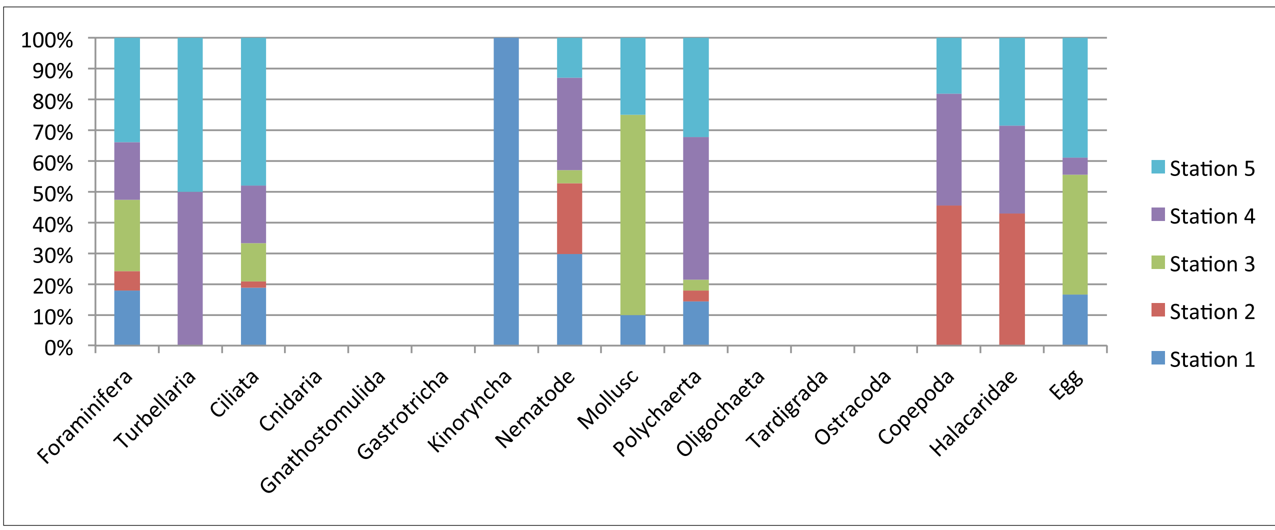

Fig. 2. Variation in the percentage contribution of meiobenthos during monsoon.

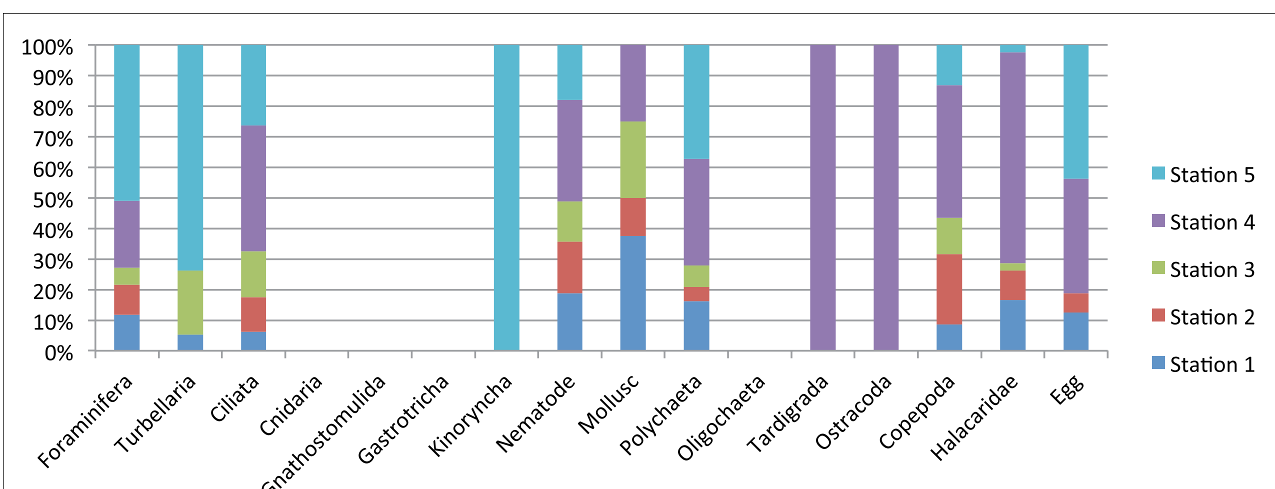

Fig. 3. Variation in the percentage contribution of meiobenthos during post monsoon.

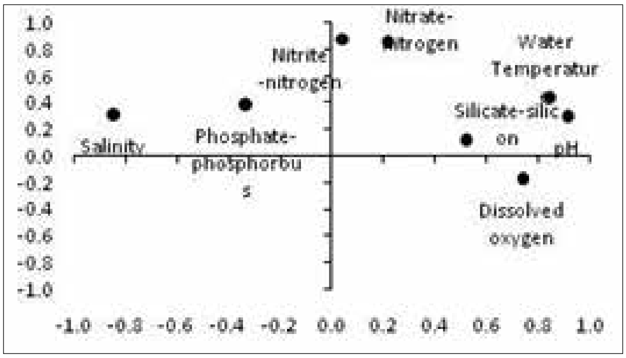

Fig. 4. PCA plot of hydrological variables.

Table 1.Occurrence and composition of meiobenthic assemblages at five different stations

Taxa	Station I	Station II	Station III	Station IV	Station V
Foraminifera	+	+	+	+	+
Turbellaria	-	-	-	-	+
Ciliata	-	+	+	+	+
Cnidaria	-	+	-	-	-
Gnathostomulida	-	-	-	+	-
Gastrotricha	-	-	-	+	-
Kinoryncha	+	-	-	-	-
Nematode	+	+	+	+	+
Mollusca	+	+	-	+	-
Polychaeta	+	+	-	+	+
Oligocheta	-	-	-	+	+
Tardigrada	-	-	-	-	-
Ostracoda	-	-	-	+	-
Copepod	-	-	+	+	+
Halacaridae	-	+	+	+	+
Egg	+	+	+	-	+

during monsoon. Hydrogen ion concentration varied from 8.2 at station III during post-monsoon to 7.54 at station I during monsoon, dissolved oxygen varied from 5.95 ml/ L at station III to 4.11ml/L at station II during monsoon. Salinity ranged from 34.3 ppt at station I and IV during monsoon to 32 ppt at station IV during post-monsoon. Nitrate-nitrogen varied from 0.88μg/L at station III during pre-monsoon to 0.0097μg/L at station II during post-monsoon. Nitrite-nitrogen varied from 0.549μg/L at station V during pre-monsoon to 0.0006μg/L at station III during post-monsoon. Phosphate-phosphorous ranged from 0.044μg/L at station I during pre-monsoon to 0.0006μg/L at station III during post-monsoon. Silicate- silicon varied from 0.201μg/L at station II during pre-monsoon to 0.002μg/L at station IV during pre-monsoon.

PCA analysis for hydrological variables revealed that the first principal component (PC1-water temperature, pH, dissolved oxygen and silicate-silicon) rendered with 41.8% variance had greater impact on meiobenthic assemblages while the second component (PC2-nitrate-nitrogen and nitrite-nitrogen) rendered with 24.0% variance contributed less to faunal abundance whereas the third component (PC3-phosphate-phosphorous and salinity) rendered with 13.8%

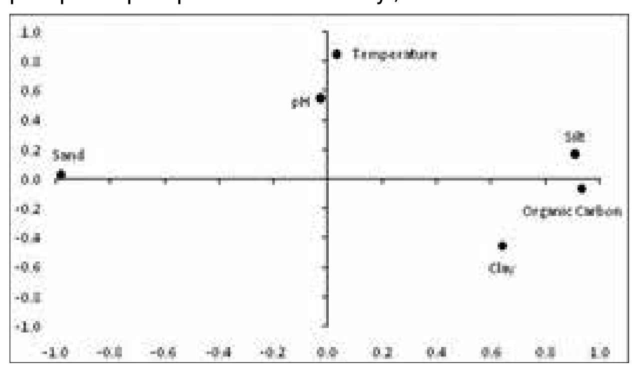

Fig. 5.PCA plot of geological variables.

Table 2. Diversity indices of meiobenthic assemblages at five different stations

Season	Station	Taxa	Fauna	Margalef's Index (d)	Shannon Index (H')	Pielou's eveness (J')	Simpson's Index (λ')
Pre-monsoon	I	12	1399	1.519	0.878	0.353	0.467
	II	9	1615	1.083	0.611	0.278	0.269
	III	12	484	1.779	0.859	0.346	0.355
	IV	7	522	0.959	1.297	0.666	0.624
	V	9	337	1.375	1.500	0.683	0.691
Monsoon	I	7	322	1.039	0.935	0.481	0.536
	II	6	195	0.948	0.770	0.430	0.415
	III	6	210	0.935	0.897	0.501	0.426
	IV	8	342	1.200	1.048	0.504	0.568
	V	9	356	1.362	1.118	0.509	0.541
Post-monsoon	I	9	292	1.409	1.081	0.492	0.518
	II	8	267	1.253	1.097	0.528	0.540
	III	8	202	1.319	1.149	0.552	0.537
	IV	10	601	1.407	1.361	0.591	0.631
	V	9	550	1.268	1.249	0.568	0.619

TTable 3. Season-wise variationof hydrological variables along Arthunkal coast.

	Pre-monsoon	Monsoon	Post-monsoon
Temperature (°C)	29.80 ± 0.447	21.80 ± 0.447	28.90 ± 2.408
pH	8.110 ± 0.049	7.644 ± 0.073	8.140 ± 0.047
Dissolved oxygen (ml/ L))	5.245 ± 0.789	4.684 ± 0.768	5.661 ± 0.312
Salinity (ppt)	33.52 ± 0.130	34.24 ± 0.055	32.02 ± 0.192
Nitrate-nitrogen (μg/L)	0.510 ± 0.265	0.036 ± 0.014	0.031 ± 0.021
Nitrite-nitrogen (μg/L)	0.242 ± 0.207	0.005 ± 0.002	0.004 ± 0.004
Phosphate-phosphorous (μg/L)	0.014 ± 0.017	0.009 ± 0.009	0.002 ± 0.001
Silicate-silicon (μg/L)	0.085 ± 0.078	0.018 ± 0.018	0.055 ± 0.027

variance accounted for the least impact on meiobenthic assemblage (Fig. 4).

Sediment parameters

The season-wise variation of sedimentological variables at the five stations is given in Table 4. Temperature varied from 31°C at station IV during post-monsoon to 22°C at station II and V during monsoon, hydrogen ion concentration from 8.66 at station V to 7.74 at station I during pre-monsoon, organic carbon from 4.7 % at station II during post-monsoon to 0.11 % at station IV during pre-monsoon, sand from 8.66% at station V during post-monsoon to 0.39% at station II during monsoon, silt from 9.44% at station III during pre-monsoon to 1.4% at station V during post-monsoon, clay from 2.35% at station II during monsoon to 0.01% at station IV and V during pre-monsoon.

PCA analysis for sedimentological variables revealed that the first principal component (PC1 -organic carbon, sand, silt and clay) rendered with 51.6% variance had greater impact on meiobenthic assemblages while the second component(PC2 -temperature and pH)rendered with 20.4% variance contributed less to faunal abundance (Fig.5).

The correlation coefficient analysis between hydrological and sedimentological variables revealed that bottom water temperature and pH recorded a significant positive correlation whereas salinity is negatively correlated ($P<0.01$). Bottom water nitrite-nitrogen and pH showed significant positive correlation ($P<0.05$). Results of ANOVA (three-way) indicated a significant difference in the faunal abundance between seasons and stations ($P<0.01$).

Discussion

The present investigation reveals spatio- temporal variation in the meiobenthic structural patterns along the coast of Arthunkal with nematodes as dominant taxa, followed by foraminiferans, ciliates and copepods. The higher abundance of nematodes at station II during pre-monsoon may be attributed to moderate input of organic enrichment, silty substrata and alkaline nature of both water and sediment. Ansari *et al.,* (2014) observed that meiobenthic population increases with moderate organic input while excessive organic load creates stress conditions. The distribution and abundance of meiobenthos is also strongly related to sediment granulometry (Somerfield *et al.,* 1995). In the present study it was observed that foraminiferans are abundant in clayey substrata with moderate temperature and ciliates dominate in low organic rich sediments.

Priyalakshmi and Menon (2014) while studying the ecology of interstitial faunal assemblages of sandy beaches of Kerala, recorded extremely low organic matter in the sediment. They also recorded only 9 taxa of meiobenthos at Arthunkal. Within a span of seven years, the sediment organic carbon was found to have increased three times signaling a negative impact of the flourishing pilgrim influx at Arthunkal. Higher species

Table 4. Season-wise variation of geological variables along Arthunkal coast

	Pre-monsoon	Monsoon	Post-monsoon
Temperature (°C)	29.60 ± 0.548	22.20 ± 0.447	30.00 ± 0.707
pH	8.248 ± 0.355	8.098 ± 0.079	8.144 ± 0.215
Organic carbon (%)	2.108 ± 1.593	2.232 ± 1.516	2.805 ± 2.189
Sand (%)	2.250 ± 1.950	2.760 ± 3.037	3.686 ± 3.949
Silt (%)	8.050 ± 1.543	6.430 ± 2.416	5.554 ± 3.183
Clay (%)	0.064 ± 0.061	0.828 ± 0.933	0.812 ± 0.757

diversity obtained in the present study may be attributed to the exhaustive nearshore and offshore sampling attempted in the present work.

PCA have been widely used in the evaluation of spatial and temporal variations in water quality and benthic characteristics of aquatic ecosystems (Ingole *et al.,* 2010). In the present study, PCA analysis confirms the influence of hydro-geochemical variables (temperature, pH, dissolved oxygen, silicate-silicon, sediment organic carbon, sand, silt and clay) in determining meiobenthic abundance and diversity. Ramaswamy *et al.,* 2010 reported the influence of environmental factors such as temperature, pH, dissolved oxygen and salinity in nematode distribution along Palk Bay.

The state and composition of meiobenthic assemblages reflect the general health of the marine realm (Kennedy and Jacobi, 1999). Species evenness index is the expression of abundance that is, how equally the species are abundant. High evenness occurs when species are equal or virtually equal in abundance (Chandra and Chakraborty, 2008). In the present investigation, evenness values clearly indicated the uneven distribution of meiobenthic assemblages. Shannon's index, a sensitive indicator of pollution reveals moderate pollution of the coast which is further confirmed by the abundance of nematodes, a bioindicator taxa.

The pressure on natural habitat associated with increasing anthropogenic stress like tourist traffic will continue to impact the biodiversity of Arthunkal coast. Recognition of the scale of the problem, the nature of underlying causes and the limited resources available to counteract powerful distractive trends may be the best way of conserving the biological diversity of marine systems of India.

Faunal abundance was found to be related to sediment granulometry and water chemistry prevailing along the coast of Arthunkal. PCA analysis helped to define spatial and temporal patterns in water quality and meiobenthic assemblages. Temperature, pH, salinity, dissolved oxygen, silicate-silicon, sediment granulometry and organic matter content all proved to be important descriptive parameters related to the abundance and distribution of meiobenthos. A decisive shift in the organic load is discernable warranting the need for biomonitoring along the Kerala coast.

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