

## Original Article

# Community structure of macrobenthos in Ponnani estuary, South India with reference to occurrence of invasive alien species

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**Abstract:** Benthic organisms have been studied in past to assess the health of an aquatic ecosystem. Moreover, being sedentary forms they have been used as indicator organisms. In the present study, an attempt has been made to study the distribution and assemblage of major macrobenthic forms occurring in Ponnani estuary. A total of 23 genera of benthic invertebrate fauna belonging to 6 groups viz., Polychaetes, Bivalve, Gastropod, Amphipod, Isopod and Tanaidacian were recorded during the study. Faunistic study revealed that in high saline regions of the estuary (Veliyancode), a very good macrobenthic biodiversity was present. Bivalves were the major group enumerated from Veliyancode and Ponnani (39% and 35%, respectively), while in Biyyam predominance of gastropods (37%) were observed. Among the bivalve groups, presence of *Maculista senhousia* and *Pholas candida*, both considered as invasive species was noteworthy. Another interesting observation was the presence of Amphipod *Melita zeylanica*, another alien species evenly represented in all the three stations, indicating that the species had well established in Ponnani estuary. The present study is the first description of benthic organism assemblages inhabiting in the region. Results indicate that salinity is a major parameter that governs the diversity, occurrence, abundance and distribution of macrobenthos in Ponnani estuary. It also elucidates that any perturbation in the physico-chemical nature of the estuary favours the invasiveness of alien macrobenthic species in Ponnani backwaters.

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## Introduction

Estuary is one of the most important coastal life supporting system and an ideal tryst of various economically important marine and fresh water organisms. However, owing to the high primary productivity, suitable physico-chemical conditions and less hydrographical perturbations, they also are favourable grounds for establishment of new alien species. Usually the establishment of a new group in estuary is facilitated with sharp fluctuation in the physico-chemical parameters as part of climate change in the region (Occhipinti-Ambrogi, 2007). Climate change could alter the structure and composition of native communities and, as a consequence, the way an ecosystem functions, increasing the risk of biological invasion. As

invasive species and climate change are considered two of the three main threats to biodiversity, the two operating together could be expected to produce extreme outcomes (Masters and Norgrove, 2010). It is also likely to increase the potential distribution and abundance of invasive species, further enlarging areas at risk of invasion, and threatening even the survival of less prolific groups such as the benthic forms.

Temperature is a major factor influencing the settlement of tropical alien species (Ben Rais Lasram et al., 2008). Warming of seawater influences the spatial and temporal distribution of many marine organisms, ranging from phytoplankton and zoobenthos to higher trophic levels (Beaugrand et al., 2008). This warming not only stresses the native

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dwellers, but also facilitates the arrival of alien ones, adding extra pressure on the ecosystem (Harris and Tyrell, 2001). Macrobenthos are an important component of estuarine ecosystem and play an important role in the system dynamics (Herman et al., 1999). They are a central element of estuarine food webs, being an important food resource for large crustaceans, fish and birds (Day et al., 1989). Macroinvertebrates cycle nutrients throughout the water column and provide a food source for many economically important fish species (Silva et al., 2006). The spatial heterogeneity of macrobenthos along the estuarine gradient is traditionally described in relation to salinity and sediment composition (Ysebaert et al., 1993). Studies have shown a complex interaction between hydrodynamics, sediment dynamics, and benthic biology in structuring distribution patterns of benthos (Herman et al., 2001). Benthic communities are sensitive to many environmental stresses. Benthic invertebrates are extremely important indicators of environmental changes.

The study of the alien species is necessary to understand the long term consequences of marine ecosystems, their goods and services. Since estuarine environments are continuously dominated by species that can thrive well under harsh physico-chemical conditions, the possibility of invasive species establishing in the new environment cannot be ruled out. The impact of these species on native communities has been evaluated in many localities all over the world leading to the concept of biotic pollution. Once invasive alien species become established in large numbers, their consequences are often irreversible. Although there has been fairly good research on the ichthyofaunal diversity of Ponnani estuary, an open estuary of South India, very little works pertaining to the diversity of macrobenthic community in the region has been published. Moreover, the influence of hydrographical parameters on the resident community and occurrence of any invasive alien species in the region has yet to be reported. Under the above pretext, a study was conducted to understand the distribution

of macrobenthic community in Ponnani backwaters with a view to develop an in depth knowledge on the environmental dynamics prevailing in the region and also to investigate the establishment of any alien/invasive groups in the region. The major objectives included to make community structure analysis of benthic fauna in Ponnani estuary, analyze spatial distribution of benthos based on salinity regime prevailing in the region and to identify the presence of any alien/invasive macrobenthic group in the region.

### **Materials and Methods**

**Study Area:** The Ponnani estuarine system is located between 10°46' and 10°48' N and 75°54' to 75°56' E. It is an open estuary drained by a tributary of the Bharathappuzha River, the largest river of South India, and drains into the Arabian Sea at this region. The estuarine system is exposed to tides from the Arabian Sea and hence water is brackish almost throughout the year. The region receives an annual average rainfall of 180 mm. In the present study, three stations viz., Veliyancode, Ponnani and Biyyam that are 2 Km apart from the barmouth were selected as sampling stations. This ensured that a judicious representation of the varying hydrographical parameters of Ponnani estuary was represented.

**Sampling:** All sampling for the collection of water and sediment samples in the estuary was made during the early morning hours. The water quality parameters recorded on site were temperature, dissolved oxygen, salinity, pH, turbidity and total suspended solids (EI-Model 191). Nutrients such as Nitrate and Phosphate were analyzed in lab based on Strickland and Parsons (1972) and measured on Systronics UV-VIS Spectrophotometer. The data were pooled in to three separate seasons (Monsoon, Post monsoon and Pre-monsoon) for analysis. Macro benthos samples were collected using a grab. Two replications were made at each of the two stations. These samples were washed through sieves of mesh size 500 micron for separating the macro fauna from sediments and preserved in 5% formalin and stained

Table 1. Mean values of environmental variables during different seasons in the three stations of Ponnani backwaters.

Environmental Variables	Veliyancode						Ponnani						Biyyam					
	Premonsoon		Monsoon		Post Monsoon		Premonsoon		Monsoon		Post Monsoon		Premonsoon		Monsoon		Post Monsoon	
	Mea	SD	Mea	SD	Mea	SD	Mea	SD	Mea	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Temperature Surface (°C)	28.25	0.38	25.60	1.07	27.05	0.41	28.00	0.42	26.95	0.47	27.28	0.75	30.00	1.59	31.18	1.01	28.75	0.61
Dissolved Oxygen (ppm)	6.95	0.71	6.78	0.38	7.05	0.25	7.28	0.33	6.68	0.29	7.25	0.37	5.98	0.25	5.48	0.64	5.98	0.13
Salinity (ppt)	22.00	2.45	14.00	1.63	18.00	2.94	17.75	0.50	11.75	1.71	15.00	2.58	13.25	2.50	9.00	2.00	10.50	3.00
pH	7.63	0.13	7.40	0.24	7.58	0.17	7.70	0.12	7.83	0.39	7.53	0.28	7.83	0.21	7.85	0.34	7.73	0.10
TSS	4.68	1.45	4.20	1.86	4.18	1.69	5.70	0.73	7.08	0.80	4.53	1.66	3.55	0.76	4.55	0.60	3.50	1.78
Turbidity (ntu)	14.00	1.83	29.75	17.26	27.75	9.63	14.25	1.71	22.25	5.32	21.00	2.94	15.00	2.58	19.00	1.83	12.00	1.63
Nitrate (ppm)	3.48	1.91	5.28	1.27	5.23	0.68	4.85	1.09	5.90	0.75	4.18	1.24	3.75	0.44	3.90	0.22	3.73	0.36
Phosphate (ppm)	8.35	3.55	6.58	0.50	7.28	3.76	15.20	4.90	9.80	2.42	11.38	5.47	7.95	4.94	10.10	2.30	10.05	3.87

in Rose Bengal (1:500) to facilitate segregation of the organism from other components of the soil. The samples were then analyzed for macro fauna by hand picking and microscopic analysis. In the laboratory, the samples were sorted into different groups and the actual numbers of organisms counted were converted to nos. ind. /m<sup>2</sup>. The fauna were identified to the lowest taxonomic level (species) wherever possible following standard references (Gosner, 1971).

**Data Analysis:** The enumerated samples were pooled for different stations and analysis on the incidence of occurrence, percentage of abundance and species diversity were worked out following Gosner (1971). The species identified were cross referred with the National database on benthic forms under the website for World Register of Marine Species (WORMS) for identifying alien species.

**Results**

The physico-chemical parameters in the three stations of the Ponnani estuary were influenced by the tidal regime, freshwater inflow and other biological processes. The mean values of different environmental variables recorded in the present study are depicted in Table 1. The results indicate a significant difference ( $P < 0.01$ ) in all the parameters studied during the three seasons and across the three stations. A detailed checklist of macrobenthic communities recorded from Ponnani backwater is depicted in Table 2. A total of 23 species of benthic invertebrate fauna belonging to 6 groups and 23 genera were collected from the Ponnani backwaters during the study.

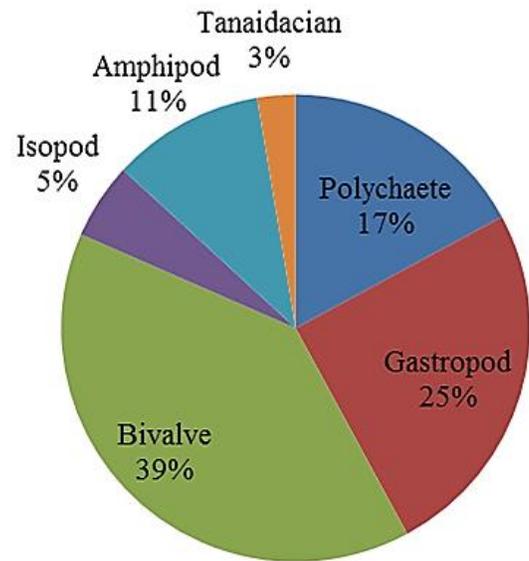


Figure 1. Macrobenthic representation in Veliyancode station.

The benthic macrofauna at Ponnani backwater was represented by 6 groups viz. Polychaetes, Bivalve, Gastropod, Amphipod, Isopod and Tanaidacian. More number of species were represented under polychaetes (10) followed by bivalves (5). Among the three stations, Veliyancode was comparatively more saline due to its proximity to the Arabian Sea, and likewise corroborated to the high diversity of polychaetes. The three stations also showed diverse pattern in the abundance of bivalves and other macrobenthic groups. Among the bivalve group, presence of *Maculista senhousia* and *Pholas candida*, both considered as invasive species was noteworthy. Another interesting observation was the presence of Amphipod, *Melita zeylanica*, considered as an alien species evenly represented in all the three stations, indicating that the species had very well established in Ponnani backwaters. Figures 1, 2, and

Table 2. Distribution of macrobenthos in different studied stations.

Macrobenthos	Biyyam	Ponnani	Veliyancode
<b>Polychaete</b>			
<i>Ancistrosyllis constricta</i>	-	+	-
<i>Branchiocapitella singularis</i>	-	+	-
<i>Capitella capitata</i>	-	+	+
<i>Dendronereis aestuarina</i>	-	-	+
<i>Eunice tubifex</i>	-	+	-
<i>Lumbrinereis impatiens</i>	-	-	+
<i>Nephtys dibranchis</i>	-	+	+
<i>Notomastus aberans</i>	-	-	+
<i>Perinereis cavifrons</i>	-	-	+
<i>Prionospio polybranchiata</i>	-	-	+
<b>Gastropod</b>			
<i>Baccinum sp.</i>	-	+	-
<i>Dentalium sp.</i>	-	-	+
<i>Littorilla littorea</i>	+	+	+
<b>Bivalve</b>			
<i>Masculista senhousia</i>	-	-	+
<i>Meretrix casta</i>	-	+	-
<i>Paphia malabarica</i>	+	+	-
<i>Perna viridis</i>	-	-	+
<i>Pholas candida</i>	-	-	+
<b>Isopod</b>			
<i>Cirolana fluviatilis</i>	+	+	+
<b>Amphipod</b>			
<i>Melita zeylanica</i>	+	+	+
<i>Eriopisa chilensis</i>	-	-	+
Caprillids	-	+	-
<b>Tanaidacian</b>			
<i>Apeudes sp</i>	-	+	+

+ Present, - Absent

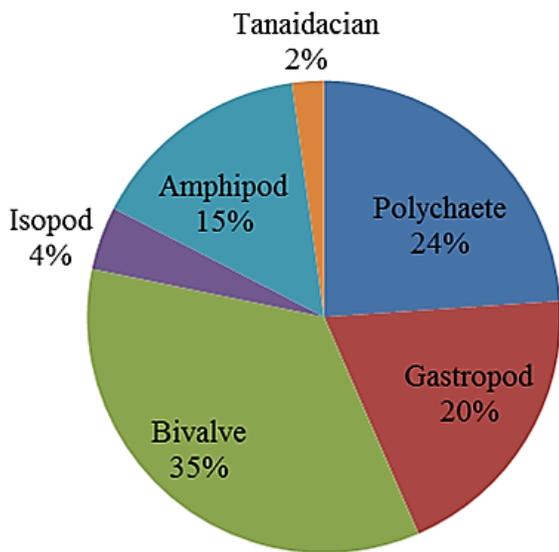


Figure 2. Macrobenthic representation in Ponnani station.

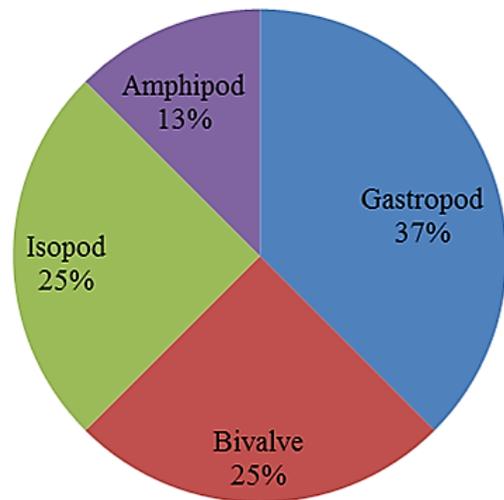


Figure 3. Macrobenthic representation in Biyyam station.

3 depict the percentage composition of the benthic macro invertebrate fauna in Veliyancode, Ponnani and Biyyam, respectively.

Bivalves were the major group enumerated from Veliyancode and Ponnani (39% and 35%, respectively), while in Biyyam it was gastropods (37%). Polychaete population was high in Ponnani

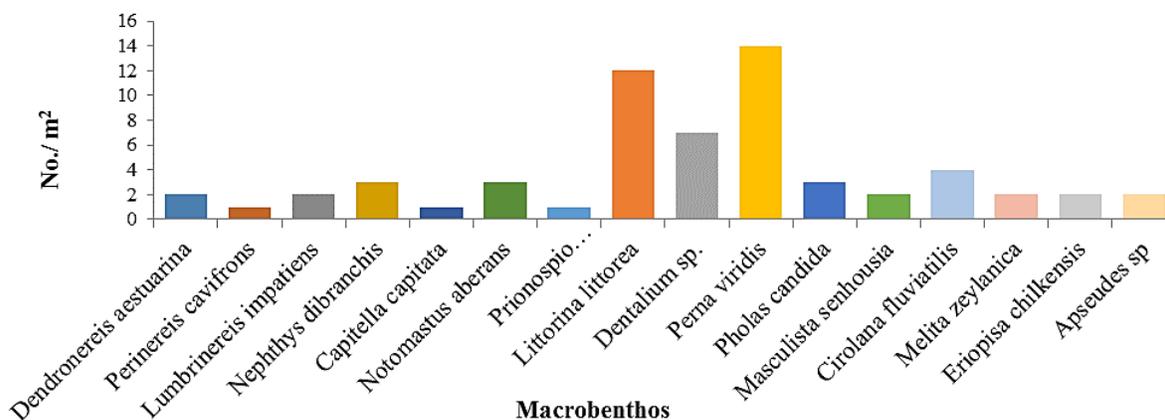


Figure 4. Abundance of macrobenthic fauna in Veliyancode station.

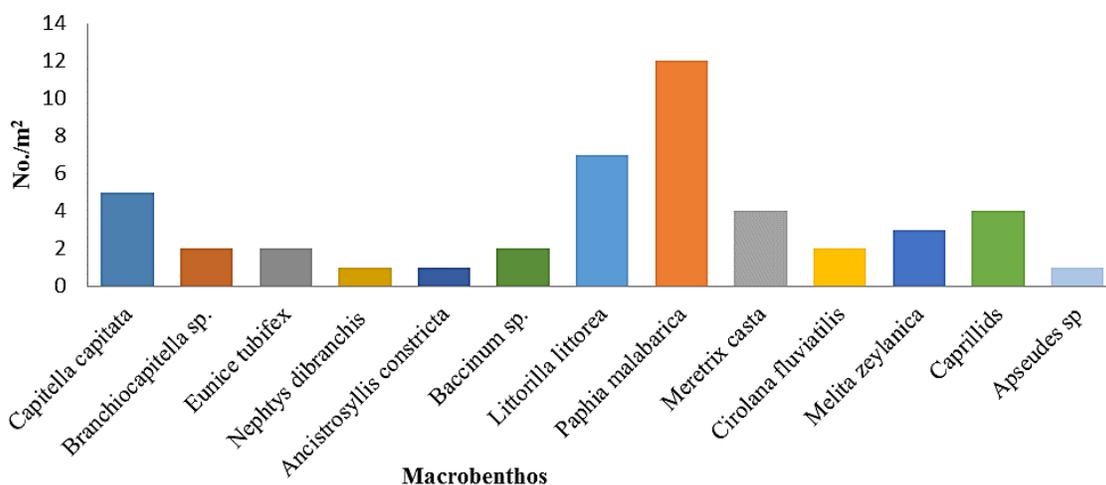


Figure 5. Abundance of macrobenthic fauna in Ponnani station.

(24%) compared to Veliyancode (17%). Gastropod population was rather evenly distributed ranging from 20% in Ponnani to 37% in Biyyam. Nearly 25% of the total species present in Veliyancode was contributed by gastropods. Isopods, amphipods and tanaidacians together contributed 19% of total biodiversity of station Veliyancode. In Ponnani, the bivalves were found to be dominant group representing 35% of the total population followed by gastropods and polychaetes. The other groups' viz. amphipod, tanaidacian and isopods were meagerly represented in both the stations. Among the three stations, polychaetes were more abundant in Ponnani. In Biyyam, the diversity is very less compared to other two stations. Here only four groups are identified in the present study. Here, the gastropod contributed 37% of total biodiversity. The half of the total biodiversity in Biyyam was

contributed by the bivalve (25%) and isopod (25%).

Figures 4, 5 and 6 shows the abundance of macrobenthic fauna in the three stations i.e., Veliyancode, Ponnani and Biyyam, respectively. The species abundance was very high in Veliyancode. The polychaetes were the most diverse taxon followed by bivalve and gastropod. The polychaetes are lesser in number and higher in diversity. Veliyancode provides a good environmental condition and habitat for a variety of polychaetes and bivalves. The presence of juveniles of *M. senhousia* shows that Veliyancode also provides breeding ground for invasive species. Abundance of macrobenthic fauna in Ponnani station is shown in Figure 5. In Ponnani however, bivalves such as *Paphia malabarica* was predominant followed by the gastropod, *Littorina littorea*. Polychaetes, *Capitella capitata* is also seen

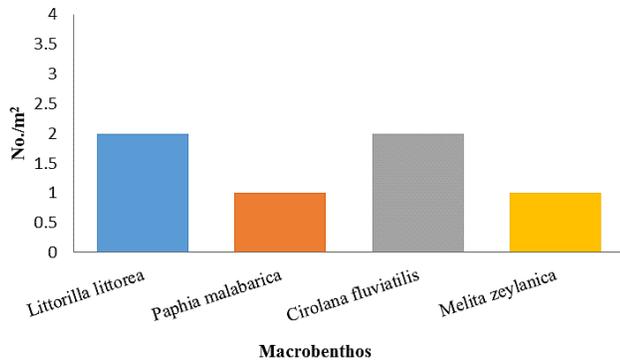


Figure 6. Abundance of macrobenthic fauna in Biyyam station.

abundantly in Ponnani. The number of *C. capitata* was comparably higher in less saline Ponnani than in high saline Veliyancode. The number of juveniles of *Mertrix casta* and *Baccinum spp.* was also higher in this region. It shows that the Ponnani is also provides a nursery ground for these molluscs. Figure 6 shows the macrobenthic abundance in Biyyam. The macrobenthic abundance and diversity are very less in Biyyam. Only four types of species are found in the present study. In Biyyam, the isopod *Cirolana fluviatilis* is seen abundantly followed by the bivalve *Littorina littorea*. The bivalve, *P. malabarica* and amphipod, *M. zeylanica* are also found in lesser number i.e., 1 nos./m<sup>2</sup>. While studying the species richness it could be seen that polychaetes were more prolifically distributed in Ponnani estuary than any other group. Among them *Capitella capitata* and *Nephtys dibranchis* were recorded in two stations. Bivalves are another dominant group observed in the present study, while, gastropod, amphipod, isopod and tanaidacian were sporadically represented. The present study clearly indicates that physico-chemical parameters in Ponnani estuary is responsible for the distribution pattern of macrobenthic groups in the region. Among them salinity had an inverse relationship with species richness.

### Discussion

The present study is the first description of benthic organism assemblages inhabiting in the Ponnani estuary. Among the 23 species reported from the study area only one species, *M. zeylanica*, alone was found to be both alien and invasive in nature as it was

distributed in all the three stations. Among the three stations, Biyyam was less saline compared to Ponnani and Veliyancode, therefore species diversity in Biyyam was comparatively less than the other two regions. The present study shows the higher abundance of *M. zeylanica* in Veliyancode (3.80 nos.m<sup>-2</sup>), followed by Ponnani (2.35 nos.m<sup>-2</sup>). Population in Biyyam was rather meagre (0.52 nos.m<sup>-2</sup>). This indicates that the distribution of *M. zeylanica* is dependent on the salinity, similar to the results of the earlier study by Ysebaert et al. (2003). *Melita zeylanica* is found in the bottom of the estuary. It is a slow moving community. Therefore, its distribution depends on many factors like temperature, salinity and most importantly sediment characteristics since the distribution of benthos is closely related to the sediment characteristics. The different types of benthos require different sediment characteristics and salinity. The sediment characteristics include pH, nitrates, phosphates and organic carbon etc. Sediment characteristics and salinity vary for different species. According to the present study, the sediment characteristics of Veliyancode and Ponnani was rather same, however in Biyyam the sediment were more of silt. The heterogeneity in the distribution also depends on the sediment composition (Ysebaert et al., 1993). This may be the reason for greater abundance and heterogeneity in macrobenthos community in Veliyancode.

The benthic community in Ponnani estuary was characterized by low species richness but with better abundance of individuals, especially bivalves of *P. viridis* and *P. malabarica*, and gastropod of *L.littorea*. The great abundance of juveniles of both the bivalve and gastropod observed from certain pockets of the back water also indicated that this region provides good conditions as nursery grounds for these species. The results showed the higher macrobenthic abundance and diversity in Veliyancode. It designates that the macrobenthos distribution is dependent on the salinity regime. This may be the reason for better species abundance and heterogeneity for macrobenthos in Veliyancode.

The distribution and assemblage of macrobenthos depends on many factors like tide, fresh water inflow and environmental factors etc. Environmental parameters such as temperature, salinity and DO have major role in the availability and abundance of macrobenthos as reported earlier by Racchor (1990). In the present study, macrobenthic distribution is different in studied stations. The fresh water inflow has greater importance in the spatial and temporal distribution of macrobenthic species (Zajac and Whittach, 1982). Fresh water inflow decreases the salinity and likewise the species dwelling in the region. In Veliyancode, the species richness and diversity is high for both polychaetes and bivalves. In the present study, species richness was found to decrease gradually in Ponnani and Biyyam. This corroborates with earlier studies of Mannino and Montagna (1997), describing that the pattern of species richness and diversity decline with decreasing salinity. Similar results from other parts of India have been reported (Kathiresan, 2000; Saravanakumar et al., 2007).

Although the present study was not intended to delineate the influence of alien species and their influence to native community, the impact has very well been defined by earlier authors. Still it would be worth investigating their influence on native biodiversity and ecosystem process and their competition for food and or space. This is particularly important for benthic ecosystems that are not able to adjust as fast as alien species. The results emerging from the present study indicate that salinity is the most important driving force determining the distribution of macrobenthos in Ponnani backwaters. Presence of alien species is yet another important information which implies to certain bivalves and amphipod that have established well in the region. With better adaptability, these alien species have better chance of coping with the stressful environment such as changing salinity profile, surface temperature, siltation and other anthropogenic alterations. Hence, there is a possibility that these species would displace native species altogether from the region, owing to the

harsh physico-chemical factors prevailing in the region. Presence of specific alien species such as *M. zeylanica* which have established in these waters is also alarming and whether or not they have turned into invasive species needs further investigations.

### Conclusion

The present study was carried out to understand the biodiversity of macrobenthos in Ponnani backwaters and thereby determine its health. Presence of invasive benthic species was also another area of interest. The results showed a direct correlation between the physico-chemical parameters and distribution of macrobenthos in three stations of Ponnani backwaters. The abundance of macrobenthos depends on the parameters like temperature, salinity, DO and pH. The abundance and distribution are high in more saline station i.e., Veliyancode. Ponnani backwater is a good water body for bivalves because from three stations bivalves are found profoundly. The three species that have potential to be invasive were seen from the Veliyancode, i.e. *M. senhausia*, *M. zeylanica* and *P. candida*. Presence of invasive species has not yet posed any threat to other macrobenthic groups however, under harsh environmental conditions in future, these groups have all possibilities to distribute and establish in the region thereby causing competition among natives groups for food and space and ultimately changing the community structure in Ponnani backwaters. The present study is particularly important and once again establishes the fact that the benthic organisms are important because they are biological indicators of environmental changes in aquatic ecosystem and also help to assess the health of an aquatic ecosystem.

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