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Spatiotemporal diversity, abundance and distribution of zoobenthos community of a temporary estuary in Kerala, India

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ABSTRACT

Zoobenthic diversity of Veli-Akkulam Lake, a temporary estuary in Kerala, was assessed for the period from October 2008 to September 2010. The benthic macroinvertebrate community comprised of 17 species; categorized into Oligochaeta, Polychaeta, Crustacea, Chironomidae, Gastropoda and Bivalvia. Oligochaeta formed the most diverse group with six species included. The numerical abundance of zoobenthos during the study period varied from 951 to 1748 no.m^{-2} during 2008-09 and from 824 to 1856 no.m^{-2} during 2009-10 between different study locations. The highest abundance was observed at Station 3 in both the years, and the least was recorded from Station 2 during the first year and Station 1 for the second year. Chironomidae was found to be the most dominating group among the zoobenthos of the Veli-Akkulam Lake during the present study, comprising 38% of the total abundance. The overall deterioration of the water quality and eutrophication of the Veli-Akkulam Lake has resulted in decreased diversity of zoobenthos. The most abundant groups were found to be chironomids and *Tubifex* sp., indicating the polluted nature of the water body.

Key words : *Veli-Akkulam lake, Pollution, Eutrophication, Indicator species*

Introduction

Zoobenthos are organisms that live on or within sediments, rocks, logs, debris and aquatic plants during some period in their lifespan and include immature forms of aquatic insects, molluscs, aquatic worms and crustaceans (Rosenberg and Resh, 1993). Benthic organisms link the primary producers with higher trophic levels such as fishes by consuming phytoplankton and then being consumed by larger organisms. Thus, they provide the key linkage between primary producers and higher trophic level animals, in the aquatic food web.

Most of the bottom dwelling animals are detritus feeders. The role of predators decline as depth increases and detritus feeders and other bottom feeders become the predominant forms. Benthic fauna has a direct relationship with the type of the bottom substratum and the physical nature of the substratum act as a limiting factor to a considerable extent (Sanders, 1958). Benthos therefore may be treated as sensitive indicators of the conditions of accumulation of organic matter in sediments and its nature (Bordovsky, 1964).

Small invertebrates are functionally important in many terrestrial and aquatic ecosystems (Wilson, 1992). In freshwater sediments, benthic invertebrates are diverse and abundant, but they are often patchily distributed and relatively difficult to sample, especially when they live in deep subsur-

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face sediments. Thus, the species richness and functional importance of freshwater benthic invertebrates generally go unnoticed until unexpected changes occur in ecosystems. Unanticipated changes in freshwater ecosystems are often due to alterations in the complex connections among sediment-dwelling species and associated food webs (Goedkoop and Johnson, 1996).

Coastal lakes play a very important role among the aquatic ecosystems since they harbour unique biodiversity. The Veli-Akkulam Lake is a small coastal lake along the west coast of India, which acts as a temporary estuary mainly during monsoon periods. The studies on benthic organisms of Veli-Akkulam Lake have been scanty. Investigations on distribution and seasonal variations of benthic fauna and macroinvertebrates in Veli and Kadinamkulam lakes were carried out by a few workers (Murugan *et al*., 1980; Gopinathan, 1985; Latha and Thanga, 2010). These studies highlighted the declining trend in the species diversity of the benthos due to low dissolved oxygen of water and high organic content and instability of the sediment texture brought about by various pollutants. The present study aims at recording the diversity and abundance of the zoobenthos in Veli-Akkulam Lake, particularly in light of the ecological changes the lake has been suffering for the last three decades.

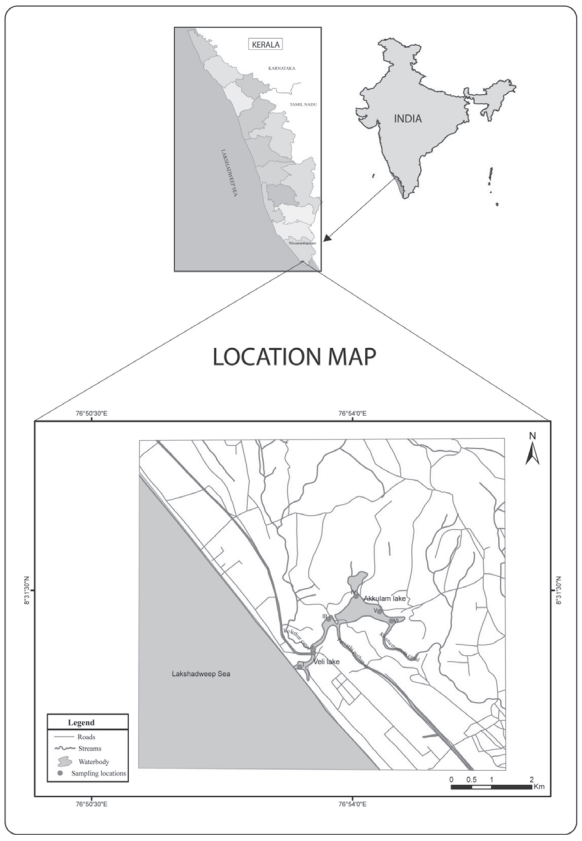

Fig. 1. Map of Veli-Akkulam Lake showing sampling locations

Materials and Methods

***Study area*:** The Veli-Akkulam Lake (Fig. 1), located approximately 5 km northwest of Thiruvananthapuram city, is one of the smallest and the southernmost of the lakes along the southwest coast of India. It is a part of the backwater system that lies adjacent to the Lakshadweep Sea along the coastal belt of Kerala. The lake is situated between latitudes 8°25′ and 8°35′ N and longitudes 76°50′ and 76°58′ E. The lake has a total area of 0.853 sq. km. It is partially separated into two segments by the existence of a bund across the lake; the western part is the Veli Lake and the northeastern part starting from the bund forms the Akkulam Lake. For most part of the year, the Veli-Akkulam Lake remains separated from the sea by a sand bar. For the present study, six study stations were selected at various locations of the lake. Stations 1, 2 and 3 were in the Veli side of the lake and Stations 4, 5 and 6 at the Akkulam region.

***Benthic fauna*:** Bottom sediments were collected monthly from all the six sampling locations of Veli-Akkulam Lake using a Van Veen grab with a mouth area of 0.048 m^2. The sampling was carried out for two years from October 2008 to September 2010. The sediments collected were fixed in 10% formalin at the collection site itself and brought to the laboratory. The samples were washed and stirred thoroughly in tap water and the organic debris decanted. Sieving of the sediment samples was done through 40 mm and 10 mm sieves. Organisms visible to the naked eye were sorted and counted and the material retained in the sieve were preserved in 10% neutral formalin and stained with Rose Bengal dye. The sorted benthic organisms were identified to group level with the help of standard identification keys (Pennak, 1989; Edmondson, 1993) and counted under a research microscope.

Results

***Species composition and distribution*:** The zoobenthos collected from the Veli-Akkulam Lake

during the present study included 17 species, categorized into six groups, *viz*., Oligochaeta, Polychaeta, Crustacea, Chironomidae, Gastropoda and Bivalvia. Oligochaeta formed the largest group with six species included. Polychaeta, Crustacea and Gastropoda included three species each and Chrionomidae and Bivalvia were represented by single species. The group-wise zoobenthos species composition is shown in Table 1, and the percentage composition of different zoobenthos groups is represented in Fig. 2.

Out of the 17 species collected from the Veli-Akkulam Lake, eight species were observed to be present in all the six study sites. Species distribution of zoobenthos was found to be more in the Veli region of the lake with 14 species being present each at Stations 1, 2 and 3. The Akkulam region showed lesser zoobenthos species distribution, comprising only 13 and 11 species respectively at Stations 4 and 5. The distribution was found to be least at Station 6, with 9 of the total 17 zoobenthos species being absent at this location. The station-wise distribution pattern of the different zoobenthos species is presented in Table 1.

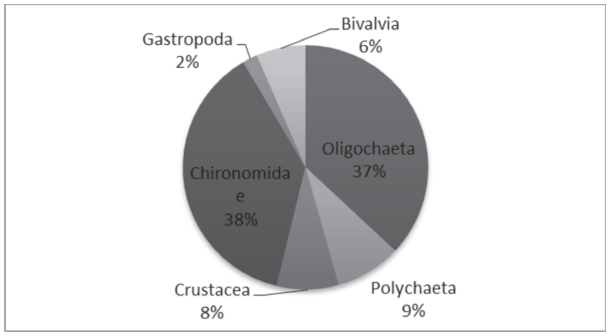

Fig. 2. Percentage composition of zoobenthos groups of Veli-Akkulam Lake

***Spatiotemporal variations in zoobenthos abundance*:** Polychaetes constituted 50% of the total benthic organisms collected from Station 1 during 2008-09 and 37% during 2009-10 and formed the dominant group there. *Nereis* sp. and *Capitella capitata* formed the major species included in this group. The monthly abundance of polychaetes ranged from 2 to 148 no.m^{-2} during the first year and 19 to 186 no.m^{-2} during the second year of study. Crustaceans (22%) formed the second dominating group at this station during 2008-09 and were represented by *Photis longicaudata*, *Cyathura carinata* and *Scylla serrata*. During 2009-10, oligochaetes ac-

Table 1. List of zoobenthos in Veli-Akkulam Lake (+ present, – absent) at different stations

No.	Species	Stations					
		1	2	3	4	5	6
	Oligochaeta						
1	*Aulophorus furcatus* Müller	+	+	+	–	–	–
2	*Pristina* sp.	+	+	–	–	–	–
3	*Chaetogaster* sp.	+	+	+	+	+	+
4	*Tubifex tubifex* (Müller)	+	+	+	+	+	+
5	*Limlodrilus* sp.	+	+	+	+	+	+
6	*Dero dorsalis* Ferroniere	+	+	+	+	+	+
	Polychaeta						
7	*Capitella capitata* (Fabricius)	–	+	+	+	+	–
8	*Nereis* sp.	+	+	–	–	–	–
9	*Sabella* sp.	+	–	–	–	–	–
	Crustacea						
10	*Photis longicaudata* (Bate & Westwood)	+	+	+	+	–	–
11	*Cyathura carinata* (Krøyer)	+	+	+	+	+	+
12	*Scylla serrata* (Forskäl)	+	+	+	+	+	+
	Chironomidae						
13	*Chironomus* larvae	+	+	+	+	+	+
	Gastropoda						
14	*Lymnaea acuminata* Lamarck	+	+	+	+	+	+
15	*Indoplanorbis* sp.	–	–	+	+	+	–
16	*Vivipara bengalensis* Preston	–	–	+	+	–	–
	Bivalvia						
17	*Villorita cyprinoides* (Gray)	+	+	+	+	+	–

counted for 29% of total benthic population and their maximum abundance was observed in February 2010. *Chironomus* larvae also formed a major constituent at this location, which varied from zero to 19 no.m^{-2} during the first year and zero to 33 no.m^{-2} during the second year of study. Gastropods were very scant at this location and none were collected during 2009-10 from this station. The bivalve *Villorita cyprinoides* was collected from Station 1 only during November 2008, April and August 2009, and March and September 2010.

At Station 2, Oligochaeta was the dominant group during both the years of study; in 2008-09, they formed 35% of the total zoobenthos population collected, ranging from 15 to 114 no.m^{-2} within different months. The major bulk of the oligochaete abundance was contributed by *Chaetogaster* sp., which was found maximum in April 2009 (44 no.m^{-2}). During 2009-10, Oligochaeta formed 41% of total population. *Tubifex tubifex* was found in large numbers and formed the dominating oligochaete species. *Chironomus* larvae ranged from zero to 40 no.m^{-2} during the entire study period and they contributed to 19% and 18% of the total benthos during the two years of study respectively.

Station 3 was dominated by oligochaetes during 2008-09 (39%) and chironomids during 2009-10 (44%). *Tubifex tubifex* formed the major component of Oligochaeta in both the years (475 and 544 no.m^{-2} respectively), with maximum in October 2008 (121 no.m^{-2}) and October 2009 (211 no.m^{-2}). Other major constituents of the group were *Chaetogaster* sp. and *Limlodrilus* sp. Maximum number of *Villorita cyprinoides* was observed in October 2008 at this station. Polychaetes were represented in this location by *Capitella capitata*, which varied from zero to 26 no.m^{-2} and zero to 17 no.m^{-2} respectively for the two years of study. The total abundance of crustaceans collected from this station was 74 no.m^{-2} during 2008-09 and 76 no.m^{-2} during 2009-10. Gastropods were collected from this location in very few numbers, the maximum in April 2009 and March 2010 respectively for the two years.

Chironomids formed the major benthos group at Station 4 both years (48% and 47%), with maximum abundance in October 2008 (256 no.m^{-2}) and October 2009 (243 no.m^{-2}). Oligochaetes formed the second dominating group (35% and 39%) and were found to be present throughout the year in 2008-09, with peak abundance in October 2008 (112 no.m^{-2}), mainly contributed by *Tubifex tubifex* and *Chaetogaster* sp. During the second year, October 2009 registered the maximum oligochaete abundance (176 no.m^{-2}). The total abundance of *Chironomus* larvae in this location was 673 and 496 no.m^{-2} respectively for the two years. Polychaete abundance was found to be scanty at this station with *Capitella capitata* observed in very few numbers during certain months during both years.

In Station 5, chironomids and oligochaetes dominated the zoobenthic community. *Chironomus* larval abundance ranged from nil to 328 no.m^{-2} with peak in October 2008 during the first year and from zero to 114 no.m^{-2} during the second year. Oligochaetes were represented mainly by *Tubifex tubifex, Chaetogaster* sp. and *Limlodrilus* sp. *Aulophorus furcatus* and *Pristina* sp. were found to be absent during both the years. Benthic crustacean abundance at this station during the study period ranged from zero to 18 no.m^{-2}, with maximum (18 no.m^{-2}) observed in March 2010. Gastropods were present in few numbers and were represented by *Lymnaea acuminata* and *Indoplanorbis* sp. *Villorita cyprinoides* was collected in January 2009 only during the first year and April and May 2010 during the second year of study.

Polychaetes and bivalves were not observed in Station 6 throughout the study period. Chironomids formed the most dominating benthos group here, accounting for 51% and 59% of total abundance for 2008-09 and 2009-10 respectively. *Tubifex tubifex* formed the bulk of oligochaetes at this station, which accounted for 46% and 37% respectively for the two years. *T. tubifex* abundance was found to be highest during July 2009 (172 no.m^{-2}). Crustaceans were found only in scant numbers at this location and were represented by *Cyathura carinata* and *Scylla serrata. Lymnaea acuminata* was observed to be the lone member of benthic gastropod present in Station 6, in very few numbers.

Discussion

Benthic organisms play a vital role in the transfer of energy from primary producers through the detritus pool into higher trophic levels, including commercially exploitable fish (Ingole *et al*., 2002). Majority of the benthic fauna are sedentary and sessile and thus cannot avoid any environmental perturbation (Danulat *et al*., 2002); and are considered sensitive indicators of changes in the environment caused by natural and anthropogenic disturbances.

The benthic fauna of the Veli-Akkulam Lake were a combination of marine, brackishwater, and freshwater inhabitants. The diversity of the zoobenthos in the lake during the present study was represented by six groups (Oligochaeta, Polychaeta, Crustacea, Chironomidae, Gastropoda and Bivalvia). A total of 17 species were recorded from the lake belonging to these groups. Oligochaeta formed the most diverse group comprising six species. Polychaeta, Crustacea and Gastropoda had three species each while Chironomidae and Bivalvia were represented by single species.

The numerical abundance of zoobenthos during the study period varied from 951 to 1748 no.m^{-2} during 2008-09 and from 824 to 1856 no.m^{-2} during 2009-10 between different study locations. The highest abundance was observed at Station 3 both the years, and the least was recorded from Station 2 during the first year and Station 1 for the second year.

Chironomida was found to be the most dominating group among the zoobenthos of the Veli-Akkulam Lake during the present study, comprising 38% of the total abundance. Chironomids, represented by *Chironomus* larvae, recorded maximum abundance on October 2008 (328 no.m^{-2}) at Station 5. The presence of increased numbers of *Chironomus* larvae in the lake suggests their preference for eutrophic condition (Roy and Nandi, 2008). Similar observation was recorded in Mir Alam Lake in Andra Pradesh (Anitha *et al*., 2004). Increase in population of *Chrinomus* larvae in Veli part of the lake was previously recorded (Murugan *et al*., 1980). Oligochaeta contributed to 37% of the total zoobenthos abundance in the Veli-Akkulam Lake during the present study. The highest oligochaete abundance in the lake was recorded in Station 6 during 2008-09 (699 no.m^{-2}) and in Station 3 during 2009-10 (684 no.m^{-2}). *Tubifex tubifex* and *Chaetogaster* sp. were the main species representing this group.

Generally, oligochaetes increase with eutrophication of the water body. This is in conformity with the observations in eutrophicated water bodies (Cole and Underhill, 1965). The higher abundance of oligochaetes in Veli Lake was also observed in the earlier studies (Murugan *et al*., 1980; Gopinathan, 1985; Latha and Thanga, 2010). Chironomids and oligochaetes have long been used by limnologists and aquatic ecologists as biotic indicators to classify lakes in terms of trophic status and hypolimnetic oxygen concentration and also to assess the impact of environmental change and pollution on the structure and function of aquatic communities (Maskey, 2007; Nazarova *et al*., 2008).

The benthic molluscs (gastropods and bivalves) and crustaceans were encountered in fewer numbers in the lake during the present study when compared to previous benthic investigations done there (Murugan *et al*., 1980; Gopinathan, 1985; Latha and Thanga, 2010). Crustaceans have been reported to be dominant (Gopinathan, 1985) accounting to more than 70% of the benthic fauna in the Veli-Akkulam Lake. At the same time, the numerical abundance of chironomids and oligochaetes have increase manifold during the present study, which can be attributed to the decreasing water quality and increasing eutrophication of the lake.

The spatial and temporal differences in distributions suggest that benthic species have different preferences for microhabitats within the lake ecosystem. Colonization studies also suggest that there are important differences in preferred use of microhabitats (Malmqvist *et al.,* 1991). These differences in the ability of species to disperse to and live in certain microhabitats become especially important after major disturbances, when species abundances and community structure may shift.

In general, the overall deterioration of the water quality and eutrophication of the Veli-Akkulam Lake has resulted in decreased diversity of zoobenthos. Although quantitative abundance of benthic organisms were comparatively better in the Akkulam region of the lake, this was caused by the increase in abundance of certain limited species like *Chironomus* larvae and *Tubifex tubifex*, which are good indicators of pollution.

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