# MACROBENTHOS AND ITS RELATION TO ECOSYSTEM DYNAMICS IN THE COCHIN ESTUARY

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**ABSTRACT**

Cochin estuary is a shallow brackish water body situated on the south west coast of India. It is a tropical positive estuary extending between $9^0$ 40' and $10^{0\ 12'}$ N and $76^0$ 10'and $76^0$ 30' E with its northern boundary at Azhikode and southern boundary at Thannermukkom bund.The abundance of benthic fauna in an ecosystem shows the close relationship to its environment and reflects the characteristics of an ecological niche. Seasonal and monthly variations in the distribution of macrobenthos in relation to sediment characteristics were conducted in Cochin estuary from 2009-10 periods. Oxidation-reduction potential showed reducing trends that affected the distribution and diversity of fauna. Seasonal variations in water quality and river discharge pattern affected the faunal composition in the different stations. Sewage mixing was the principal source of organic pollution in the Cochin estuary. The sediment pH was generally on the alkaline side ranging from 4.99 at St.9 and 8.33 at St.1.The Eh ranged from -11mV at St.3 to -625mV at St.2.The temperature varied from $26^0$C to $32^0$C in the estuary. The moisture content ranged from 1.63 to 12.155%, that of organic carbon from 0 09 at St. 6 to 4.29% at St.9 and that of organic matter from 0.16 to 7.39%. Seasonally, the average of Eh was highest during the monsoon (156.22 mV) and in the pre monsoon (140.94 mV). The average pH for the 9 study stations was 7.68 during monsoon period and 7.08 during post monsoon. Based on group wise seasonal analysis, the average mean abundance was maximum for polychaetes (43.47) followed by nematodes (33.62), crustaceans (21.62), molluscs (11.94) and Pisces (0.05) in the estuary. Monsoon season was most favourable for benthic faunal abundance followed by the post monsoon period in the study. The series of human interventions like dredging, discharge of industrial effluents, urbanisation and related aspects had a strong influence on the distribution, abundance of benthic macrofauna in the wetland.

**INTRODUCTION**

Macro as well as micro invertebrates plays an important role in the ecosystem. They not only serve as food for fish, amphibians, and water birds, they are also involved in the breakdown of organic matter and nutrients .Macrobenthos is defined as the invertebrates retained on a sieve of defined mesh size (usually 0.25 or 0.3 mm) with the exceptions of meiofaunal taxa like Nematoda,Copepoda and Foraminifera.

The macrobenthos alters their habitat by their metabolism and bioturbation activities on a local scale. Any critical change in an estuary alters the entire aquatic food web. Perturbation of any anthropogenic or natural reasons

may cause shifts in the diversity and numerical abundance of species and relative sizes of population. These affect the all biological activities in a macrobenthic fauna. The small scale distribution of benthic organisms in an estuary is related to factors such as depth, current speed and sediment characteristics. Impacts of human intervention cause disturbance and damage in the natural ecosystem. Estuarine water is not stable due to the wave action. So there is a change in the distribution of salinity, temperature and Eh. All these physical, biochemical, anthropogenic activities lead to the ecosystem dynamics in the estuaries. Distribution of macrobenthos is based on biological characteristics and physicochemical nature of the habitat. The physical alteration also plays their role in changing the abundance of flora and fauna (Goplan *et al.*, 1983). Ideally the indicator organisms are those species that have narrow and specific environmental tolerance. Benthic invertebrates are the useful tool in the ecological monitoring and their production is important in assessing the biological productivity of an area.

Studies on the composition, distribution and abundance of benthic fauna of the Cochin estuary extending upto Aleppey was reported by Desai and Krisnankutty (1967), Kurian (1972), Unnithan *et al* (1975), Batcha (1984), Gopalan *et al* (1987) and Kurup *et al* (1987).Remani *et al*(1980) studied the benthic faunal abundance in Cochin backwaters in relation to pollution aspects. Nair *et al* (1983) gave an account on the population dynamics of amphipods in Cochin backwater area. Sarala Devi *et al.* (1991) reported 30 species of polychaetes in the northern limb of Cochin backwater. Different species exhibit different tolerance to stress and have an important role in cycling nutrients between the underlying sediments and overlying water column. Investigations by Sivadasan and Joseph (1995) also found that the estuary was rich in benthic fauna which played a key role in the overall productivity of the ecosystem. Menon *et al* (2000) gave a review on the composition, distribution and species diversity of macro and meiofauna in the estuary in relation to various hydrographic factors. Recently the biodiversity of estuarine systems of south west coast of India including the benthic fauna has been discussed in depth by Bijoy Nandan (2007, 2008).The trophic dynamics of benthic fauna in the estuary has also been in this elaborate review. Cochin estuaries is known for their rich bio resources, but in the pristine conditions have suffered severe depletion due to human intervention (Menon *et al.*, 2000).The dredging Impact Assessment (DIA) at Cochin Port (Rasheed & Balchand1997) brought out the direct and indirect effects of desilting covering both positive and negative impacts based on turbidity, sediment texture, benthic fauna and production. Several reports are available on the sediment characteristics of Vembanad Lake (Murty and Veeryya, 1972; Padmalal and Sreelathan, 1991; Sundaresan, 1991; Sunilkumar, 1995). Decline in the benthic suspension feeders lead to enhanced turbidity levels, changes in nutrient storage. Benthic invertebrates are extremely important indicators of environmental change.

However of late the Cochin estuary and its environs are facing modifications on a large scale mainly due to the impact of major developmental projects like the Goshree, Vallarpadam container transshipment terminal and others being implemented in the region .The recent EIA reports also suggests that due to the implementation of such developmental projects in an unprecedented manner, the ecology and carrying capacity of the ecosystem has been greatly affected (Anon,1996).Therefore it was in this context that, this study is proposed to critically map the macro benthic fauna and its relation to ecosystem dynamics in the Cochin estuary, based on the following objectives. To

study the biomass, composition, distribution and abundance of macro benthic fauna. To make community structure analysis of fauna in the context of its diversity, richness, evenness and dominance. To assess the faunal abundance of macrobenthos in relation to the trophic structure. And to study the time scale changes in the ecosystem with reference to benthic faunal abundance.

**PHYSIOGRAPHY**

Cochin estuary is a shallow brackish water body situated on the south west coast of India. It is a tropical positive estuary extending between 9°40' and 10°12'N and 76°10' and76° 30' E with its northern boundary at Azhikode and southern boundary at Thannermukkom bund. Its length varies from 60-80 Km and the width from 500 and 4000 meters. The estuary is connected to the Arabian Sea through a wide channel of about 450m width at Cochin and another at Azhikode. The depth of the estuary varies considerably and major portion of the estuary has a depth range of 2-7 meters. The Chalakkudy, Periyar, Muvattupuzha, Meenachil, Manimala, Pampa and Achencoil rivers discharge into the Cochin estuary. The backwater plays a paramount role in the socio-economic and cultural history of this region. Among the 30 backwaters, Vembanad Lake is the biggest in the state as well as the largest backwater lake in Asia. Vembanad Lake is an important Ramsar Site in India. As per the Environmental (Protection) Act, 1985(29 of 1986) the Cochin backwater, which is a part of the Vembanad Lake and the ecosystem is classified under the 'ecological sensitive zone'. The brackish water as biotic niche is highly dynamic and productive and has vast diversity of migratory marine as well as freshwater living resources and also nursery areas for many commercially important organisms.

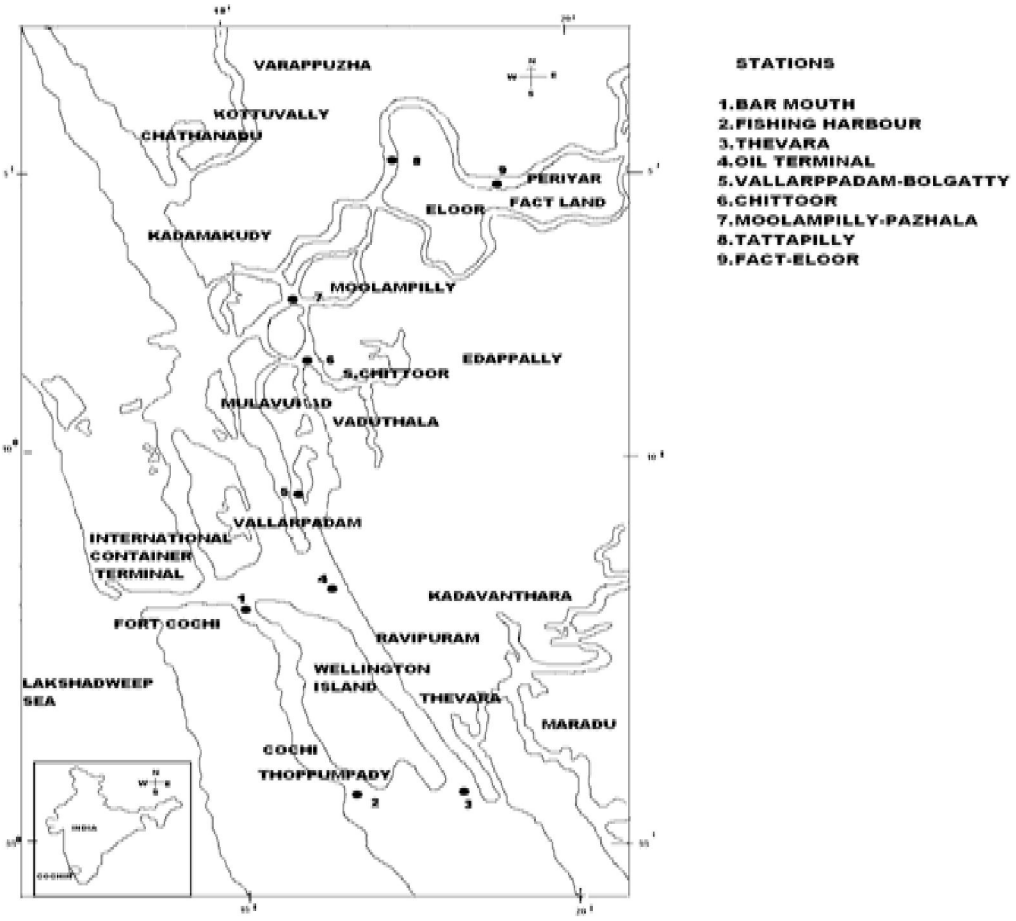
**MATERIALS AND METHODS**

The nine ecologically different zones in the Cochin estuary were selected for monthly collection and analysis of various parameters for 12 months from July 2009 to June 2010 period (fig.1). St.1 is bar mouth area opening to the Arabian Sea. St.2 & St.3 is fishing harbor areas; St.4 is the oil terminal region having effects of oil discharge or contamination; St.5 is subject to effects from construction activities and industrial activities. St.6 influenced by fishing and duck culture; St.7 zone is influenced by activities associated with Vallarpadam container transshipment terminal; St.8 is intensely subjected to sand mining. In st.9 is near to the FACT-factory area where waste and effluents disposal occur in this region.

Monthly observations were made for 1 year from the selected 9 stations in the Cochin estuary for the collection of water samples for hydrographic analysis. All sampling for the collection of water and sediment samples in the estuary would invariably be made during the early morning hours Macro fauna samples was collected using a standard Van Veen grab having an area of 0.1 or 0.2 $m^2$ (Anastasios Eleftheriou and Alasdair McIntyre 2005,Holme and McIntyre, 1971). These preserved samples were washed through suitable sieves of mesh size 500 micron for macro fauna and preserved in formalin and stained in Rose Bengal for identification (APHA, 2005, Anastasios Eleftheriou and Alasdair McIntyre 2005, Holme and McIntyre, 1971). The samples were then be analyzed for

macrofauna by hand picking and microscopic analysis. The standard as well as published references were employed for identification of different faunal groups (Fauvel, 1953, Holme & McIntyre, 1971, Anastasios Eleftheriou and

**FIGURE.1.MAP OF THE COCHIN ESTUARY INDICATING THE STUDY STATIONS**




Alasdair McIntyre 2005).

The bottom water sample along with sediment was selected stations for the estimation of different

parameters. Water samples were collected using a Niskin water sampler (Hydrobios 5 L) and was kept in ice boxes and brought to the laboratory for analysis. The temperature was measured using a standard degree centigrade thermometer and pH, Eh, of water and sediment samples would be measured using the Systronics analyzer (Model 335) (APHA, 2005). Sediment characteristics such as Moisture content, organic matter ( Wiseman and Bennet,1996) and organic carbon by Walkley and Black (1934) Were estimated .The diversity indices are calculated using the PRIMER (Plymouth Routines in Multivariate Ecological Research)Software 6.1(Clarke and Warwick,2001).

**RESULTS AND DISCUSSION.**

The mean depth of the Cochin estuary during the present study ranged from 2.97 m to 5.86m.The bottom water temperature in the estuary ranged from 26°C in January to 33.1°C in May. The redox potential value of bottom water showed a positive trend with a mean average 19.78 mV. The pH ranged from 4.83 to 8.2.Based on the seasonal analysis temperature mean value is highest at monsoon, pH, Eh and depth recorded the maximum mean values during post monsoon.(Fig.1 &2 )

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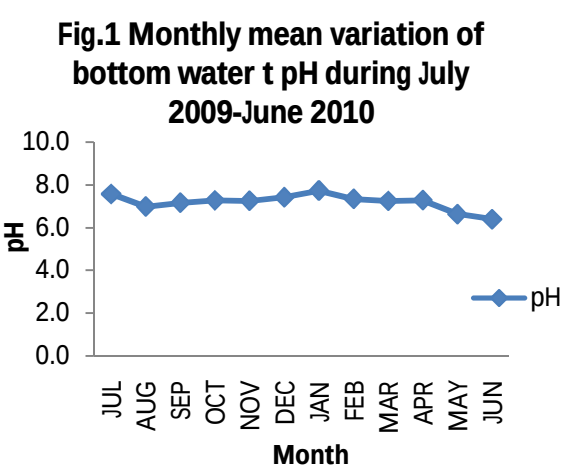
The sediment pH generally on the alkaline side ranged from 4.99 at St.1 to 8.33 at St.9.The Eh values ranged from -358 mV at St.4 with a maximum of 48 Mv at St.5. Temperature of the sediment recorded maximum at 32°C to minimum at 26°C and there are no remarkable variation in the values. Moisture content value of soil ranged from 1.6 % at St.2 to 11.41 % at St.1.The organic carbon value ranged from 0.1% at St.6 to 4.23 % at St.9. Organic matter value ranged from 0.2 % at St.6 to 7.39 % at St.9.Based on the seasonal analysis of the sediment parameters temperature and Eh was highest during pre- monsoon and pH recorded maximum during monsoon. Moisture content value showed the highest values during pre- monsoon. Mean average of organic carbon and organic matter was maximum during post - monsoon period (Fig.8)

The macrofauna in all the stations were sorted and identified up to group level. The fauna is mainly composed of polychaetes, nematodes, crustaceans, molluscs, pisces. Based on the station wise analysis the macrofauna showed variation in their number and composition. The maximum number of polychaetes at St.6 (1532 no:/$cm^2$) nematodes at St.3 (306 no:/$cm^2$), crustaceans at St.5 (1436 no:/$cm^2$), molluscs at St.2 (3576 no:/$cm^2$) and pisces at St..3, St:4,St:5(4 no:/$cm^2$).Based on the analysis the seasonal average of each group showed variation in their abundance. In the monsoon season the nematodes represented the major groups and second largest group is crustaceans. Polychaetes were dominant in the post monsoon season followed by the molluscs In pre-monsoon season polychaetes dominated over the nematodes. The numerical abundance of Pisces was highest in pre-monsoon. Based on the seasonal analysis of the mean values, the numerical abundance of benthos was highest during monsoon period and lowest in pre-monsoon . Based on the group wise analysis the ploychaetes were the dominant group and smallest group was pisces (Fig.6). The highest diversity indices (H') value was observed in St.1 Barmouth(1.98) and minimum at St.8 and St.9.The richness index(d) value was varied from 0.1359 at St.5,June to 0.9003at St.2,March.The Pielou's evenness index(j) was ranged from 0.2281 at St.1 in December to 1 at St.8 in May and December.

In the present study the spatial and temporal distribution of fauna showed variation in each station. Polychaetes and nematodes are present in all stations, but molluscs and pisces are completely absent in St.8 Tattappilly & St 9.FACT.Eloor .Pisces are present in St.1 Bar mouth, St.3 Thevra , St.4 Oil terminal and St.5Vallarpadam-Bolgatty . It may due to the effect of variations in the physical factors such as Eh, pH, temperature of bottom water and sediment. The distribution of benthos depends on the amount of organic carbon and organic matter in the study area. The polychaetes constitute the major group, because t they are able to withstand wide variations in salinity and changes in the substratum. The macrofaunal composition showed remarkable variation with respect to the salinity changes. Polychaetes, nematodes and crustaceans are more abundant in St.1 to St.6 in the Cochin estuary. Less number of organisms were present at St.7 to 9. It may be due to the variations in the pH and the amount of organic carbon. Molluscs are absent in the St.9. FACT-Eloor due to the absence of the required factors in that area for their shell formation and survival. Ansari (1977), Devi and Venugopal (1989) and Devi *et al* (1991) have observed the changes in the quality of benthos due to the influence of effluents in Cochin backwaters. Amount of organic carbon and organic matter are very high in the St.9. The industrial effluents discharge in to the water from the FACT. And the enormous amount of organic matter leads to the eutrophication in the estuary. Anoxic conditions created in the water column and sediment and this may be the reason for absence of organisms in that area. Effluents impact on the identity and diversity of primary producers and consumers with consequent alterations in the food web structure. Estuaries, which are critical habitats for nutrient recycling and ecosystem productivity, often receive large inputs of nutrients derived from human activities and agricultural discharge followed by severe eutrophication, Cloern (2001) Bode *et al*.,(2006).The total absence of benthos at stations dominated by the silt in the sediment. The spatial distribution of organic carbon by and large showed that the range is higher in vicinity of effluent outfall, Kumar, *et al*., (2004).In St.1 (bar mouth) polychaetes, nematodes, crustaceans, molluscs are abundant in almost all season. But in the month of July 2009 nematodes, crustaceans and molluscs are absent in St.1.Salinity and pH fluctuations are very high in this area. It may be due to the effect of high river discharge and rainfall in the monsoon season. Numerical abundance of Polychaetes varied seasonally and spatially in all stations. In St.6 number of polychaetes is very high ie (1532 no:/$cm^2$). It may be due to the presence of organic enrichment in that area. Depth of this region is very low. It also agrees with the observation of Thorson (1959) that the higher densities of benthic organisms are found in shallow water with ample water renewal and surrounded by a higher precipitation. In St.5 polychaetes, nematodes and crustaceans are abundant in monsoon. Many constructional activities are progressing in this area and nutrient enrichment was very high .In St.4 & 5 is mostly covered with *Eichornia sp*. In St.4 the benthic fauna is less in their number and water column disturbed by ship navigation. Oil terminal is present in this region. So ballast water discharge and oil contamination is occurred in this station and it may be the reason for alterations in the natural environment. The ballast water discharge is harmful to the ecosystem, because the ballast water contains exotic species of certain organisms, they can enter in to the new habitat. The invasive species alters the native species. This may be the reason for the competition for food and other ecological factors. The shift in the benthic primary producers has changed trophic structure of benthos (Patricio and Marques 2006; Dolbeth *et al*.2007).

In St.7 polychaetes, molluscs and crustaceans are present in all season. This area is highly polluted due to the anthropogenic activities. The construction of Railway Bridge for the Vallarpadam container trans shipment terminal is progressing in this region. The water column is turbid and contaminated by human interventions. Continuous human interference and sewage discharge also reduce the diversity and density of benthic fauna, Achuthankutty *et al* (1978). At St.8 the benthic organisms are less or absent in all seasons. It may be due to the disturbance of bottom sand in the area. Sand mining is the major problem in this area. The disturbance of bottom water and substratum is lead to the death or migration of benthic fauna in that area. And siltation is occurring by the mining processes. This station had low population density on account of the unstable nature of the substratum. The fauna is unable to withstand in this area. Macrobenthic fauna of tropical sedimentary systems experiences fluctuations in salinity and sediment erosion leading to wide variations in species diversity, Alongi (1989).

Seasonally, the individual groups exhibited wide variation in numerical abundance. Maximum diversity observed Station 2: Fishing harbour. Post monsoon season was the most productive. It may be due to the hydrographical changes associated with rainfall and freshwater discharge in to the estuary. In pre monsoon had low population density. nematodes and crustaceans were maximum during monsoon and polychaetes and molluscs are abundant in post-monsoon season. Of the nine stations, St.6 Chitoor was the most productive station and the least one is St.8. Tattappilly. Polychaetes are the dominant group in the present study. Harkantra *et al* (1980), Gopalakrishnan and Nair (1998), which have revealed a clear-cut seasonal and spatial variation in relation to sediment characteristics. One of the important characteristics of benthic fauna along the coasts of India is their wide seasonal and regional variations (Achuthankutty 1976, Divakaran *et al.*, 1981, Murukan *et al*., 1986).



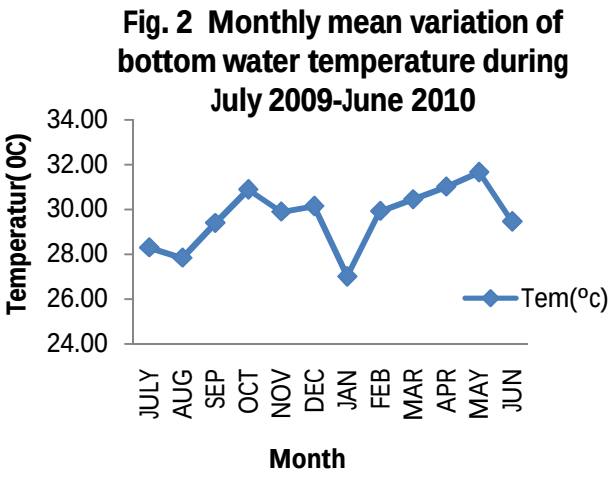



**Fig.3 Mean variation of Eh parameter of bottom water duringJuly 2009-June 2010**

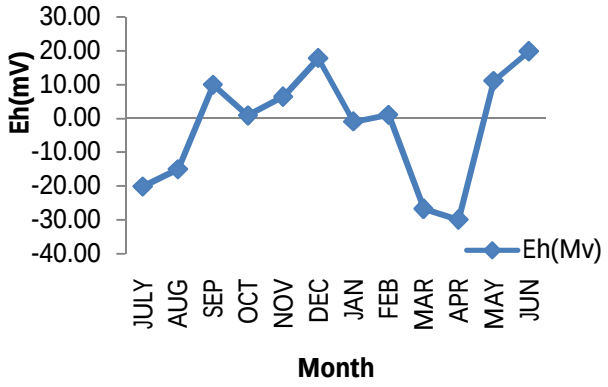



**Fig. 4 Monthly mean variation of sediment temperature during June 2009-July 2010**

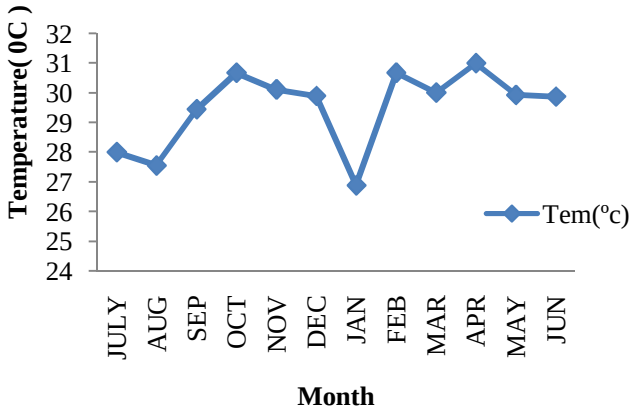



**Fig. 5 Mean variation of Eh (Mv) of sediment during July 2009-June 2010**

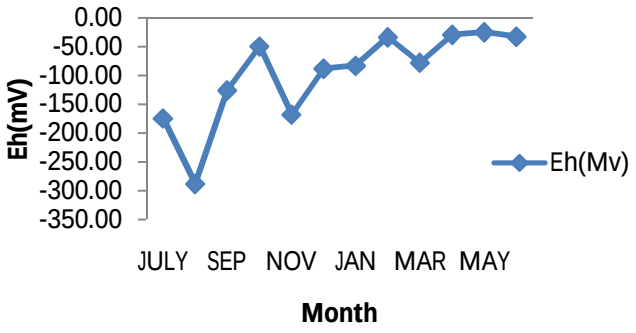
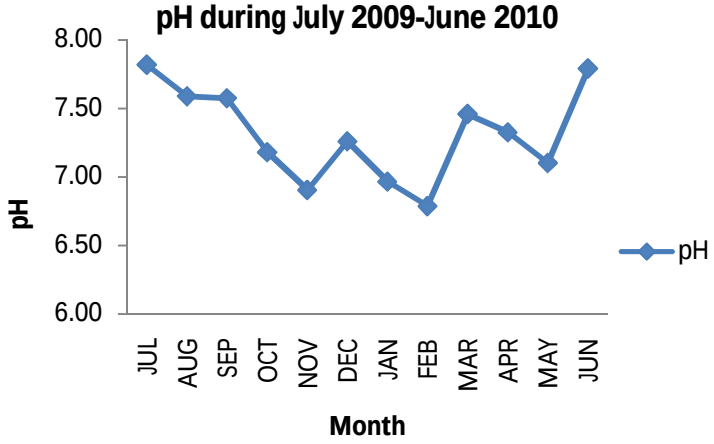
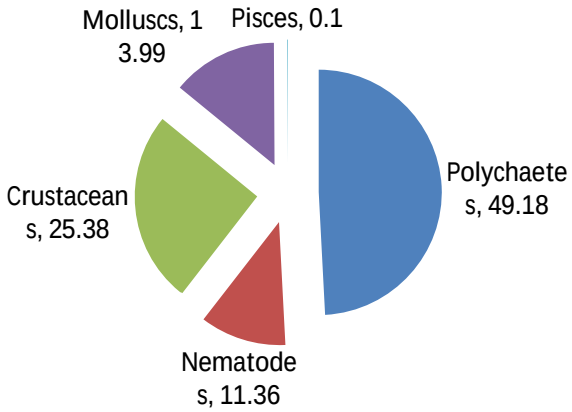
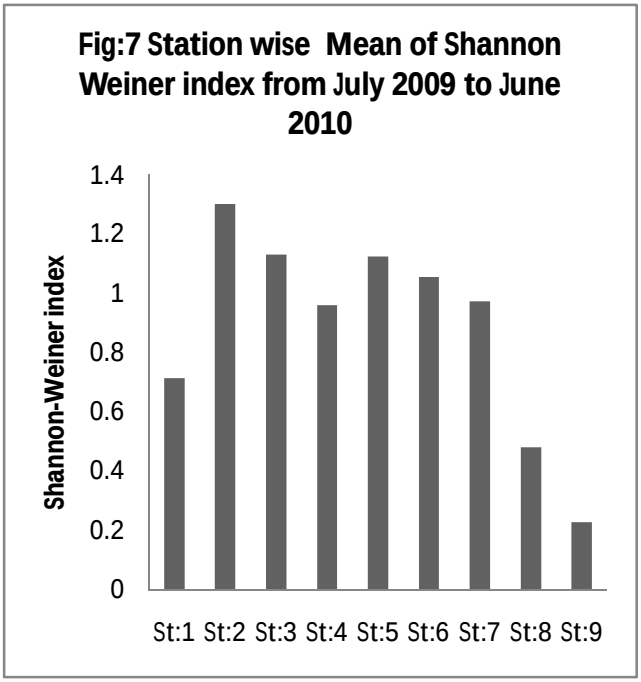
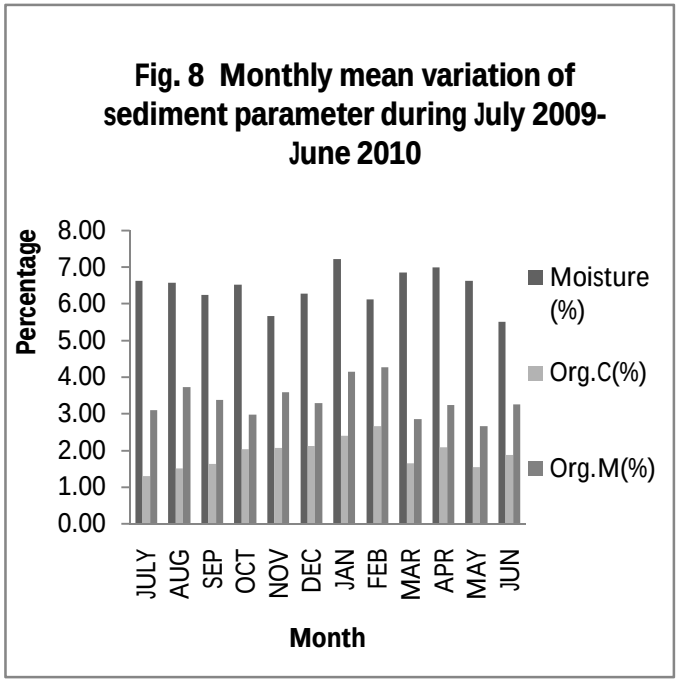



**Fig.6 Monthly mean variation of sediment pH during July 2009-June 2010**






**CONCLUSION**

The present study concluded that the high abundance and diversity of macrofauna in the Cochin estuary is the result of spatial and temporal variations in the sediment and bottom water characteristics. The factors such as higher salinity, favourable substratum, and rich supply of nutrients are the causes for abundance of bottom fauna. Unstable nature of the substratum and the pollution is the reason for low population density. Macrobenthic analysis have proven to be useful in assessing the environmental impacts of coastal discharges, sludge dumping, dredging, sand mining, oil pollution, chemical contamination of sediments, effect of exotic species on the benthos etc. Climate change can result in changes in the amount and timing of freshwater inputs into the estuarine ecosystems, change in temperature, increase in Sea level, more frequent and intense tropical storms, and variations in coastal currents. All of these changes can cause stress to estuarine organisms. These all factors affect the benthic faunal abundance and it may be the reason for ecosystem dynamics in the Cochin estuary.

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