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Original Research Paper

Macroinvertebrate Communities in the Bottom Sediment of Arthunkal Coast in Kerala, Southwest Coast of India

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ABSTRACT

The present paper is an attempt to assess the macroinvertebrate communities in the bottom sediment along the coast of Arthunkal in Kerala, India in order to elucidate the community structure and the factors influencing the benthic faunal distribution. Samples were collected from five stations (Station I, II, III, IV, V) representing the depths of 5m, 10m, 15m, 20m and 30m from the coast during monsoon in the year 2012. Hydrological variables such as temperature, hydrogen ion concentration, dissolved oxygen, chlorophyll-*a*, salinity and inorganic nutrients were analysed. Sedimentological parameters such as temperature, hydrogen ion concentration, organic carbon and sediment texture were also analysed using standard methods. Biological indices were used in the calculation of taxa richness, general diversity and evenness. The correlation coefficient of chemical variables and benthic fauna were also computed. Macrobenthic fauna consisted of 43 taxa belonging to nine major groups. Macrobenthic fauna included foraminiferans, polychaetes, oligochaetes, nemertines, gastropods, bivalves, crustaceans, scaphopods and echinoderms. Polychaetes were the dominant group (71.59 %) followed by gastropods (23.86 %) and foraminiferans (26.47 %). Highest general diversity was recorded at station II and least at station III. Highest evenness was recorded at station II and the least at station V. All the stations revealed an alkaline nature. The sediment texture revealed variation between stations with a predominance of sand at station V and silt at station I. Percentage of organic matter is low in sandy sediments where total abundance of benthic fauna is high. Chlorophyll-*a* and inorganic nutrients were present only in negligible amounts indicating low productivity along the coastal waters of Arthunkal. As macrobenthic communities are key indicators of pollution and stress, the study will pave the way for Environmental Risk Assessment and monitoring of coastal waters.

INTRODUCTION

Coastal ecosystems are subject to a variety of stressors which may interact to produce combined impacts on biodiversity and ecosystem functioning. Fluctuations in the condition, nature and characteristics of aquatic ecosystems affect benthic community composition, function, diversity and production. Macrobenthos in marine sediment plays an important role in ecosystem processes such as nutrient cycling, pollution metabolism, dispersion and secondary production (Snelgrove 1998). They act as connecting link between the biotopes of substratum and water column in the aquatic systems. Many larval forms of macrobenthic organisms are pelagic, contributing much to plankton communities which in turn are consumed by pelagic fishes. Distribution of macro benthos mainly depends on the physical nature of the substratum, nutritive content, degree of stability and oxygen content. Slight fluctuation in the environment will have considerable impact on the benthic community.

Arthunkal is a coastal hamlet, the economy of which mainly resides in the fishery sector-the source of livelihood for the fishing communities. The coast is unexplored as far as benthos is concerned. The present paper explores the macrobenthic invertebrate assemblages of this coast along with the hydrogeo-chemical variables. As benthos are key indicators of pollution and stress the study will pave the way for Environmental Risk Assessment and monitoring of the coastal waters of Arthunkal.

MATERIALS AND METHODS

Study area: The present study was carried out along the coast of Arthunkal (9°39'19''N and 76°17'23''E) in Kerala during monsoon of 2012. Samples were taken from five stations (station I, II, III, IV and V) representing depths of 5m, 10m, 15m, 20m and 30m from the shoreline along one transect (Fig. 1).

Sampling protocol: Samples were collected in triplicate with a Van Veen grab (0.1m^2 mouth area), sieved through 0.5mm mesh and preserved in 5% neutral formaldehyde and later identified up to lowest possible taxonomic level (Fernando & Olivia 2002).

Hydrogeo-chemical parameters: The temperature of the surface, bottom water and sediment samples was analysed

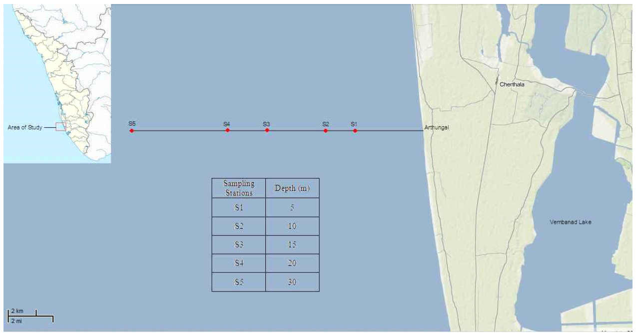

Fig. 1: Study area and sampling sites.

using a thermometer having an accuracy of 0.5°C. pH was determined by a digital pH pen, dissolved oxygen of water samples was estimated by Winkler's method (Winkler 1883), salinity was measured by water analyser (Systronics-model 371), water nutrients such as nitrate-nitrogen, nitrite-nitrogen, phosphate-phosphorus and silicate-silicon were also analysed (Strickland & Parsons 1972, Grasshoff 1983). Chlorophyll-*a* was determined spectrophotometrically. Organic carbon in sediment samples was determined by Wakeel & Riley (1957) while sediment texture was determined by Krumbien & Pettijohn (1938).

Statistical analysis: Biological indices such as Margalef's index (d) (Margalef 1968), Shannon Weiner index (H') (Shannon et al. 1949), and Evenness (J') (Pielou 1966) were used in the calculation of taxa richness, general diversity and evenness. The correlation coefficient of chemical variables and benthic organisms was also computed using SPSS-20 version.

RESULTS

Hydrological parameters: The variation in the hydrological parameters of the surface and bottom waters is depicted in Figs. 2 to 10. The surface water temperature varied between 28°C (station IV) and 30°C (station I and II) with a mean of 29°C. Bottom water temperatures ranged from 28°C (station III) to 30°C (station I) with a mean of 29°C. pH of surface water samples ranged from 8.10 (station I) to 8.22 (station IV and V) with a mean of 8.18. Hydrogen ion concentration (pH) of bottom water varied from 7.90 (station I) to 8.14 (station V) with a mean of 8.05. The surface water dissolved oxygen ranged from 4.7mL/L (station III) to 5.9mL/L (station I) with a mean of 5.33mL/L. The bottom water dissolved oxygen content varied from 3.9mL/L (station I) to 6.2mL/L (station III) with a mean of 5.56mL/L. Salinity of surface water varied from 31.5ppt (station III) to 32.5ppt (station II) with a mean of 31.94ppt. Salinity of bottom water samples ranged from 32.1ppt (station IV) to 33.6ppt (station I) with a mean of 32.88ppt. Chlorophyll-*a* of surface water ranged from 0.0001 mgc/m^3 (station V) to 0.001 mgc/m^3 (Station I) while that of bottom water ranged from 0.0001mgc/m^3(Station V) to 0.0007 mgc/m^3 (Station I).

Nitrate-nitrogen of surface water samples varied from 0.010µg/L (station I) to 0.520µg/L (station II) with a mean of 0.23µg/L. Nitrate -nitrogen in bottom water samples varied from 0.033µg/L (station V) to 0.123µg/L (station III) with a mean of 0.07µg/L. Nitrite-nitrogen of surface water ranged from 0.0007µg/L (station IV and V) to 0.005µg/L (station I). Bottom water samples of Nitrite-nitrogen varied from 0.002µg/L (station IV) to 0.029µg/L (station II) with a mean of 0.01µg/L. Surface water phosphate-phosphorus ranged from 0.0007µg/L (station II and III) to 0.0026µg/L (station IV). Bottom water Phosphate- phosphorus ranged from 0.0009µg/L (station III and IV) to 0.003µg/L (station I). Silicate-silicon in the surface water ranged from 0.027µg/L (station III) to 0.174µg/L (station I) with a mean of 0.07µg/L. Bottom water silicate-silicon varied between 0.037µg/L (station III) and 0.184µg/L (station I) with a mean of 0.09µg/L.

Geo-chemical parameters: Sedimentological parameters in the five stations are given in Figs. 11 to 13. Sediment temperature ranged from 28°C (station IV) to 30°C (station I and III) with a mean of 29.2°C. pH of sediment samples varied between 7.92 (Station II) and 8.20 (Station I) with a mean of 8.076. Organic carbon in sediment varied from 0.0869% (station IV) to 5.4895% (station III). Mean percentage of organic carbon was 2.10. Sand varied from 0.425% (station I) to 7.94% (station V). Silt varied from 0.4% (station V) to 8.875% (station I). Clay content ranged between 0.35% (station IV) and 2.35% (station III). Mean value recorded for sand, silt and clay was 3.43%, 5.35% and 1.22% respectively.

Macrobenthic invertebrate composition: The occurrence and distribution of macrobenthic assemblages along the five stations are given in Table 1. Percentage composition of macrobenthic groups is given in Fig. 14. Macrobenthic fauna consisted of foraminiferans, polychaetes, oligochaetes, nemertines, gastropods, bivalves, crustaceans, scaphopods and echinoderms. Polychaeta was the highest dominant group at station V (3643 No./m^2) with 71.59%. Thirteen polychaete species were identified which include *Prionospio* sp., *Nephtys* sp., *Lumbriconeries* sp., *Asychis* sp., *Nicomache* sp., *Cossura* sp., *Sternapsis* sp., *Glycera* sp., *Capitella* sp., *Nereidae*., *Aricidea* sp., *Polydora* sp and *Ophiodromus* sp. Of this, high abundance was recorded by *Polydora* sp. (94.76%). Gastropods was the second dominant group and recorded higher abundance at station V (1214 No. /m^2) with 23.86%. Of the total Gastropods, *Umbonium* sp. showed higher numerical abundance followed by *Marginella* sp., *Bullia* sp., *Epitonium* sp., *Nassarius* sp., *Turritella* sp.,

Table 1: Occurrence and distribution of macrobenthic assemblages at five different stations.

Species	Station I	Station II	Station III	Station IV	Station V
Foraminifera					
Elphidium sp.	+	+	+	+	+
Cyclammina sp.	-	-	-	-	-
Tritaxia sp.	-	-	-	-	+
Vaughania sp.	-	+	-	-	-
Polychaeta					
Prionospio sp.	-	-	-	-	+
Nephtys sp.	-	-	-	-	+
Lumbriconeries sp.	-	-	+	+	+
Asychis sp.	-	+	-	-	-
Nicomache sp.	-	-	-	-	-
Cossura sp.	+	-	-	-	+
Sternapsis sp.	+	+	-	-	-
Glycera sp.	-	-	-	-	+
Capitella sp.	-	-	-	-	-
Nereidae sp.	-	-	-	+	+
Aricidea sp.	-	-	-	+	-
Polydora sp.	-	-	-	-	-
Ophiodromus sp.	+	+	-	+	+
Miscellaneous	+	+	+	+	+
Nemertina					
Lineus sp.	-	+	-	+	+
Oligochaets	+	+	+	+	+
Scaphopods					
Dentalium sp.	+	+	+	+	+
Gastropods					
Umbonium sp.	+	+	+	+	+
Architectonia sp.	-	-	-	-	-
Marginella sp.	+	+	+	+	+
Bullia sp.	+	-	+	+	+
Epitonium sp.	+	-	+	+	+
Turritella sp.	-	+	+	+	+
Natica sp.	-	-	-	-	+
Oliva sp.	-	-	-	+	+
Babylonia sp.	-	-	-	-	-
Melo Sp.	-	-	-	-	-
Cronia sp.	-	-	-	+	-
Nassarius sp.	-	-	-	-	-
Cerithium sp.	-	+	-	-	+
Cronia sp.	-	-	-	+	-
Telescopium sp.	-	+	-	-	-
Miscellaneous	+	+	+	+	+
Bivalves					
Mactra sp.	+	+	+	+	+
Anadara sp.	-	-	-	-	-
Miscellanious	+	+	+	+	+
Crustaceans					
Mysidaceae	-	-	-	-	+
Isopoda	-	-	-	+	+
Amphipoda	-	-	-	+	-
Balanus sp.	-	+	-	+	+
Miscellaneous	+	+	+	+	+
Cumaceae					
Pseudocuma sp.	-	-	-	-	-
Echinodermata					
Amphiura sp.	-	-	-	-	+

Presence (+), Absence (-)

Cronia sp., *Oliva* sp., *Architectonia sp., Natica* sp., *Cerithium* sp., *Melo* sp., *Telescopium* sp. and *Babylonia* sp. Bivalves was the third group in numerical abundance with a higher value at station I (282 No./m^2) with 47.24%. *Mactra* sp. and *Anadara* sp. were recorded from the coast. Foraminiferans form the fourth dominant group with higher numerical abundance at station I (158 No./m^2) with 26.47%. *Elphidium* sp. represented greater numerical abundance compared to *Cyclammina* sp., *Tritaxia* sp. and *Vaughania* sp. The other groups include *Dentalium* sp. Mysidaceae, Isopoda, Amphipoda, *Psedocuma* sp., *Balanus* sp., oligochaetes, nemertines and echinoderms recorded uneven distribution.

Statistical analysis: Gastropods showed positive correlation with sand ($p>0.01$) and a negative correlation with silt ($P<0.01$). Bivalves showed negative correlation with dissolved oxygen ($p<0.05$) and a positive correlation with chlorophyll-*a* ($p<0.05$) and silicate-silicon ($p<0.01$). Scaphopods showed negative correlation with nitrite-nitrogen and positive correlation to sand ($p<0.01$). Scaphopods showed negative correlation with silt. Crustaceans showed negative correlation to nitrite-nitrogen ($p<0.05$) and positive correlation to percentage of sand and negative correlation to percentage of silt ($p<0.05$).

Biological indices such as Margalef's index (d), Shannon's Index (H) and Evenness (J') were used in the calculation of benthic fauna (Fig. 15). Shannon's index showed its higher value at station II (H = 1.303) whereas lower value at station III (H = 0.931). Evenness values were greater at station II (J' = 0.66) and lower at station V (J' = 0.498). Species richness is greater at station II (d = 0.031) and lesser at station V (d = 0.004).

DISCUSSION

In the present study, the macrobenthic composition showed the dominance of polychaetes, gastropods, bivalves, foraminiferans, oligochaetes, scaphopods, crustaceans, cirripedians and echinoderms. Higher abundance of polychaetes in the present study may be due to the alkaline nature of both water and sediment and sandy substrata. Most of the polychaete species reported in the present study were instability indicators (Harriague et al. 2007) which may be due to bottom-trawling for demersal fishery resources. pH recorded at all stations were justified with the observations of Philip (1970). In the present study, percentage of organic matter is low in sandy sediments, where total abundance of benthic fauna is high. Saraldevi et al. (1999) and Jayaraj et al. (2007) reported similar findings in their studies. Crustaceans showed positive correlation with the percentage of sand in sediment, which was found only at two stations

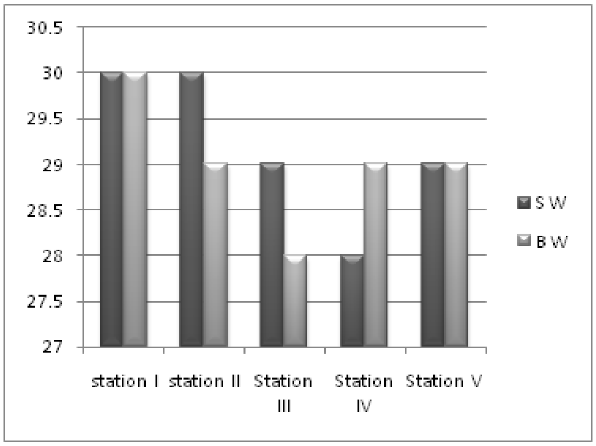

Fig. 2: Variation in the water temperature (°C).

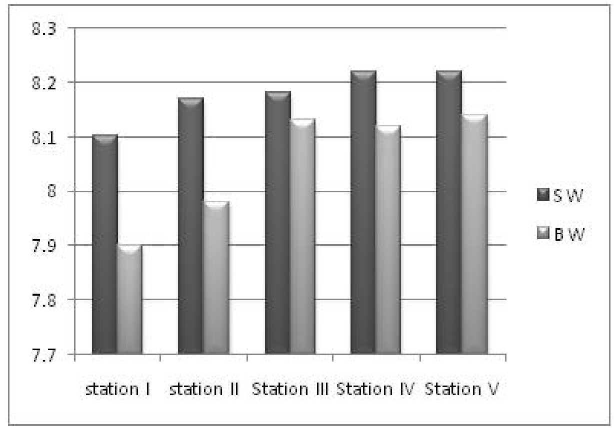

Fig. 3: Variation in the pH.

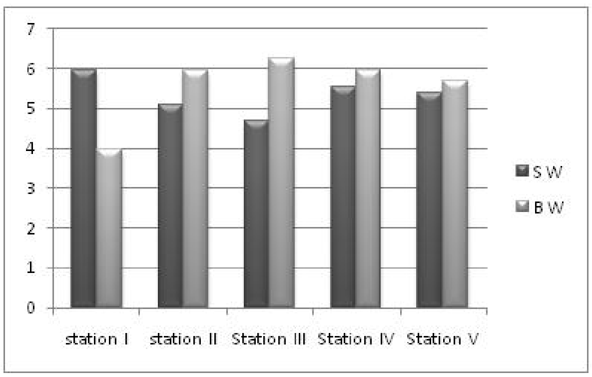

Fig. 4: Variation in the dissolved oxygen (mL/L).

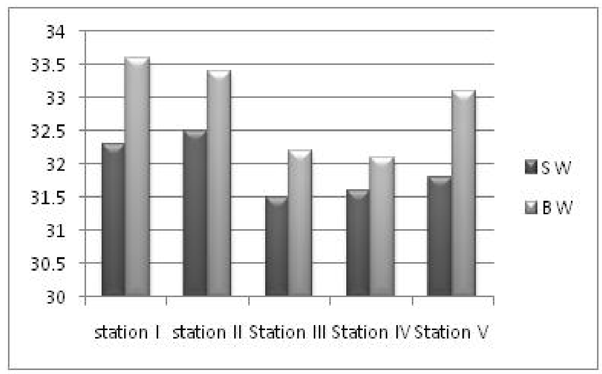

Fig. 5: Variation in the salinity (ppt).

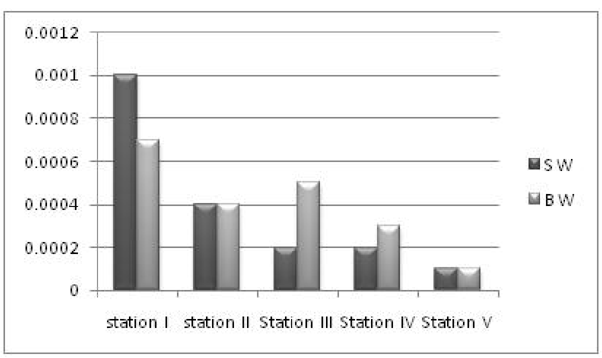

Fig. 6: Variation in the chlorophyll-*a* (mgc/m^3).

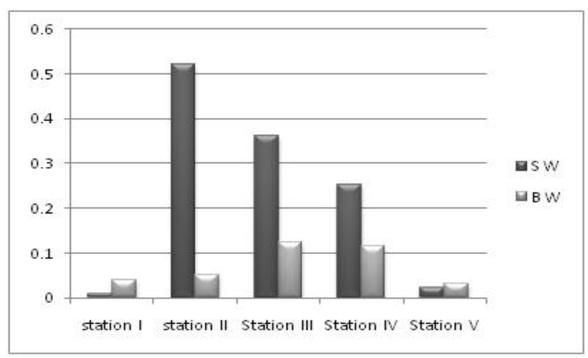

Fig. 7: Variation in the Nitrate-nitrogen (µg/L).

with the substrata rich in sand. Saraldevi et al. (1999) also recorded the same findings in their benthic studies in south-west and south-east coast of India. The less abundance of crustaceans and echinoderms compared to molluscs and polycheates were reported by Chen et al. (2010). In the present study, ophiuroidea, cirripedians and crustaceans occurred in fewer numbers. Chlorophyll-*a* and inorganic nutrients showed lower values at all stations. This may be due to the effect of the monsoon season. Temperature, an important limiting factor, recorded its maximum value which is reflected in the faunal abundance. Ahamed et al. (1992) reported that the high temperature regime can alter

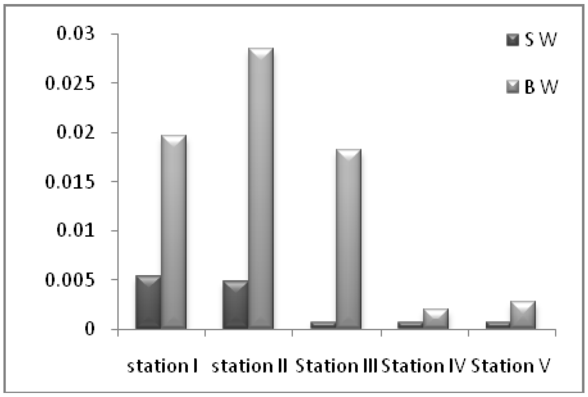

Fig. 8: Variation in the Nitrite-nitrogen (µg/L).

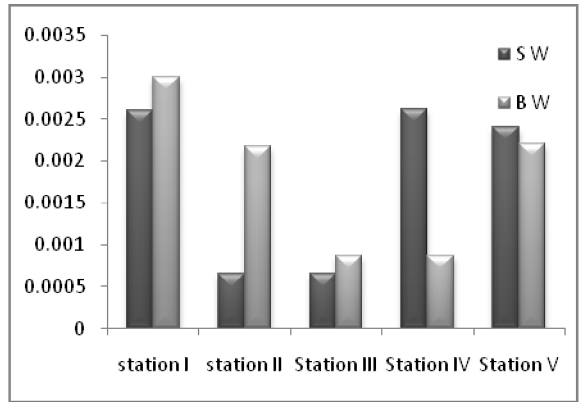

Fig. 9: Variation in the Phosphate-phosphorus (µg/L).

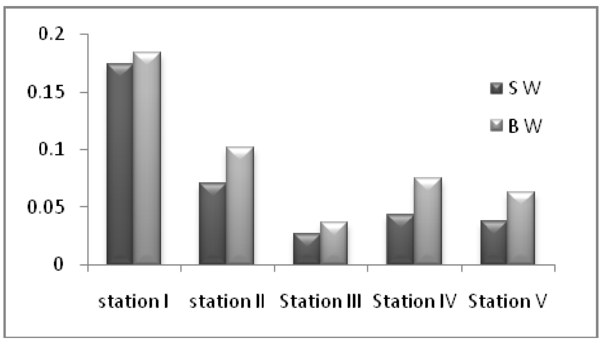

Fig. 10:Variation in the Silicate- silicon (µg/L).

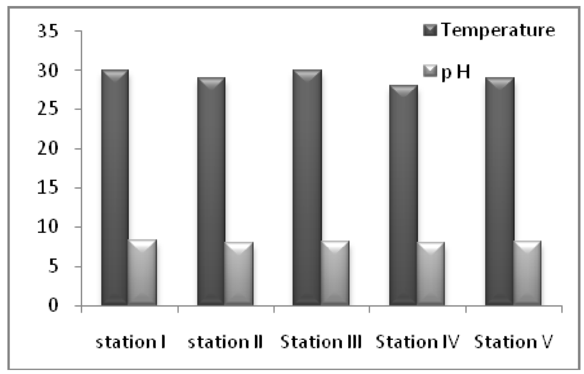

Fig. 11: Variation in the temperature (°C) and pH.

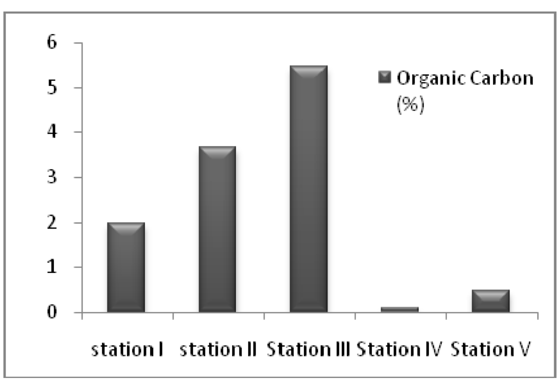

Fig. 12: Variation in the organic carbon (%).

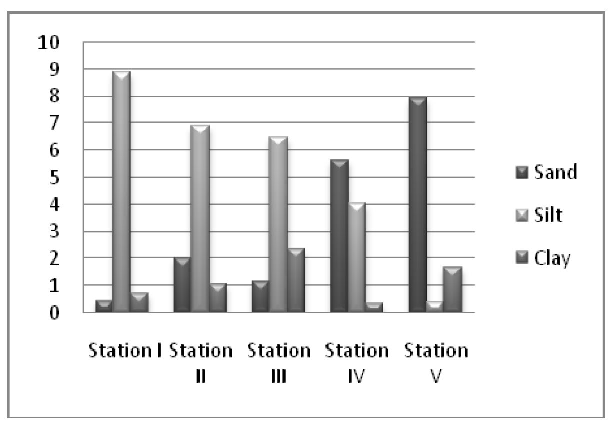

Fig. 13: Variation in the sediment texture (%).

the normal physiological functions of aquatic fauna. As coastal water quality changes with time and space, and continuous water quality measurements and analysis are necessary for effective water quality management along the Arthunkal coast. Since environmental factors would influence the spatial and temporal distributions of macrofaunal abundance, which on deterioration will causes stress to these organisms. Depletion of benthic fauna will adversely affect the homoeostasis and ecosystem services. For preserving these resources regular biomonitoring is recommended along the coastal waters of Arthunkal.

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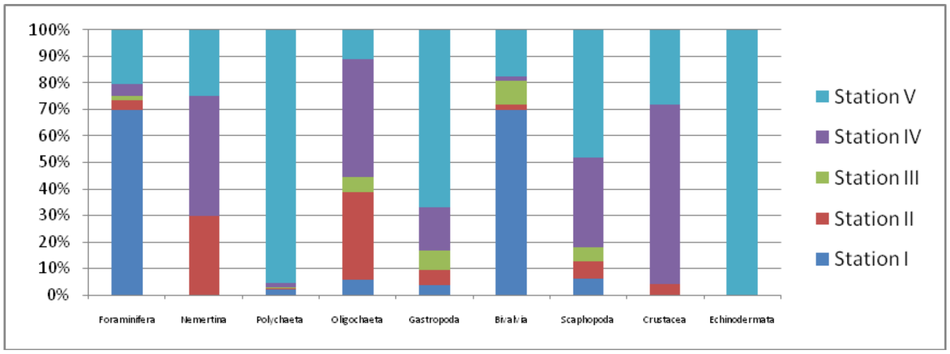

Fig. 14: Percentage composition and abundance of macrobenthic fauna at five different stations.

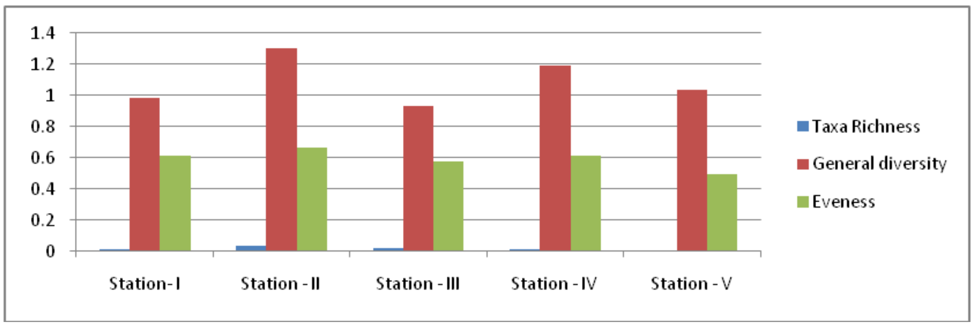

Fig. 15: Diversity of macrobenthic invertebrates at five different stations.

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