World Journal of Fish and Marine Sciences 3 (4): 323-331, 2011
ISSN 2078-4589

Macrofauna Community Structure of Bardestan Mangrove Swamp, Persian Gulf

[1]*Amir Vazirizadeh*, [1]*Reza Kamalifar*, [2]*Alireza Safahieh*, [1]*Mehdi Mohammadi*, [2]*Ameneh Khalifi*, [1]*Fatemeh Namjoo and* [1]*Ali Fakhri*

[1]Department of Marine Ecology, Persian Gulf Research and Study Center, Persian Gulf University, Bushehr, Iran
[2]Department of Marine Biology, Khoramshahr Marine Science and Technology University, Khorramshahr, Iran

Abstract: Macrobenthic community of Bardestan creek was investigated during four seasons from September 2008 to April 2009. The studied area was muddy flat and a narrow mangrove forest consisting of patches of mature *Avicenia marina* fringes each side of the creek (about 1 hectare in mangrove trees). Macrofauna and sediment were sampled in four distinct transect lines and five station along each transect line. Three replicates of samples were taken at each station. Some environmental parameters also were measured near each sampling place, from gathered water in a handy excavated hole through sediments. The number of 44 macrobenthic species belongs to four taxonomic classes of gastropoda (20 species) malacostraca (12 species), polychaeta (6 species) and bivalvia (6 species) were identified. *Paphia galus*, *Cerithidea cingulata*, *Hydrobia sp.*, *Capitella capitata* and *Ceratonereis sp.* were dominant species. Density and species number of macrofauna increased in colder seasons. Diversity and density of macrofauna increased from landward margin toward the seaward border of the habitat. Environmental parameters played important role in spatial and temporal variation of macrofauna structure. For instance, temperature and TOC content of sediment showed considerable correlation to species richness during different seasons. Spatial alteration in density of gastropoda and bivalvia were correlated to the percentage of mud. Polychaeta density was correlated to Eh, salinity, mud, TOC and DO. Density of malacostraca was correlated to TOC content.

Key words: Macrofauna · Mangrove · Community structure · Bardestan · Persian Gulf

INTRODUCTION

Mangrove forests are one of the most productive ecosystems worldwide [1] which is distributed circum-tropically, occurring in 112 countries and territories [2]. These ecosystems protect shoreline against soil erosion [3] and reduce transportation of pollutants like heavy metals to estuarine and marine ecosystems [4]. The presence of considerable amounts of organic compounds and diverse benthic communities attract many other organisms to this ecosystem for various propose such as feeding and breeding. Mangroves provide a nursery ground for many valuable species like shrimps and fishes. Muddy or sandy sediments of mangrove swamps may serve as habitat for a variety of macrofauna and meiofauna. Brachyuran crabs, gastropods, bivalves, hermit crabs, barnacles, sponges, tunicates, polychaetes and sipunculids make the main groups of mangrove's macrofauna communities [5]. Composition of macrofauna structure changes through varied tidal levels and different parts of an ecosystem [6]. Distribution of macrofauna is affected by environmental properties [7]. The main factors including structure of mangrove trees [8], hydrological changes [9], sediment type [10], temperature, salinity [11], organic matter, mud content and dissolved oxygen [7] have been reported as effective factors which influence distribution and density of macrofauna.

The burrowing activities of certain benthic invertebrates have an important effect on sediment. They assist flushing toxic substances by increasing water movement through sediment particles. In addition, their deposits and detritivory feeding enhance nutrient

Corresponding Author: Reza Kamalifar, Persian Gulf Research and Study Center, Persian Gulf, University, Iran. E-mail: reza_k581@yahoo.com

recycling [12, 13]. They also are important source of food for vertebrate predators including shallow-water fishes that enter mangrove habitats by incoming tides [14]. Sensitivity of these organisms to increased levels of pollution [15] has caused to be frequently used as important indices to evaluate ecological health and environmental status [16]. Having sedentary life style and being in touch with sediment make these communities suitable to estimate the environmental impacts of pollutants which have accumulated in the sediments [17]. Mentioned characteristics of macrofauna suggest that these organisms are important part of mangrove ecosystems, but lack of research about these communities restricted our knowledge about them in Iranian coasts of the Persian Gulf. Unfortunately, no study has been performed to investigate benthic communities of Bardestan mangrove swamp. This habitat and its live parts are faced to some impacts. It is predicted that some global threats like climate changes and global warming will impact mangrove ecosystems. Based this theory, sea level rising can be the greatest threats for mangrove habitats [18]. Besides, industrial development, residential and tourism activities in the Persian Gulf have impacted this unique ecosystem during past years [19]. Bardestan mangrove swamp as a coastal habitat of the Persian Gulf also may be affected by mentioned anthropogenic effects. Short distance of the habitat to the urban and industrial places of Bardestan town has affected live part of this habitat too. Present study was carried out to compensate lack of information about current status of macrofauna community of this habitat and to improve our knowledge about its ecology and biota. This information could be useful in comprehensive and sustainable management and protection of it against anthropogenic impacts.

MATERIALS AND METHODS

Study Area: The present study was carried out in Bardestan mangrove swamp close to Bardestan town in Bushehr province, Iran (51° 57' 28" E and 27° 50' 27" N), (Fig. 1), consisting of narrow mangrove forests, approximately 50-60m up shore patches of mature *Avicennia marina* fringes. The area of mangrove forest is about 1 hectare in mangrove trees [20, 21]. The main central canal of this mangrove forest which is lined across the Persian Gulf, is the only place covered with water in low tide. Distribution of mangrove trees is not the same in two sides of the central canal. Most trees are located in the western side and have expanded from north to south along the canal. There are only a small patch of trees in eastern side of the habitat. The ecosystem lacks any constant waterway from land and just seasonal runoffs affect this habitat. Industrial and urban regions surrounded the habitat and have made it so susceptible to anthropogenic effects.

Sampling Design: Sampling was carried out during four seasons. It was performed in September and November 2008 as well as February and April 2009. According to distribution of mangrove trees and for covering the whole habitat, four transect lines were selected which transects 1, 2 and 3 were situated in western side and transect 4 was located in the eastern mangrove patch (Fig. 1). With regard to apparent horizontal zonation, each transect line was divided into five distinct stations from high tide to low tide. These stations were named: High tide zone (Ht), Upper mid tide zone (Up), Mid mid tide zone (Mm), Lower mid tide zone (Lm) and Low Tide zone (Lt), from high to low tide, respectively (Fig. 2).

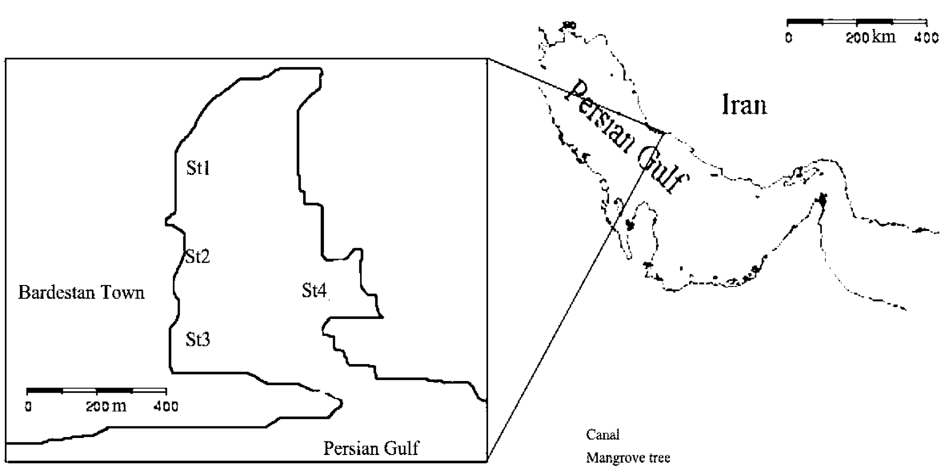

Fig. 1: Sampling site, Bardestan mangrove estuary, Persian Gulf

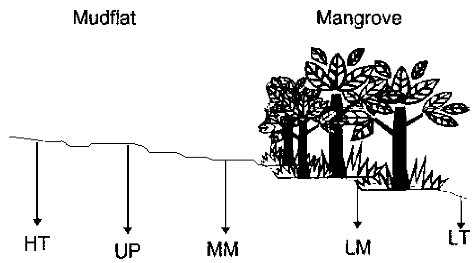

Fig. 2: A schematic view of tidal levels in each transect line

Three replicates of macrofauna were taken randomly using a 0.25 m^2 quadrate framework to the depth of 10 cm of sediment. For Grain Size (G.S) and Total Organic Carbon (TOC) analysis, three samples of sediment were taken close to sampling stations, using core sampler. Samples were put into plastic bags and were carried to the ecology laboratory of the Persian Gulf Research and Study Centre (PGRSC), for further laboratory processes.

Some physiochemical factors (including salinity, pH, temperature, dissolve oxygen and redox potential) were determined using portable instruments. These factors were measured through gathered water in artificially excavated holes in sediment.

Laboratory Processes: Isolated macrofauna were identified until possible taxonomic levels, often to species level using available identification key books [e.g 22, 23]. Grain (particle) size of sampled sediment was determined by applying sieve series of 4 mm to 63 µm [24]. Colorimetric method was used to determine TOC of sediment [25].

Data Analysis: Pearson correlation test was used in order to test correlation between biological and physicochemical parameters as well as correlation among value of various indices. Biological parameters (i.e. density and species number) among different stations and different tidal levels were compared using One-Way ANOVA analysis. K-Related test (Chi-Square, Friedman Test) was used to compare biological and physiochemical parameters among different seasons or different transect lines. These analyses were performed using SPSS statistical software (Ver. 14.0 for Windows) and "STATISTICA" programs.

RESULTS

Abiotic Parameters: Environmental factors measured in Bardestan mangrove swamp are summarized in table (1). There was no significant difference among different transect lines in various parameters (P>0.05). Hence, data belong to the same stations of different transects were pooled together to summarize them. Mud was the major portion of sediment. Its percentage varied from 15% to 92% among different stations. Amount of mud increased

Table 1: Summary results of some abiotic measured parameters (Mean±SD) at different tidal levels of Bardestan creek

	Station	Mud (%)	TOC (%)	T (°C)	DO(ppm)	Salinity (psu)	pH	Eh (mv)
Summer	Ht	46.7±22	1.6±0.6	33.7±0.2	4.3±0.27	47.2±0.95	7.9±0.1	66.2±6
	Up	56.2 ±18.9	1.6±0.5	33±0.1	2.3±0.13	42±0.81	8.1±0.15	66.5±4.7
	Mm	73.5±15	3.7±1.2	32.8±0.15	2.1±0.06	41.2±0.50	7.8±0.3	43.7±2.5
	Lm	88±4.8	5.9±1.6	32.5±0.4	1.9±0.18	40.2±0.50	7.7±0.24	30±4.7
	Lt	39.7±6.3	1.4±0.2	31±0.05	2.6±0.34	44.5±0.57	7.9±0.1	53.5±2.51
Autumn	Ht	40 ±17	4.2±0.6	25±0.15	6.6±0.50	50.2±0.96	7.7±0.3	57.7±5.37
	Up	50.5±12	2.5±1.2	25.2±0.9	6.2±0.30	43.5±0.57	8±0.3	73.5±3.69
	Mm	74±8.3	4.2±0.5	23.2±0.1	3.7±0.40	41.2±0.50	7.8±0.24	67±3.46
	Lm	88.5±3.4	5.4±0.9	23.2±0.2	2.6±0.50	42.5±1.73	7.9±0.2	54.7±5.9
	Lt	50.2±31	2.8±0.8	23±0.26	5.8±0.20	45.2±0.50	8±0.18	43.7±10.7
Winter	Ht	54.7±26	14.5±0.4	18.8±0.25	6.2±0.23	51.2±2.88	8±0.38	70.2±0.5
	Up	64±22	13.6±0.5	20.8±0.5	5.6±0.43	43.7±1.25	8±0.33	72.2±4.9
	Mm	74.7±15	14.9±0.5	22.5±0.13	3.9±0.55	41.7±1.25	7.9±0.16	46.5±12.3
	Lm	82.7±10	15.8±0.9	24.4±0.6	2.9±0.57	42±0.81	7.9±0.14	35.7±12.3
	Lt	45±28	13.2±0.9	24.4±0.38	5.1±0.60	45.5±0.57	8±0.12	63.2±7.3
Spring	Ht	48.2±22	10.8±2.1	26.5±0.64	4.7±0.34	59±1.15	7.8±0.08	55.2±14.7
	Up	62.7±20	10.1±0.7	26.5±0.4	4.4±0.78	47.5±0.57	7.8±0.17	46.7±11.9
	Mm	68±15	11±2	24.9±0.15	3±1.30	46.5±1	7.9±0.21	38.2±10.9
	Lm	77±7.4	16.1±1.2	25.2±0.5	2.1±0.74	44.5±0.57	7.7±0.35	26.7±7.9
	Lt	75±14	13.2±2.1	24.5±0.17	2.8±1.61	44.7±0.96	8±0.05	40.2±14.2

Table 2: Density of macrofauna (inds. M^{-2}) during sampling seasons in Bardestan creek

Species	Summer	Autumn	Winter	Spring
Acteocina involuta	2.2	0.8	5.6	3
Alpheus sp.	-	-	0.53	-
Barbatia sp.	-	-	0.13	0.07
Capitella capitata	16	48.66	329	190.4
Ceratonereis sp.	36	64	98.3	28.53
Cerithidea cingulata	494.7	601.1	478.5	106.7
Cyclaspis picta	0.07	-	0.2	-
Cyclostrema sp.	-	-	2.2	0.7
Clypeomerous bifasciatus	-	-	0.93	0.5
Clypeomerous sp. 2	-	-	1.3	-
Dardanus tinctor	-	2.26	4.2	-
Epitonium sp.	-	-	-	0.07
Epixanthus frontalis	-	-	0.33	0.26
Finella sp.	-	0.07	-	10.3
Glycera sp.	-	0.2	-	-
Gonodactylus demani	-	0.07	-	-
Hydrobia sp.	195.1	109	100.6	20.5
Leucosiidae sp.	-	-	0.53	0.07
Macrophthalmus pectinipes	2.3	5.33	28.3	11.4
Melanella cumingi	-	0.2	1.86	0.4
Mitrella misera	-	-	0.2	-
Natica vitelius	-	-	7.46	-
Nereis sp.	-	-	-	0.6
Ocypode sp.1	-	0.46	2.2	4.1
Ocypode sp. 2	-	-	4.4	-
Onchidium peroni	0.26	1.13	0.73	4.2
Paphia galus	823.5	460.7	1085.3	217.8
Tellina walace	-	15	18.6	2.3
Phasionella solida	-	1.6	20.2	0.4
Paraclistostoma arabicum	-	-	2	-
Penaeus sp.	-	-	0.07	0.2
Perinereis cultrifera	0.7	-	17.13	40.7
Perinereis sp. 2	-	-	-	0.8
Planaxis sulcatus	-	-	-	0.8
Spetifer bilicularis	-	-	0.07	-
Soletellina diphos	-	-	-	4.26
Tellina capsoides	-	0.4	5.9	0.66
Trochus sp.	-	1.73	0.86	0.73
Truncatella subcylindrica	-	-	0.07	-
Turbo sp.	-	-	0.2	-
Uca sindensis	8.7	3.1	0.46	0.26
Umbonium vestiarium	0.33	0.73	3.2	4
Umbonium sp.2	0.6	0.6	1.9	18.7

from station Ht to Lm and then decreased from station Lm toward Lt, along each transect line. The highest value of TOC was detected in the winter and spring; in contrast the lowest values were measured in the summer and autumn. In almost all seasons, sampled sediment from station Lm contained the highest value of TOC. The average temperature ranged between 32.72±1.01 and 22±2.27 in the summer and winter respectively. The amount of DO increased in cold seasons. Generally, the lowest levels of DO were observed in station Lm and the highest occurred in station Ht. High salinity was measured in Bardestan mangrove swamp (between 40 to 60 psu). The value of pH did not change significantly among different stations or seasons ($P>0.05$).

Redox potential (Eh) was positive in all stations and seasons. The maximum and the minimum levels of Eh were recorded in the winter (76 mv) and spring (19 mv), respectively. This factor changed among different stations and the lowest levels was observed in stations Mm and Lm (Table 1).

Macrofauna: Species of Four taxonomic classes including gastropoda (45.5 %), malacostraca (25.5 %), polychaeta (14%) and bivalvia (14%) made the macrozoobenthic community of Bardestan creek. During sampling seasons, the total numbers of 44 macrobenthic species were identified. The maximum and minimum number of macrobenthic species was observed in the winter (35 species) and summer (13 species), respectively. In the spring and autumn 30 and 21 macrobenthic species were identified, respectively. The gastropod *Cerithidea cingulata* was dominant species of macrofauna, in the autumn and bivalve *Paphia galus* was dominated in other seasons. *Capitella capitata* and *Hydrobia sp.* were the other abundant species throughout the year. Density of each identified species is listed in table 2.

Compare to other taxonomic classes, bivalve was more abundant taxa with 47.9 % of total abundance. *Paphia galus* was dominant species of this order. *Tellina Walace* and *Tellina capsoides* were other common species of this taxonomic class. Gastropoda was the second dominant taxa with total abundance of 38.4 %. *Cerithidea cingulata* and *Hydrobia sp.* were the most abundant species of gastropoda. *Umbonium vestiarium*, *Onchidium peroni*, *Acteocina involuta* and *Umbonium sp.*2 were other important gastropod species. Polychaeta formed the third dominant group (12.1% of total abundance) which was represented by *Capitella capitata*, *Ceratonereis sp.* and *Perinereis cultrifera.* The species of *Ceratonereis sp.* was dominant polychaeta in the summer and autumn, while *Capitella capitata* was dominant polychaeta in the winter and spring. Within malacostraca species (with 1.6% of total abundance), *Macrophthalmus pectinipes* and *Uca sindensi* were abundant species. *Uca sindensis,* in the summer and *Macrophthalmus pectinipes,* in other seasons were dominant species of malacostraca.

Gastropoda in the autumn and bivalvia in the other seasons were dominant taxonomic classes. The highest density of bivalvia (1110 inds.m^{-2}), malacostraca (43.3 inds.m^{-2}) and polychaeta (444.7 inds.m^{-2}) was observed in the winter and the lowest density of all taxonomic classes, except for malacostraca, was observed in the spring. The highest density of gastropoda (717 inds.m^{-2}) was measured in the autumn (Fig. 3).

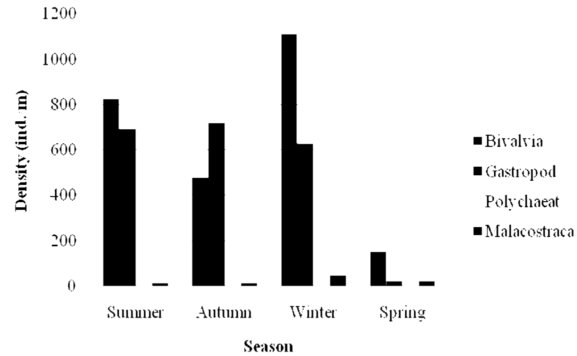

Fig. 3: Density of different taxonomic class among different seasons.

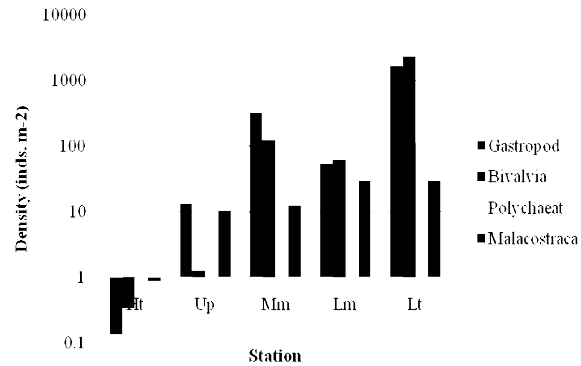

Fig. 4: Density of different taxonomic class among different stations.

The density of various taxonomic classes also changed among different tidal levels. Gastropoda and bivalvia dominated in station Lt, while polychaeta and malacostraca dominated in station Lm. Generally, there was increasing trend in individual number of each taxa from high tide (Ht and Up) toward low tide (Lm and Lt) that is illustrated in figure 4.

Ecological Indices: The results of accounted ecological indices including species richness, Shannon-Wiener diversity and Simpson dominance are shown in table 3. Generally, higher tidal stations included low number of macrofauna species, low diversity and high dominance. In contrast, lower tidal stations contained more individuals and showed more diversity as well as low dominance. Therefore, in almost all seasons and all transect lines species richness increased from landward (Ht and Up) toward canal-ward stations (Lm and Lt). This trend was also detectable about Shannon-Wiener diversity index. There were no significant difference among indices value of corresponding stations of different transect lines or seasons (P>0.05).

Table 3: Values of different indices at 20 sampling stations in the summer S: species richness (ind.), H': Shannon-Wiener diversity, D: Simpson dominance

		Summer			Autumn			Winter			Spring		
Transect	Station	S	H'	D	S	H'	D	S	H'	D	S	H'	D
Transect 1	Ht	4	1.92	0.1	1	0	1	1	0	1	1	0.65	0.66
	Up	3	1.57	0.28	2	0	1	1	0	1	1	0	1
	Mm	5	2.21	0.22	2	0.81	0.5	7	1.76	0.50	5	1.77	0.34
	Lm	8	2.22	0.25	10	1.23	0.59	17	1.35	0.78	11	1.15	0.66
	Lt	7	1.44	0.40	11	1.84	0.30	15	1.62	0.62	11	1.72	0.46
Transect 2	Ht	2	1	0.42	1	0	1	1	0	1	1	0	1
	Up	4	1.35	0.46	2	0.72	0.6	2	0.72	0.8	5	1.78	0.35
	Mm	4	0.88	0.67	2	0.99	0.45	7	1.9	0.53	5	1.33	0.54
	Lm	9	1.79	0.43	10	1.57	0.55	14	2.72	0.36	9	2.44	0.21
	Lt	7	1.54	0.36	11	1.45	0.44	17	1.5	0.6	14	1.76	0.42
Transect 3	Ht	0	0	1	1	0	1	1	0	-	4	1.74	0.28
	Up	7	2.13	0.26	2	0.98	0.42	3	1.35	0.55	6	1.99	0.27
	Mm	7	1.48	0.41	6	1.24	0.57	6	1.93	0.51	6	1.5	0.47
	Lm	7	1.35	0.52	10	1.92	0.39	13	0.96	0.84	12	1.4	0.60
	Lt	7	1.52	0,42	8	1.31	0.46	23	1.71	0.53	16	1.55	0.46
Transect 4	Ht	2	0.65	0.66	2	0.72	0.6	1	0	1	2	0	1
	Up	5	2.1	0.23	7	2.16	0.28	7	2.45	0.31	3	0.99	0.59
	Mm	6	2.14	0.24	4	0.37	0.89	10	1.75	0.59	5	1.81	0.31
	Lm	5	1.14	0.56	6	1.54	0.46	14	2.37	0.56	13	2.47	0.29
	Lt	10	0.75	0.69	10	1.77	0.38	15	1.08	0.76	14	2.3	0.25

DISCUSSION

The results obtained in this study reflect high variability and complexity of macrobenthic community in Bardestan mangrove swamp. The number of identified macrobenthic species in the present study (44 species) was more than what identified by Vazirizadeh [26] in the same habitat (22 species). Less number of identified species in that study could be mostly due to restricted sampling in his study (limited to winter). The number of identified macrobenthic species reported by Sarvankumar *et al*. [11] in mangrove forest of Gulf of Kachchh-Gujarat [60] is more than identified species by present study. Generally, difference of various mangrove habitats in macrobenthic composition could be due to specific ecological and environmental features of each habitat [2].

Bivalvia with 47.9 % of total abundance were dominant taxon in Bardestan mangrove swamp. Polychaeta is dominant macrobenthic taxa of most mangrove forests [6]. In the mentioned studies, sampling has been limited through mangrove trees, while in the present study sampling was performed also in mud flats surrounded mangrove trees. Hence, more diverse environmental conditions and wider range of habitats might provide niches for different species. Nevertheless, in the mangrove stations (Lm), polychaets were abundant and dominant taxon. Soft substrate of mangrove generally favors tube dwellers such as polychaets and results increase of their abundance [10]. Dominance of polychaets under mangrove trees is also due to stable substrate provided by roots and dense canopy of the mangroves which provide protection against desiccation [27, 10]. Therefore, high density of mangrove trees in station Lm could provides suitable condition for colonization of polychaeta in this station. Similarly, tidal current and waves provide food for suspension feeders (Gastropoda and bivalvia) in mud flats [9] and lead to increase of their abundance in station Lt where is more affected with tidal currents.

Totally, the results indicated spatial and temporal variation in distribution, density, abundance, species number and composition of macrofauna in Bardestan mangrove swamp. This variation is not unusual in intertidal zones [6]. For temporal variation of density and diversity of macrofauna, Sarvankumar *et al.* [11] reported that lower temperature and stability of environmental factors such as salinity leads to increase of density and diversity of macrofauna in mangrove forests of Kachchh-Gujarat, India. They also concluded that low species diversity in the summer could be attributed to decrease of gametogenesis and reproduction, decrease of dissolved oxygen and increase of H_2S in sediment. Kumar *et al.* [28] also reported that increase of temperature and TOC have lead to decrease and increase of density or diversity of macrofauna in the gulf of Mannar, respectively Similarly, the same results were attained for Bardestan mangrove

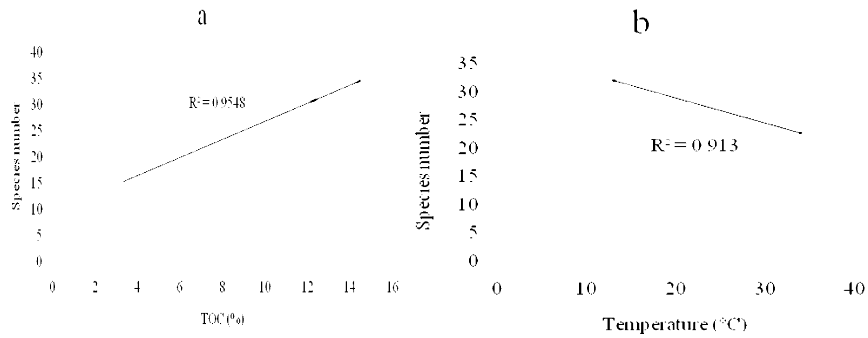

Fig. 5: The number of species as a function of average temperature and TOC among different seasons.

Table 4: Pearson correlation analysis between abundance of polychaeta and environmental parameters. ** correlation is significant at the level of 0.01 (2-tailed), * correlation is significant at the 0.05 level (2-tailed)

		pH	Eh	Salinity	Mud	TOC	T	DO
Gastropoda	Pearson Correlation	-.045	.013	-.074	-.393**	-.170	.018	.161
	Sig. (2-tailed)	.690	.911	.512	.000	.131	.874	.154
	N	80	80	80	80	80	80	80
Bivalvia	Pearson Correlation	.060	.030	-.023	-.343**	-.032	.021	.154
	Sig. (2-tailed)	.595	.792	.838	.002	.778	.855	.172
	N	80	80	80	80	80	80	80
Polychaeta	Pearson Correlation	-.105	-.368**	-.384**	.553**	.343**	-.170	-.326**
	Sig. (2-tailed)	.354	.001	.000	.000	.002	.131	.003
	N	80	80	80	80	80	80	80
Malacostarca	Pearson Correlation	.049	-.100	-.213	.054	.336**	-.128	.004
	Sig. (2-tailed)	.669	.379	.058	.631	.002	.259	.975
	N	80	80	80	80	80	80	80
Species number	Pearson Correlation	.037	-.429**	-.362**	.208	.342**	-.082	-.271*
	Sig. (2-tailed)	.746	.000	.001	.064	.002	.471	.015
	N	80	80	80	80	80	80	80

Statistically significant correlations in bold.

swamp. Figure [5] shows negative relationship between species number and temperature (R^2=0.72, $P<0.05$) or positive relationship between TOC and species number (R^2=0.89, $P<0.05$). Therefore, it is suggested that temperature and TOC percentage are important factors that influence number of macrobenthic species within different seasons, in Bardestan mangrove swamp.

There was also special variation among various tidal levels. In each transect line, higher tidal levels consisted of less density and diversity of macrofauna compare to lower tidal levels. Vazirizadeh [26] reported the same pattern in distribution of macrofauna along tidal levels of this habitat. Little [9] reported hydrological differences as effective factor on spatial variation of macrobenthic density. Edgar [8] reported that structure and distribution of mangrove trees influence distribution of macrobenthic species. With regard to increase of mangrove density from higher to the lower tidal levels, this parameter could be affective on macrofauna composition of this ecosystem. Lee [7] found close relationship between structure of benthos and environmental characteristics such organic matter, mud content and dissolved oxygen as important and effective factors on distribution of macrofauna. Statistical analysis showed that some abiotic parameters affect spatial distribution of macrofauna in Bardestan mangrove swamp too (Table 4). The table shows that abundance of gastropoda and bivalvia is correlated to mud content. Polychaeta abundance is correlated to Eh, salinity, mud, TOC and DO. Abundance of malacostraca is also correlated to TOC percentage. Pearson correlation also revealed significant correlation between species number and environmental parameters such as Eh, salinity, TOC and Do (Table 4). Some biological factors such as food source, competition, behavior also may affect composition of macrobenthic communities [9, 29-31].

The environmental indices, presence of high tolerant species such as *Capitella capitata* (329 ind.m^{-2}) and absence of sensitive taxa like amphipods [32, 33] demonstrate that Bardestan mangrove swamp is fairly polluted. This environmental status of Bardestan mangrove swamp can be attributed to proximity of this habitat to the urban and industrial regions. Discharge of sewage and industrial wastes can degrade this habitat. Proximity of Bardestan mangrove swamp to the urban (Bardestan town) and industrial regions located along the coastline may have led to discharge of sewage and industrial wastes into the estuary. Vazirizadeh [26] attained moderate or poor environmental status for this habitat based on Shannon-Wiener and Margalef indices. Therefore, it seems that environmental condition of Bardestan creek has gotten worse during last decade. It is necessary to investigate integrated environmental status of this creek and to find stress and pollution sources that impact live part of present ecosystem for future management.

ACKNOWLEDGEMENT

Present research was funded by "Persian Gulf Research and Study Center", Persian Gulf University. I would like to thank all staffs of this center that helped us in performing this study. I'm grateful to my colleagues and friends for their helps in sampling and laboratory work (Mr. Ali Mansuri, Kourosh Gharebaghi and Mrs. Fateme namjoo).

REFERENCES

1. Lee, S.Y., 1999. Tropical mangrove ecology: Physical and biotic factors influencing ecosystem structure and function. Australian J. Ecol., 24: 355-366.
2. Kathiresan, K. and B.L. Binghamnd, 2001. Biology of mangroves and mangrove ecosystems. Advances in Marine Biology, 40: 81-251.
3. Santen, P.V., P.G.E.F. Augustinus, B.M.J. Stelder, S. Quartel and N.H. Tri, 2007. J. Asian Earth Sci., 29: 566-575.
4. MacFarlane, G.R., C.E. Koller and S.P. Blomberg, 2007. Accumulation and partitioning of heavy metals in mangroves: A synthesis of field-based studies. Chemosphere, 69: 1454-1464.
5. Sasekumar, A., 1974. Distribution of macrofauna on a Malayan mangrove shore, In: I. Nagelkerken, S.J.M. Blaber, S. Bouillon, P. Green, M. Haywood, L.G. Kirton, J.O. Meynecke, J. Pawlik, H.M. Penrose, A. Sasekumar and P.J. Somerfield, 2008. The habitat function of mangroves for terrestrial and marine fauna: A review. Aquatic botany, 89: 155-185.
6. Chapman, M.G., 2006. Relationships between spatial patterns of benthic Assemblages in a mangrove forest using different levels of taxonomic resolution. Marine Ecology Progress Series, 162: 71-78.
7. Lee, S.Y., 2008. Mangrove macrobenthos: assemblages, services and linkages. J. Sea Res., 45: 40-54.
8. Edgar, G.J., 1990. The influence of plant structure on the species richness, biomass and secondary production of macrofaunal assemblages associated with Western Australian sea grass beds. J. Experimental Marine Biol. Ecol., 137: 215-240.
9. Little, C., 2000. The biology of soft shores and estuaries, Biology of habitat. Oxford publication, pp: 252.
10. Mishra, A. and A. Choudhury, 1985. Proceedings of national symposium on biology, utilization and conservation of mangroves, pp: 448.
11. Saravnakumar, A., J. Sesh Serebiah, G.A. Thivakaran and M. Rajkumar, 2007. Benthic Macrofaunal Assemblage in the Arid Zone Mangroves of Gulf of Kachchh-Gujarat. J. Ocean Uni. China, 6: 303-309.
12. Kristensen, E., 2008. Mangrove crabs as ecosystem engineers; with emphasis on sediment processes. J. Sea Res., 59: 30-43.
13. Kristensen, E., S. Bouillon, T. Dittmar and C. Marchand, 2008. Organic carbon dynamics in mangrove ecosystems: A review. Aquatic Botany, 89: 201-219.
14. Sheaves, M. and B. Molony, 2000. Short-circuit in the mangrove food chain. Marine Ecology Progress Series, 199: 97-109.
15. Gesteira, J.L.G. and J.C. Dauvin, 2000. Amphipods are Good Bioindicators of the Impact of Oil Spills on Soft-Bottom Macrobenthic Communities. Marine Pollution Bulletin, 40: 1017-1027.
16. Engle, V.D. and J.K. Summers, 1999. Refinement, validation and application of a benthic condition index for Gulf of Mexico estuaries. Estuaries, 22: 624-635.

17. Nixon, S.W., C.D. Hunt and B.L. Nowicki, 1986. The retention of nutrients (C, N, P), heavy metals (Mn, Cd, Pb, Cu) and petroleum hydrocarbons in Narragansett Bay. In: P. Lasserre, J.M. Martin, (Eds.), Biogeochemical Processes at the Land-Sea Boundary, Elsevier, New York, pp: 99-122.
18. Gilman, E.L., J. Ellison, N.C. Duke and C. Field, 2008. Threats to mangroves from climate change and adaptation options: A review. Aquatic botany, 89: 237-250.
19. Sheppard, C., M. Al-Husiani, F. Al-Jamali, F. Al-Yamani, R. Baldwin, J. Bishop, F. Benzoni, E. Dutrieux, N.K. Dulvy, S.R.V. Durvasula, D.A. Jones, R. Loughland, D. Medio, M. Nithyanandan, G.M. Pillingm, I. Polikarpov, A.R.G. Price, S. Purkis, B. Riegl, M. Saburova, K. Samimi Namin, O.Taylor, S. Wilson and K. Zainal, 2010. The Gulf: A young sea in decline. Marine Pollution Bulletin, 60: 13-38.
20. Safyari, S., 2003. Mangrove forests. Research Institute of forests and grasslands, pp: 510.
21. Reshvand, S., 1997. Study of mangrove forest structure in Bushehr province. MSc thesis, University of agriculture and natural resources, faculty of forestry.
22. Emerson, W.K. and M.K. Jacobson, 1974. Guide to shells. ALFRE A. Knopf., pp: 482.
23. Hosseinzadeh, H., B. Daghoghi and H. Rameshi, 2001. Atlas of the Persian Gulf mollusks. Iranian fisheries research organization (I.F.R.O), pp: 208.
24. Eleftheriou, A. and M.I. Alasdair, 2005. Methods for the study of marine benthos. Third edition. Blackwell science, pp: 418.
25. Gupta, P.K., 2001. Methods in environmental analysis water, soil and air. Agrobios (India), pp: 408.
26. Vazirizadeh, A. 1997. Study of macrofauna status in intertidal zone of Bushehr province's coasts. MSc thesis, Khoramshahr marine sicence and technology university, marine biology department.
27. Divakaran, O., T. Murugan and N.B. Nair, 1981. Distribution and seasonal variation of the benthic fauna of the Ashtamudi lake, south-west coast of India. In: A. Saravnakumar, J. Sesh Serebiah, G.A. Thivakaran and M. Rajkumar, 2007. Benthic Macrofaunal Assemblage in the Arid Zone Mangroves of Gulf of Kachchh-Gujarat. Journal of Ocean University of China, 6: 303-309.
28. Kumar, R., J.K.P. Edward and M. Jaikumar, 2010. Macro benthic community structure on Tuticorin coastal waters, Gulf of Mannar, South east coast of India. World J. Fish and Marine Sci., 2: 70-77.
29. Ysebaert, T., P.M.J. Herman, P. Meire, J. Craeymeersch, H. Verbeek and C.H.R. Heip, 2003. Large-scale spatial atterns in estuaries: estuarine macrobenthic communities in the Schelde estuary, NW Europe. Esturine Coastal and Shelf Science, 57: 335-355.
30. Houte-Howes, K.S.S., S.J. Turner and C.A. Pilditch, 2004. Spatial differences in macroinvertebrate communities in intertidal seagrass habitats and unvegetated sediment in three New Zealand estuaries. Estuaries, 27: 945-57.
31. Gray, J.S. and M. Elliot, 2009. Ecology of marine sediments. 2th edi. OXFORD university press, pp: 225.
32. Jeffrey, D.W., 1994. Benthic biological pollution indices in estuaries. In: K.J.M. Kreamer, (Ed.), Biomonitoring of Coastal Waters and Estuaries. CPR Press, Boca Raton, Florida, pp: 311-328.
33. Bortone, A.S., 2005. Estuarine indicators. CRC Press. pp: 531.