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Community Structure and Biodiversity of Intertidal Sandy Beach Macrofauna in Chabahar Bay, Northeast of Oman Gulf, IR Iran

Taheri, Mehrshad; Yazdani Foshtomi, Maryam and Bagheri, Hossein

Iranian National Institute for Oceanography, Research Station, Noshahr, IR Iran

Abstract

Biodiversity and community structure of macrofauna of the intertidal sandy beach at Chabahar Bay were studied for a period of ten months in 2007. A total of 32 species were observed and identified in this study so that polychaete with 16 species was numerically dominant. The results showed changing densities were influenced by monsoon season so that maximum density (1935.47 ind/m^2) was observed at pre-monsoon while minimum (181 ind/m^2) was obtained at monsoon. The highest and lowest value of diversity and richness indices were obtained at pre-monsoon and during monsoon, respectively. Also, multivariate analysis separated monsoon season from pre and post monsoon clearly. Our results show that monsoon can be the most important factor on biodiversity and community structure of macrofauna at Chabahar Bay and intertidal of this bay have not favorable environment for macrofauna development.

Keywords: *Biodiversity, Community structure, Intertidal macrofauna, Chabahar Bay, Oman Gulf*

1. Introduction

Macrofauna play an important role in the aquatic community as examples of these roles we can refer to mineralization, promoting and mixing of sediments, fluxing of oxygen into sediments, cycling of organic matter (Snelgrove, 1998; Heilskov and Holmer, 2001). These organisms show a large variety of feeding type and strategies at many levels of marine food web (Fauchald and Jumars, 1979). Moreover, macrofauna are one of the most abundant food items for birds, fishes and epibenthic invertebrate (Nybakken, 1993). On the other hand, they are used as bio indicators for environmental monitoring programs (Ajmal Khan et al., 2004).

Generally, seasonal changes in community structure of macrofauna can be related to reproduction activity, predator pressure, food source and competition (Nybakken, 1993, Mistri et al., 2002; Kevrekidis, 2005), but in the Indian Ocean they were related to monsoon period, because the lowest density and number of species were observed during monsoon (Harkantra and Parulekar 1985; Nybakken, 1993; Nikouyan and Savari, 1999; Ibrahim et al., 2006).

Intertidal zone perhaps are the best known area of the world's ocean because it is the most accessible for researchers. On the other hand sandy beaches are very dynamic environmental and wave and wind action, grain size and tide amplitude is the most important factors in their

E-mail: mehrshadtaheri@yahoo.com

physical characterization (Nybakken, 1993). Unfortunately, coastal area at the northern part of Gulf of Oman is largely unknown for its macrofauna that is why; there are not enough published accounts and ecological information of beach ecology in this area in general, which can be useful for base conservation and management programs.

Analysis of community structure is useful for coastal management and conservation of the environment. The purpose of this paper is to study and identify any invertebrate populations, biodiversity patterns and community structure of intertidal sandy beach macrofauna at this area during different monsoon seasons.

2. Materials and methods

2.1 Study area

Chabahar Bay with an area near 320 km^2 is the largest bay on the northeast of Oman Gulf along the Sistan and Baluchestan province, Iran. The average depth of this bay is 6 m while the deepest part of it, is about 20 m. No major rivers exist in the vicinity of it. This bay has a tropical climate characterized by south-west monsoon (May-September), post monsoon (October-February) and pre monsoon (March-April). Contrary the other places in Indian Ocean, no rainfall occurs during south-west monsoon at this area. Tiss and Konarak are microtidal beaches located in the east and west of Chabahar Bay (Figure 1).

The gradient and structure of the intertidal area in sampled sites was uniform and no macroalga were observed in it. During this study, tidal currents were between -0.2 – 0.2 meters, while intertidal widths were 75 – 95 meters. Sampling was conducted off Tiss and Konarak in an area defined by coordinates (25º21'49" & 60º36'37" E and 25º24'90" & 60º25'99" N).

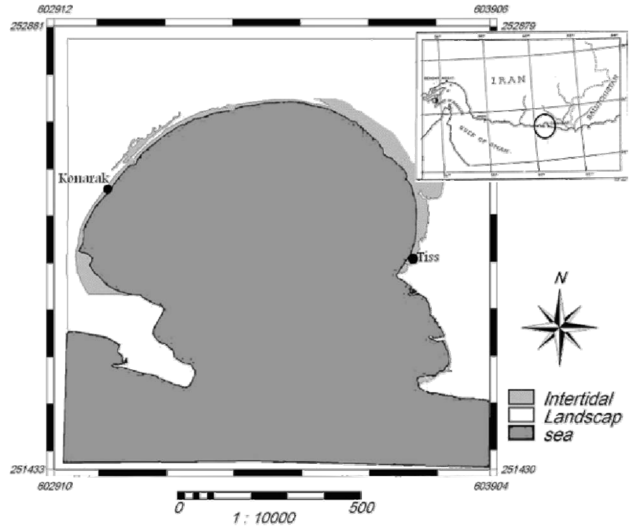


Fig 1. Map of sampling area

2.2 Data collection

Sampling was carried out monthly at low tide during pre monsoon (April), monsoon (May-September) and post monsoon (October-February) at both stations. It is necessary to mention that due to some problems, sample could not be located fromt Konarak in June. Intertidal zone (between the drift line and the water line) was divided to upper, middle and lower regions and at each region, seven cores (12 cm diameter and 20±1 cm depth) were randomly taken at 10 meters distance a total of 21 cores at each station (Pridmore et al., 1999; Honkoop et al., 2006). The contents of each core were gently sieved in using a 0.5 mm mesh and retained material fixed in 4% buffered formalin and stained with Rose Bengal (Abrantes et al., 1999). In the laboratory, macrofauna were sorted under stereomicroscope, identified and counted (Hutchings, 1984; Walker, 1986). Whenever we saw fragmentation of worms was observed, only prostominm-bearing fragment were counted (Mistri et al., 2002).

Three sediment samples were taken for particle size analysis with a plastic corer of 3 cm diameter to a depth of 10 cm. To determine sediment particle size nearly 200 g of each core sample was submitted to standard dry-sieve through a series of mesh sizes (from 63μ to 2 mm) and mechanically shaken for 10 min. The sediments retained on each sieve were weighed and the percentage of each granulometric category was determined (Diaz-Castaneda and Harris, 2004).

Monthly mean of water and air temperature were obtained from Iranian national Centre for Oceanography (INCO) at Chabahar, which is located around 4 Km of west part of Chabahar Bay (25°16'820"N, 60°39'118"E).

Macroobenthic community structure was described by univariate analysis based on: density, species number (S), diversity (as Shannon- Wiener's, H'), richness (As Margalef's, D), and evenness (as Pielou's, J) which calculated per square meter by averaging all replicates (Velso, V. G and Cardoso, R. S., 2001). Two way ANOVA (station×month) was used to test for differences in the physical (sand and silt-clay percent) and biological parameters (density, diversity, richness and evenness) and Tukey's test to assess significant differences between them. The correlation of density with percentage of sand and silt-clay also, air and water temperatures were determined using the Pearson's rank correlationcoefficient. The frequency of occurrence (F) of the species was calculated according to Arasaki et al. (2004). Data on the density was transformed by Logarithm and used for classification and ordination. Species with one individual was eliminated. Similarity was calculated using the Ward's method and Non-metric multidimensional scaling (nMDS) using Euclidean distance (Diaz-Castaneda and Harris, 2004).

3. Results

3.1 Environmental variables

No significant difference was observed in sand and silt-clay percent between stations and months (ANOVA, Table 1). At both stations, sand was the main component during the study period. air and water temperature showed a regular cycle, ranging between 21.5 and 34.6. Maximum air and water temperature were obtained in July while minimum values of them were observed in December and February, respectively (Figure 2).

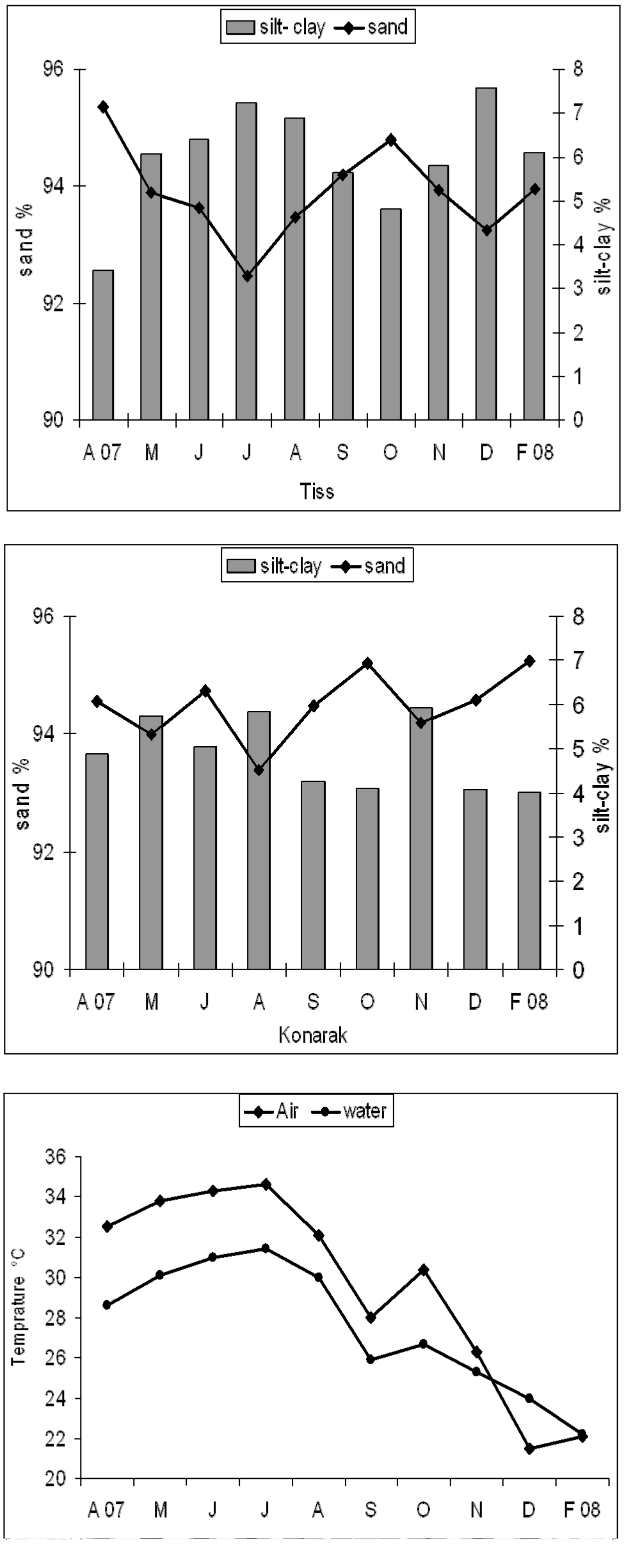


Fig 2. Mean environmental condition during present study.

3.2 Community structure

A total 32 macrofauna species were collected and identified from 420 cores during this study. Polychaeta were the dominant group of macrofauna. According to table 1, only two species was constant (Synelmis albini, F=78% and Apanthura sandalensis, F = 61%) at Tiss and Konarak beaches, and other species were common and rare (Table 1).

Two species, Synelmis albini and Magelona cornuta, were most abundant at both stations during this study. Densities of them are shown in Figure 3.

Maximum and minimum density at Tiss was obtained 1935.47±555.55 in April and 181.12±81.17 in September, respectively. At Konarak, maximum density (901.76±19.40) was observed in February while minimum (353.98±186.32) was obtained in May (Figure 4). In addition, density of macrofauna increased from post to pre monsoon while during monsoon, minimum densities were observed.

Table 1. Frequency of occurrence (%)

	Tiss	Konarak		Tiss	Konarak
Synelmis albini	78	46	*Prionospio* sp.	29	-
Magelona cornuta	38	42	*Goniadopsis incerta*	-	21
Glycera sp.	14	37	*Umbonium vestiarium*	21	-
Arabella iricolor	3	36	*Urothoe grimaldi*	11	-
Armandia leptocirris	18	4	*Lumbrinereis* sp.	-	8
Nephthys hombergii	13	6	*Pectinaria* sp.	3	-
Cirriformia tentaculata	1	14	*Syllis spongicola*	2	-
Dasybranchus caducus	3	5	*Grandidierlla exilis*	1	-
Lineus sp.	21	9	*Turitella maeulata*	1	-
Cymadusa filosa	1	21	*Turitella* sp.	1	-
Perioculodes longimanus	1	6	*Branchiostoma* sp.	1	-
Prashadus pirotansis	1	3	*Ecocuma affine*	1	-
Grandidierlla exilis	2	1	*Pupa affinis*	1	-
Ochetosoma erythogrammon	1	1	*Nephthys tulerensis*	1	-
Rhopalophthalmus sp.	1	1	*Eunice* sp.	-	1
Apanthura sandalensis	-	61	*Acrocirrus uchidai*	-	1

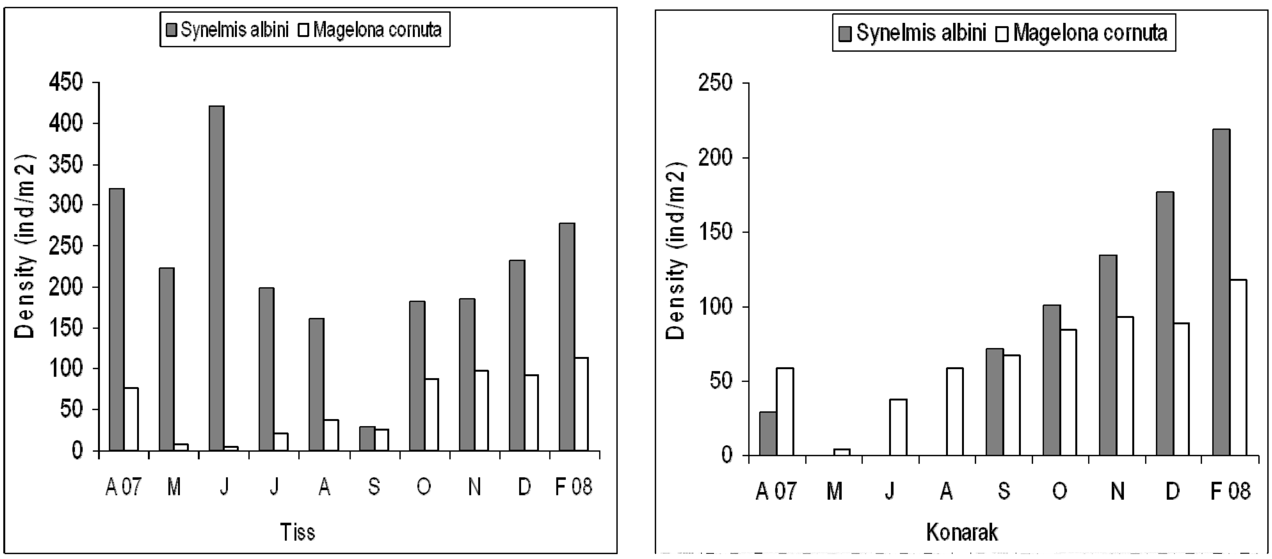
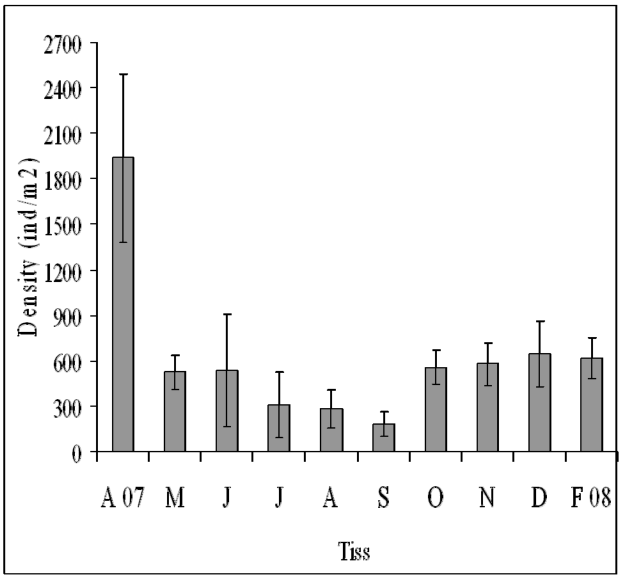


Fig 3. Densities of tow dominate species at both stations during this study

Correlations between the macrofauna density with percentage of sand and silt-clay also, air and water temperatures are shown in Table 2. Positive and negative correlations were found between density and environmental variables.



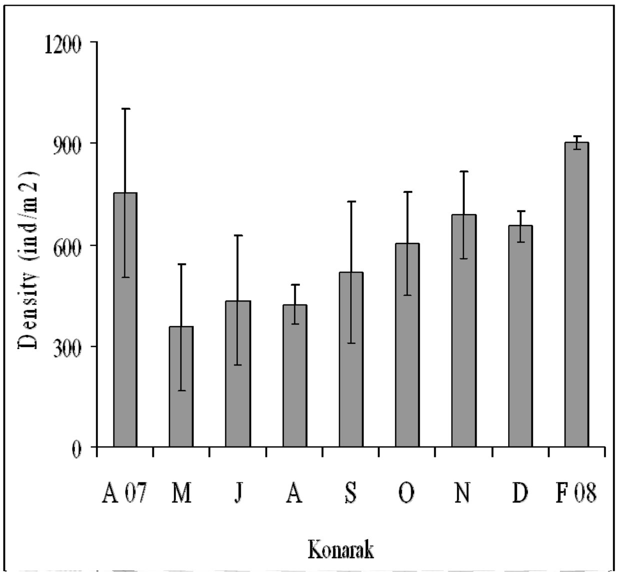


Fig 4. Mean number of species recorded (per m^2) in each season during this study

Table 2. Spearman's rank correlation coefficient between density of Polychaeta with total organic matter and percentage of sand.

	water temp	air temp	sand %	silt-clay%
Tiss	- 0.289	- 0.210	- 0.498 **	0.453 **
Konarak	- 0.685 **	- 0.625 **	0.162	0.272

**, P<0.01

4. Ecological indices

Two-way ANOVA revealed significant differences in diversity and richness only among months, but no significant differences were observed in evenness of the macrofauna between beaches and seasons. The highest number of species (21) was recovered at Konarak (Aprill) while the lowest (6) at Tiss (August and February) and Konarak in August.

Diversity was the highest at Tiss (1.41, February) and the lowest at Tiss (0.13, June). Richness was at the highest at Konarak (1.71, November) and the lowest at Tiss (0.44, June). Value of evenness were found between 0.70 (June, Tiss) and 0.95 (November, Tiss). In addition, the lowest values of ecological indices were observed during monsoon while the highest was obtained at post monsoon.

Table 3. Species number (S), diversity (H'), richness (D), and evenness (J) during this study

	Tiss				Konarak			
	S	H'	D	J	S	H'	D	J
A 07	19	1.27	1.50	0.77	21	0.87	0.94	0.92
M	9	0.37	0.63	0.93	8	0.43	0.68	0.84
J	12	0.32	0.44	0.70				
J	10	0.57	0.68	0.74	9	0.91	1.14	0.92
A	6	0.45	0.95	0.84	6	1.10	1.34	0.94
S	9	1.10	0.99	0.84	13	1.37	1.46	0.93
O	8	1.21	1.31	0.93	13	1.38	1.70	0.92
N	7	1.21	1.52	0.95	11	1.37	1.71	0.91
D	9	1.28	1.53	0.91	8	1.28	1.55	0.90
F 08	6	1.41	1.38	0.87	10	1.40	1.50	0.87

5. Multivariate analysis

The dendogram of dissimilarities shows two mains groups A and B (Figure 5). Group A divided into two subgroups in order to comprised monsoon season (May-September). Group B divided into three subgroups to comprised post monsoon season

(October-February) and pre monsoon (Aprill at Tiss). During monsoon season density have the lowest value and this season was separated from other season. In post monsoon period density of macrofauna slowly increased and reached the highest value observed in pre monsoon (April).

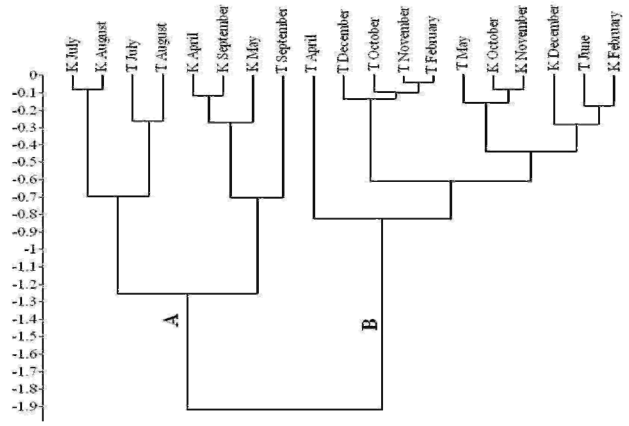


Fig 5. Similarity between stations and months using the Ward's method

The nMDS ordination plot is shown in Figure 6. The groups of stations separated by nMDS are very similar to those generated with the similarity. Stress value was obtained 0.023.

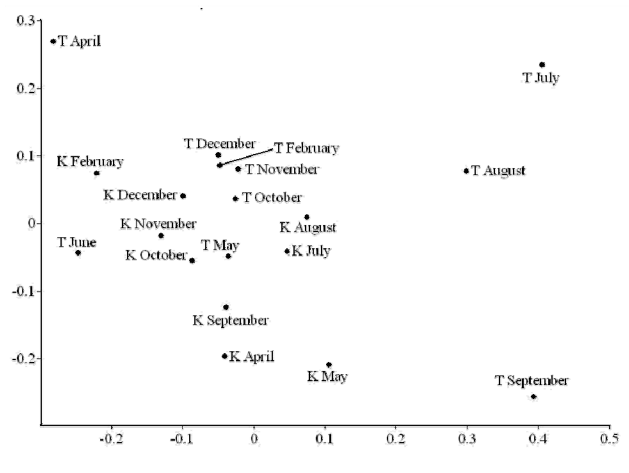


Fig 6. nMDS plot of macrofauna communities during present study

6. Discussion

Despite the fact that the intertidal zone are the best known area of the world ocean (Nybakken, 1993) the northern part of Gulf of Oman coast has been poorly studied with regard to the intertidal fauna. In this study 32 species of macrofauna were recorded. In Goa beach at India, six species of macrofauna were reported (Harkantra and Parulekar, 1985). In south India, 13 species of macrofauna were observed (Ajmal Khan et al., 2004). At Godavari delta, in east cost of India, 37 species of macrofauna were recorded (Raut et al., 2005). On the other hand in present study, the macrofauna was numerically dominant by Polychaeta with 16 species. Similar result was obtained by Ingole et al, (2002), Ajmal Khan et al, (2004) and Ibrahim et al (2006) in other regions. Unfortunately, Studies on macrofauna at the north of Gulf of Oman (Iranian waters) are rare; hence any comparison in community structure with other studies is not possible. According to above-mentioned publication, the number of species in Indian Ocean in intertidal and shallow waters is very variable. It is necessary to mentio that the lug worm *Arenicola* sp. and *Diopatra* sp., occurred in the study area with very low density but was not collected quantitatively by this sampling technique and therefore were not included in the analyses.

According to table 1, two species, *Synelmis albini* and *Magelona cornuta*, were the most abundant at both stations and they had the highest effect on density changes during this study (Figure 3). The others species were common and rare at both stations (e.g. *Dasybranchus caducus*, *Nephthys tulerensis*).

Population density showed significant differences monthly. Maximum and minimum density were observed at pre monsoon (April) and during monsoon (May-September), respectively (Figure 4). In addition, density at Tiss beach was greater than Konarak beach. At Tiss Beach Maximum and minimum density were observed 1935.47±555.55 in April and 181.12±81.17 in September, respectively but In Konarak, maximum density was observed 901.76±19.40 in February while minimum was obtained 353.98±186.32 in May (Figure 4). In general, the highest and the lowest density were observed at premonsoon and during monsoon. In Chabahar Bay, maximum and minimum density of polychaeta were reported 13000 ind/m2 (premonsoon) and 4600 ind/m2 (during monsoon), respectively (Nikouyan and Savari, 1999). In Karah Island, Malaysia maximum and minimum density were observed 25836 ind/m2 (premonsoon) and 21573 ind/m2 (during monsoon), respectively (Ibrahim et al., 2006). Harkantra, S and Parulekar, A. H (1985) showed that during monsoon density of macrofauna was the lowest while at pre monsoon maximum density was observed.

During monsoon, wind velocity and power of wave were higher. The number of species, diversity, density and species richness of macrofauna at intertidal zones increase with reduced exposure to wave action (Alongi, 1990; Dexter, 1992). On the other hand, seasonal variation between densities of polychaeta can be related to reproduction activity, predator pressure, food source and competition (Nybakken, 1993; Mistri et al., 2002; Kevrekidis, 2005). In addition, the effect of monsoon seems to be greater than other factors at this study area.

Monthly differences between values of ecological indices clearly related to monsoon period so that the lowest values of ecological indices were observed during monsoon. During this study H' value was low (maximum 1.41) which indicates that this is no suitable environment for macrofauna. In Godavari delta, India, maximum diversity and richness were obtained as 1.50, 2.25, respectively (Raut et al., 2005) that was similar than of present study. Ajmal Khan et al, (2004) reported that maximum diversity, richness and richness and evenness were observed 1.03, 0.90 and 0.69, respectively. In the present study, low value of these indices seems to be related to: (i) low number of species of macrofauna (in compare to another beach such as in Kuwait that Al Bakri et al, (1997) reported 235 taxa and 299 species was reported by Raut et al, (2005) at Godavari delta, India); (ii) existence of common and rare species so that approximately all of recorded species belong to these groups (Table 1).

Multivariate analysis can detect changes in macrofauna assemblage in space and time. Cluster analysis was separated stations and months during this study. The results show that post monsoon (October-February), pre monsoon (April) and monsoon period (May-September) are clearly separated. nMDS analysis corroborated results show in dendogram, confirming the separation between station and months. In the other hand, according results of two way ANOVA, no significant differences in sand and silt-clay percent between beaches and seasons. Hence, density seems to have not relations to sediment characteristics.

7. Conclusions

The present results show that the monsoon is the main factors that determine the distribution patterns of polychaete species in Chabahar Bay intertidal area. Other factor such as sand and silt-clay percent, air temperature and water temperature reproduction activity, predator pressure, food source and competition probably also influence the polychaete fauna.

8. Aknowlengment

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