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Distribution and diversity of Meiobenthos in southern Caspian Sea (Mazandaran-Iran)

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Abstract - Biodiversity and distribution of benthic Meiobenthos in the sediments of the Southern Caspian Sea were studied in order to introduce and determine their relationship with the environmental factors. From 12 stations (ranging in depths from 5, 10, 20 and 50 meters), sediment samples were gathered for four seasons (2012). Temperature, salinity, dissolved Oxygen and pH were measured during sampling with CTD (conductivity, temperature and Depth). Percentage grain size and total organic matter and calcium carbonate were measured. The average water temperature ranged from 9.52 to 23.93 ℃, dissolved Oxygen from 7.71 to 10.53 mg/L, salinity from 10.57±0.07 to 10.75±0.04 ppt., pH from 7.44±0.29 to 7.41±0.22, EC from 17.97±0.12 to 18.30±0.04 µs/cm^2, TDS from 8.92±0.04 to 9.14±0.02 mg/L, total organic matter from 5.83±1.43 to 6.25±0.97% and calcium carbonate fluctuated from 2.36±0.36 to 1.68±0.19%. From the 4 groups of animals (Foraminifera, Crustacea, Worms and Mollusca), 40 species belonging to 29 genera of 25 families were identified *Ammonia beccarii caspica*, was the common species in all sampling stations. Depth was an important factor in the distribution of meiobenthos. Mean of maximum and minimum Shannon index were measured at depth of 5m and 50 m and were in the order of 0.93 and 0.43, respectively. Account of Shannon and Peilou's index showed that this area is under pressure and is not steady.

Key word: Biodiversity, Caspian Sea, distribution, meibenthos.

Introduction

The Caspian Sea is the largest inland body of water in the world and accounts for 40 to 44% of the total lacustrine waters. The coastline of the Caspian Sea is shared by Azerbaijan, Iran, Kazakhstan, Russia, and Turkmenistan. The Caspian Sea is divided into three distinct physical regions: the northern, middle, and southern Caspian Sea. The studied area is located in the southern Caspian Sea region (Fig. 1). The Caspian Sea has characteristics common to both seas and lakes. It is often listed as the World's largest lake, although it is not a freshwater lake. The Caspian Sea was once part of the Tethys Ocean but became landlocked approximately 5.5 million years ago due to plate tectonics. Both the Volga River (about 80% of the inflow) and the Ural River discharge into the Caspian Sea, but it has no natural outflow other than evaporation. Thus, the Caspian Sea ecosystem is a closed basin, with its own sea-level history that is independent of the eustatic level of the World's oceans (Amirahmadi, 2000).

Biodiversity of flora and fauna of the Caspian Sea are unique. Approximate number of plant and animal species native to the Caspian Sea (Simonett, 2006). The ecology of the Caspian Sea is threatened due to several issues such as petroleum extraction, river and sea pollution, water-level rise, biological damage, the decline in numbers of Caspian seals and lack of legal regime among the neighbors. Infrastructural developments have had serious impacts on the ecosystems around the Caspian Sea and have often imposed long term damages (Nasrollahzadeh, 2010). Meiobenthos of the Caspian Sea are poorly studied despite macrobenthos. Hence, the objective of the present study is to provide a detailed account of the distribution of meiobenthos collected from the southern coast of the Caspian Sea at depths ranging from 5 to 50 m.

The meiobenthos is a remarkable and diverse component in sandy intertidal environments, having much greater diversity and abundance than the macrofauna in exposed beaches (Brown and McLachlan, 1990). The study of the meiobenthos in sandy beaches has great interest because of its accessibility and importance in coastal processes, and especially because of its use as indicator of environmental quality. Kennedy and Jacoby (1999) reviewed the role of the meiobenthos in marine benthic systems and concluded that the state of meiobenthos communities may reflect the overall health of the system, and that changes in their populations could affect different trophic levels up setting other system components with recognized ecological value. During the last years, these studies have become of great value for their use as bioindicator of pollution(Moreno *et al.*, 2008 and Cabria *et al.*, 2015).

The aims of the present work are (1) the quantitative registration of meiobenthos on species level, (2) the determination of species distribution and abundance of singular species, (3) the characterization of the sandy beaches using selected abiotic factors, and (4) the comparison of species diversity based on statistical methods.

Site Descriptions:

The study was carried out in spring, summer, autumn and winter 2012 in Mazandaran province, from Behshar to Ramsar along the southern coast of the Caspian Sea (Fig. 1 and Table 1). Sediment samples were collected from 12 stations, ranging in water depth from 5 to 50 m.

Materials and Methods

Sampling Method:

Samples were collected by boat, stations depths were measured with echo sounder and sampling coordinates were recorded with the Global Positioning System. At each station, a 0.1 m^2 Van-Veen grab sampler was used to collect bottom sediments. Three sets of samples were taken at each station by a 6.60 cm^2 area core sampler with 5cm depth and were stored in plastic boxes. For benthic studies, each sediment (33 cm^3 sample in volume) were treated with 1 g/L Rose Bengal solution immediately after its arrival on boat to distinguish living specimens, and then being mixed with 5% concentrated formalin solution (Moghaddasi *et al.*, 2009; MOOPAM, 2010; Sadoogh *et al.*, 2013).

Meiobenthos Analysis:

For determining meiobenthos, in the laboratory, wet samples were washed through 63 µm mesh sieve to remove any excess stain and were then oven dried (75°C, 8 hrs.) (Schratzberger *et al.,* 2002).

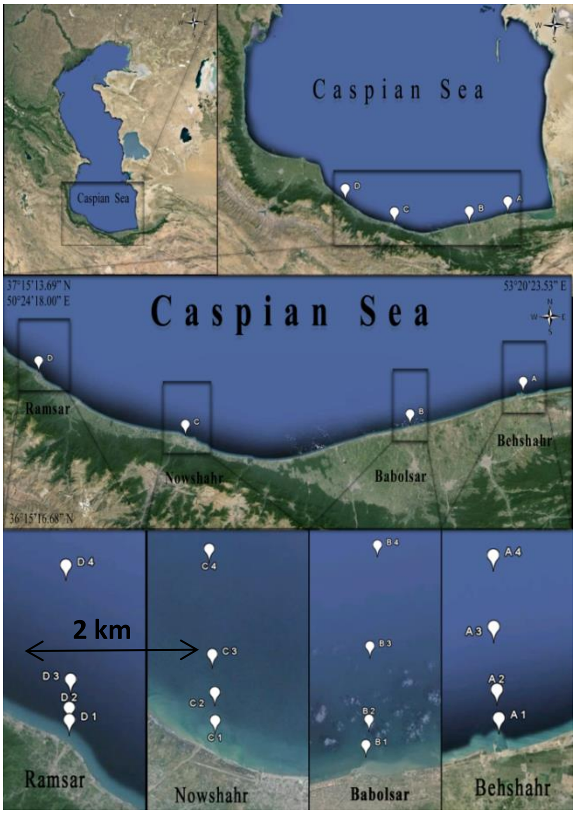

Figure 1. Situation of sampling stations in the Southern Caspian Sea.

Table 1. Position of sampling stations.

stations	Depth(m)	Longitude (°N)	Latitude (°E)
A1	5	36° 51' 31"	53° 16' 16. "
A2	10	36° 53' 10"	53° 16' 12"
A3	20	36° 56' 48"	53° 16' 09"
A4	50	37° 00' 52"	53° 16' 16"
B1	5	36° 43' 18"	52° 39' 33"
B2	10	36° 43' 58"	52° 39' 36"
B3	20	36° 45' 55"	52° 39' 28"
B4	50	36° 48' 41"	52° 39' 29"
C1	5	36° 40' 32"	51° 27' 43"
C2	10	36° 41' 04"	51° 27' 44"
C3	20	36° 41' 47"	51° 27' 42"
C4	50	36° 43' 47"	51° 27' 41"
D1	5	36° 56' 47"	50° 39' 20"
D2	10	36° 57' 18"	50° 39' 21"
D3	20	36° 58' 29"	50° 39' 26"
D4	50	37° 03' 17"	50° 39' 16"

Foraminiferal, Ostracoda and Mollusca tests were floated off using the heavy liquid CCl_4 with the upper layer of the liquid consisting of floated meiobenthos tests, which were then filtered by paper and allowed to dry. A stereomicroscope was used to examine and identify tests with reference to several previous studies (Birshtain *et al.*, 1968; Loeblich and Tappan, 1988). For identification of worms, in the laboratory, wet samples were washed through 63 µm mesh sieve to remove any excess stain and then fixed with ethanol (70%). Stereo-disecting microscope and compound microscope were used to examine and identify tests with reference to several previous studies (Birshtain *et al.*, 1968; Hayward and Ryland, 1996).

Environmental Factors:

The benthic environmental factors including temperature, dissolved oxygen, salinity and pH were measured by CTD meter during the sampling time. Sediment grain size, Total Organic Matter (TOM) and calcium carbonate concentration ($CaCO_3$) were measured. For the grain-size analysis, 100 g of oven-dried sediments (70°C, 8 hrs.) were mixed with 250 ml of tap water and 10 ml of sodium hexameta phosphate (6.2 g/L) to disaggregate the sediment. The sediments were then stirred mechanically (15 min), allowed to soak (8 hrs.), stirred mechanically (15 min) and dried again (70°C, 24 hrs.). Fifty grams of dried material were then transferred to the uppermost of a stacked series of graded sand sieves with 4, 2, 1, 0.5, 0.25, 0.125 and 0.063 mm mesh. The material that remained on the sieves were removed and weighed. Finally, the percentage of each particle were calculated (Moghaddasi *et al.,* 2009 and MOOPAM, 2010).

TOM in each sample were measured by calculating the loss of weight during combustion. An empty crucible was weighed and then half-filled with wet sediment and dried in an oven (70°C) until a constant weight was reached (about 24 hrs.). After removal from the oven, the sample was allowed to cool and reweighed (A). It was then placed in a Muffle furnace (550°C, 8 hrs.), removed, cooled and reweighed again (B). The TOM content were determined by the loss of weight on ignition at this temperature. [TOM %=100(A-B)/(A-C)] (Moghaddasi *et al.,* 2009; MOOPAM, 2010; Zarghami *et al.*, 2014 a, b; Zarghami *et al.,* 2018). Calcium carbonate concentration was measured based on the reaction with dilute Hydrochloric Acid (HCl). Twenty-five grams (W1) of dried sediment (7 – 8 hrs.) were mixed with HCl (0.1. N) and stirred until no CO2 bubbles were discernible, and then allowed to soak (24 hrs.). The upper liquid phase was discharged and the remaining sediments were filtered (with filter paper), dried (7 – 8 hrs.) and reweighed again (W2). Calcium carbonate percentage was measured by the following formula [$CaCO_3$ %= 100(W1-W2)/W1] (Moghaddasi *et al.,* 2009; Zarghami *et al.*, 2014 a, b and Zarghami *et al.,* 2018).

Data Analysis:

Principal component analysis (PCA) was used to investigate the relationship between seven variables collected during seasonal sampling cruises in 2012 (temperature, pH, dissolved oxygen, salinity, TOM %, $CaCO_3$ % and granulometry) (Fig. 2). Discriminant Analysis (DA) was used in different depths and stations (Figs. 3, 4 and 5). One Way ANOVA were performed to test for possible differences. Shannon-Wiener (H/) diversity index and Peilou's Evenness Index were measured assaying species diversity and ecological assessment in this area (Marques *et al.*, 2009). Amount of Shannon and Peilous indexes have been shown in Tables (2, 3 and 4) and Figs. (6, 7, 8, 9, 10 and 11).

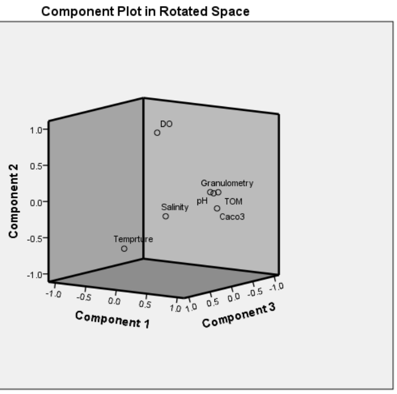

Figure 2. PCA of environmental factors in the southern Caspian Sea.

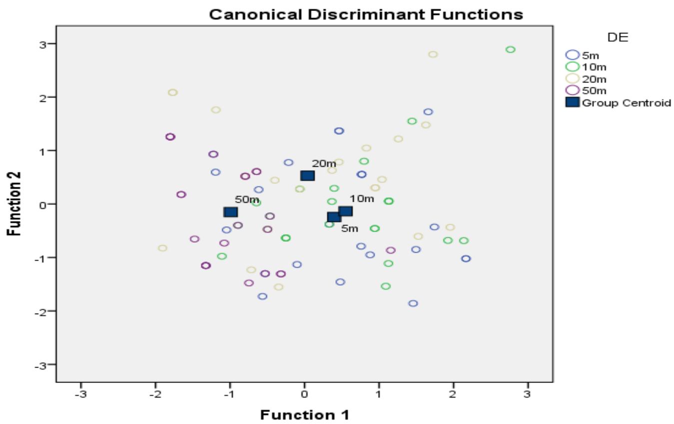

Figure 3. DA Analysis of meiobenthos animals at different depths in southern Caspian Sea.

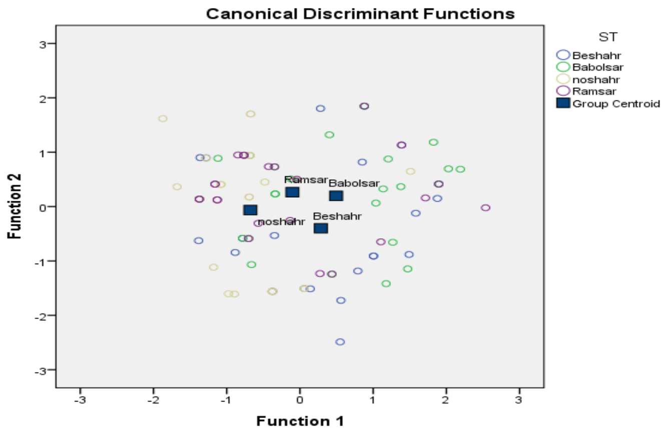

Figure 4. DA Analysis of meiobenthos at different stations in southern Caspian Sea.

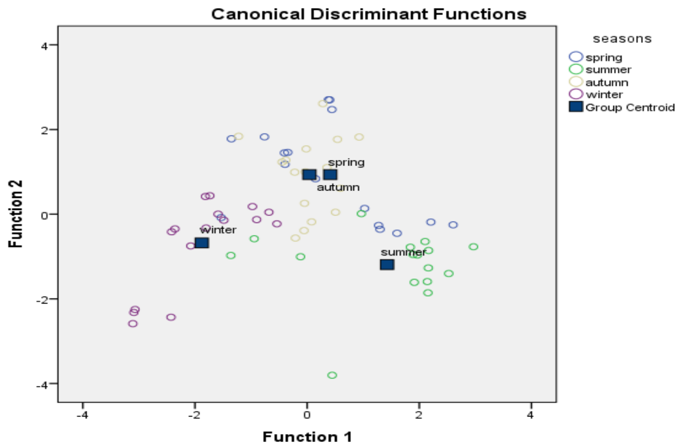

Figure 5. DA Analysis of meiobenthos at different seasons in southern Caspian Sea.

Table 2. Shannon and Peilous indices for meiobenthos animals from different seasons at the southern Caspian Sea from Behshahr to Ramsar.

index	spring	summer	autumn	winter
Shannon	0.5	0.57	0.85	0.9
Peilou's	0.31	0.3	0.4	0.46

Table 3. Shannon and Peilous indices for meiobenthos animals from different depths at the southern Caspian Sea from Behshahr to Ramsar.

Depth(m)	index	
	Shannon	Peilou's
5	0.93	0.52
10	0.82	0.39
20	0.66	0.31
50	0.49	0.39

Table 4. Shannon and Peilous indices for meiobenthos animals from different stations at the southern Caspian Sea from Behshahr to Ramsar.

Depth(m)	index	
	Shannon	Peilou's
Behshahr(A)	0.28	0.13
Babolsar(B)	0.88	0.43
Noshahr (C)	0.78	0.5
Ramsar (D)	0.96	0.55

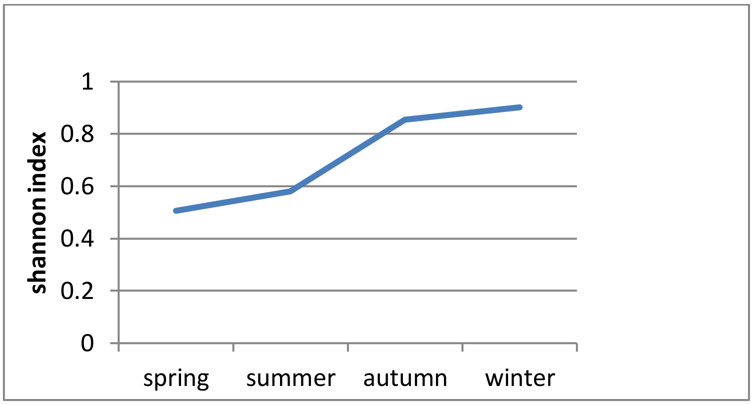

Figure 6. Shannon index for meiobenthos at different seasons (in Mazandran province).

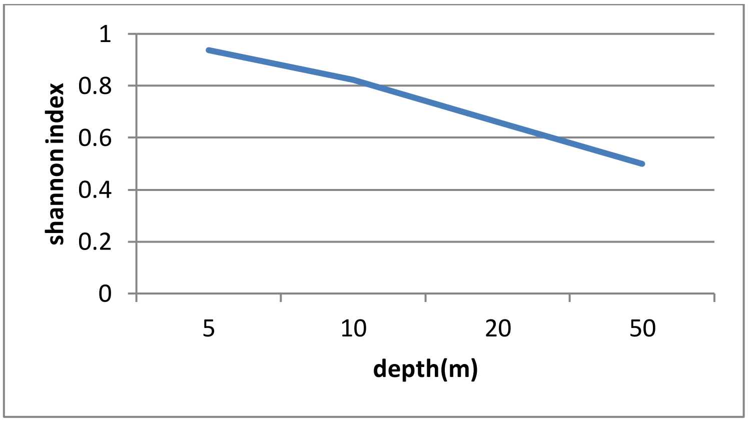

Figure 7. Shannon index for meiobenthos at different depths (in Mazandran province).

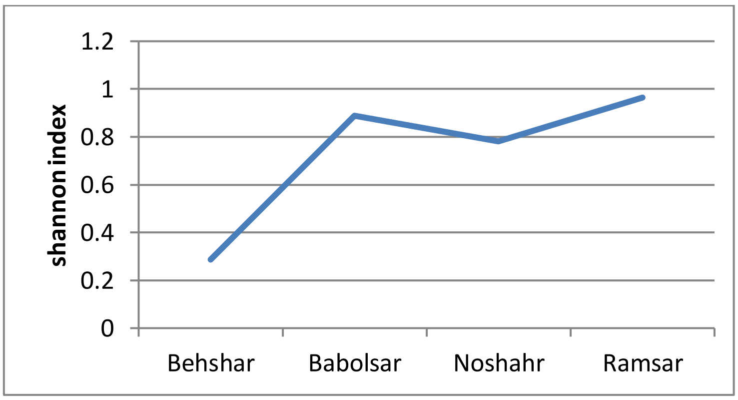

Figure 8. Shannon index for meiobenthos at different stations (in Mazandran province).

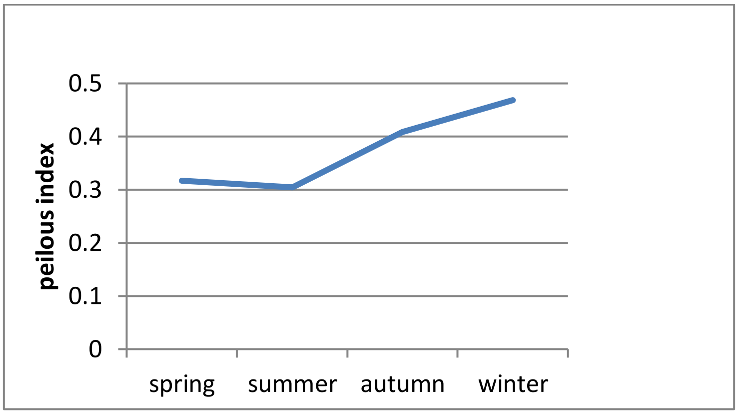

Figure 9. Peilou's index for meiobenthos at different seasons (in Mazandran province).

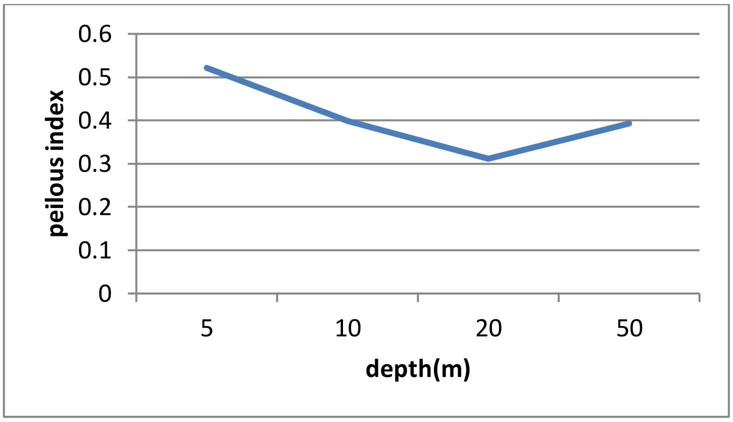

Figure 10. Peilou's index for meiobenthos at different depths (in Mazandran province).

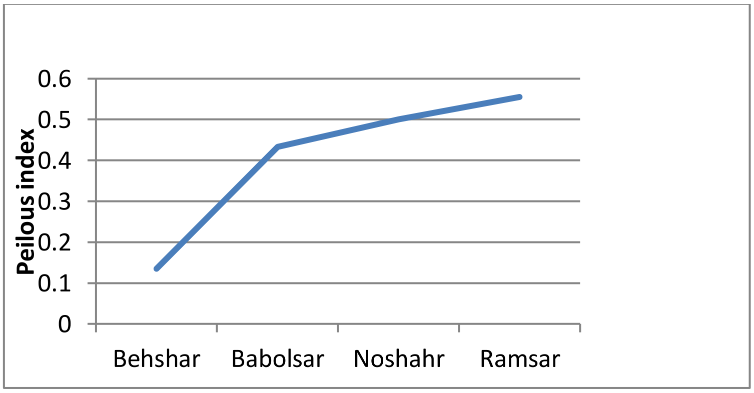

Figure 11. Peilou's index for meiobenthos at different stations (in Mazandran province).

Results

Environmental Factors:

The results of environmental Factors were shown in Tables (5, 6 and 7). The temperature of the water near the bottom was nearly similar at all stations (17.54 to 18.52°C).

The results of measuring dissolved oxygen concentration indicated enough oxygen in water near the bottom and the high average of dissolved oxygen concentration was in Ramsar transect. Salinity was also had low difference between stations (10.94 to 11.28) and increased with depth, pH was nearly equal at all stations (8.28 to 8.43).

The grain size analysis of the sediments showed that the structure of the sediment samples mostly consisted of; sand, silt and clay and seldom gravel. The grain size decreased with water depth. The silt and clay rate increase with depth at all stations (Fig. 12).

Table 5. Mean Temperature, Salinity, DO, pH, Total Organic Matter (TOM) and $CaCO_3$ in different Seasons at the southern Caspian Sea from Behshahr to Ramsar (±SD).

Season	Temperature (C°)	Salinity (ppt)	DO (mg/l)	pH	TOM %	CaCO %$_3$
Spring	20.74 ±0.02	11.01 ±0.01	10.23 ±0.04	8.27 ±0.01	7.00 ±1.00	9.00 ±4.47
Summer	23.93 ±0.008	11.22 ±0.005	8.17 ±0.014	8.56 ±0.005	8.52 ±1.64	9.61 ±3.29
Autumn	17.34 ±0.007	11.14 ±0.01	8.10 ±0.007	8.11 ±0.051	8.08 ±1.03	9.19 ±2.22
Winter	9.52 ±0.009	11.39 ±0.02	10.53 ±0.01	8.41 ±0.01	8.23 ±1.60	9.72 ±3.92

Table 6. Mean Temperature, Salinity, DO, pH, Total Organic Matter (TOM) and CaCO3 in different Seasons at the southern Caspian Sea from Behshahr to Ramsar (±SD).

Depth	Temperature (°C)	Salinity (ppt)	DO (mg/l)	pH	TOM %	$CaCO_3$ %
5	20.83 ±0.011	11.08 ±0.019	8.71 ±0.034	8.28 ±0.016	3.41 ±0.66	3.33 ±0.653
10	20.71 ±0.023	11.2 ±0.008	8.72 ±0.015	8.29 ±0.019	6.43 ±1.14	7.09 ±1.968
20	18.8 ±0.019	11.25 ±0.009	8.6 ±0.03	8.35 ±0.03	7.86 ±0.881	13.4 ±5.873
50	11.27 ±0.013	11.21 ±0.04	9.20 ±0.007	8.48 ±0.01	14.56 ±2.77	12.76 ±4.572

Table 7. Mean Temperature, Salinity, DO, pH, Total Organic Matter (TOM) and CaCO3 in different Depths in the southern Caspian Sea from Behshahr to Ramsar (±SD).

Stations	Temperature (C^{o})	Salinity (ppt)	DO (mg/l)	pH	TOM %	$CaCO_3$ %
A	18.52 ±0.34	10.97 ±0.032	8.69 ±0.036	8.4 ±0.024	10.59 ±1.88	14.73 ±6.26
B	18.18 ±0.011	11.24 ±0.024	8.42 ±0.036	8.3 ±0.033	7.78 ±1.1	7.95 ±2.59
C	17.37 ±0.01	11.28 ±0.014	9.01 ±0.007	8.43 ±0.013	7.04 ±0.95	7.27 ±1.66
D	17.54 ±0.017	11.24 ±0.01	9.1 ±0.006	8.28 ±0.005	6.85 ±1.52	6.63 ±2.544

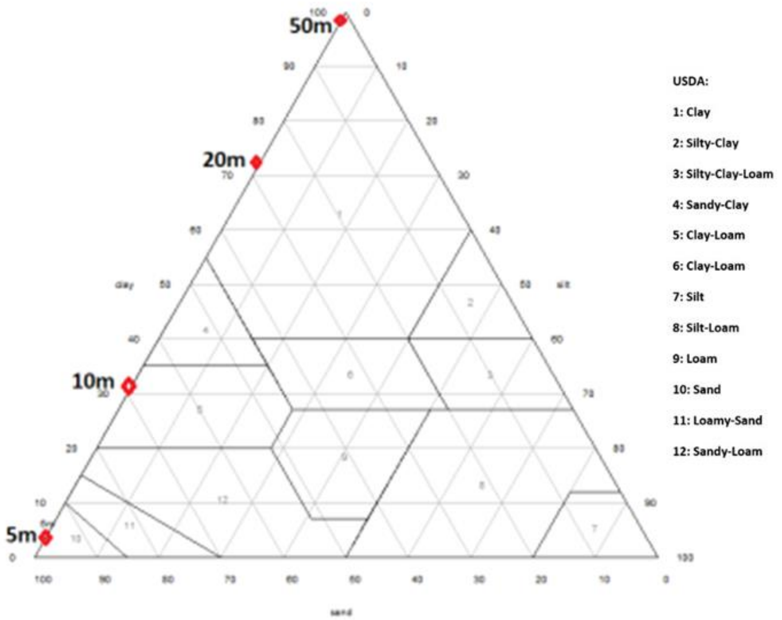

Figure 12. Percentage of gravel, sand, silt and clay in different depths in the southern Caspian Sea from Behshahr to Ramsar.

Meiobenthos Groups:

From the 4 animal groups (Foraminifera, Crustacea, Worms and Mollusca), 40 were recognized of which 38 species belonging to 29 genera of 25 families were identified.

About 34 species were alive (Table 8 and 9) and six species were dead or with empty shells (Table 10). Foraminifera were the dominant group of meiobenthos (70.3 %) (Fig. 13).

Table 8. Species of meiobenthos, identifiedfrom the southern Caspian Sea (Behshahr to Ramsar) at different stations.

Group of Meiobenthos	Species	Stations			
		Behshahr (A)	Babolsar (B)	Noshahr (C)	Ramsar (D)
Foraminifera	*Ammonia beccarii*	*	*	*	*
	Ammonia tepida	*	*	*	*
	Ammonia parkinsoniana	*	*	*	*
	Elphidium littorale	*	*	*	*
	Criboelphidium sp.	*	*	*	*
	Elphidium excavatum	*	*	*	*
	Ammobaculites agglutinans	*		*	*
	Ammotium sp.		*	*	
	Miliammina fusca	*			
	Miliammina sp.	*	*	*	*
	Cornuspira sp.		*		
Crustacea	*Amnicythere longa*		*		
	Amnicythere bacuana	*		*	
	Amnicythere reticulata		*		
	Amnicythere striatocostata	*	*	*	
	Loxoconcha lepida	*	*	*	*
	Loxoconcha rhomboidea		*		*
	Xestoleberis depressa	*	*		*
	Cyprideis littoralis	*	*	*	*
	Darwinula stevensoni	*	*	*	*
	Polyphimidae		*		*
	Copepoda				*
	Mysidae	*	*	*	*
Mollusca	*Didacna protracta*	*	*	*	*
	Hypanis caspia	*	*	*	*
	Abra ovata	*	*	*	*
	Anisus kolesnikovi	*	*	*	
	Abeskunus sphaerion	*	*		*
	Ulskia ulskii	*			
Worms	*Paranais litoralis*	*	*	*	*
	S. gynobranchiata	*	*	*	*
	Nereis diversicolor		*		
	Annulovortex sp.	*	*	*	*
	Nematoda	*	*	*	*
Total		26	29	23	24

Table 9. Species of meiobenthos identified from the southern Caspian Sea (Behshahr to Ramsar) at different seasons.

Species	Spring	Summer	Autumn	Winter
Ammonia beccarii	*	*	*	*
Ammonia tepida	*	*	*	*
Ammonia parkinsoniana	*	*	*	*
Elphidium littorale	*	*	*	*
Criboelphidium sp.	*	*	*	*
Elphidium excavatum		*	*	*
Ammobaculites agglutinans		*	*	
Ammotium sp.		*	*	
Miliammina fusca		*		
Miliammina sp.	*	*	*	*
Cornuspira sp.			*	
Amnicythere longa	*			
Amnicythere bacuana		*		
Amnicythere reticulata	*			
Amnicythere striatocostata	*	*	*	
Loxoconcha lepida			*	*
Loxoconcha rhomboidea	*			
Xestoleberis depressa	*	*		
Cyprideis littoralis	*	*	*	
Darwinula stevensoni	*	*	*	*
Polyphimidae	*			
Copepoda			*	
Mysidae	*	*	*	*
Didacna protracta	*	*	*	
Hypanis caspia	*	*	*	
Abra ovata	*	*	*	
Anisus kolesnikovi	*			
Abeskunus sphaerion	*	*	*	
Ulskia ulskii	*			
Paranais litoralis	*	*		*
S. gynobranchiata	*	*	*	*
Nereis diversicolor				
Turbellaria	*	*		*
Nematoda	*	*	*	*
Total	25	24	22	14

Table 10. Nonliving species of meiobenthos from the southern Caspian Sea(Behshahr to Ramsar).

Group of Meiobenthos	Species
Foraminfera	*Rosalian* sp.
	Sp1. (unidentified)
Crustacea (Ostracoda)	(Cytheroidae) spII
	Leptocythere sp.
Mollusca	*Pyrgula* sp.
	SpIII. (unidentified)

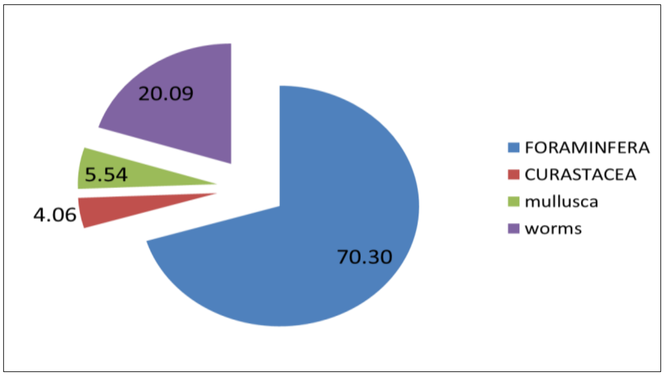

Figure 13. Percentage of meiobenthos groups at the southern Caspian Sea from Behshahr to Ramsar.

Data Analysis:

Among seven parameters evaluated the results of PCA showed that granulometry, TOM % and $CaCO_3$ % had an important role (Table 8 and Fig. 8). The results of Pearson correlation showed that had been negative correlation between density of meiobenthic, TOM and depth. However, according to the results of One Way ANOVA the density of meiobenthos were significantly different with the stations, seasons and depths (Figs. 14, 15 and 16).

Maximum Shannon–Wiener and Peilou's index for meiobenthos were observed in winter. The values of Shannon and Peilous indexes were showed in Tables (2, 3 and 4).

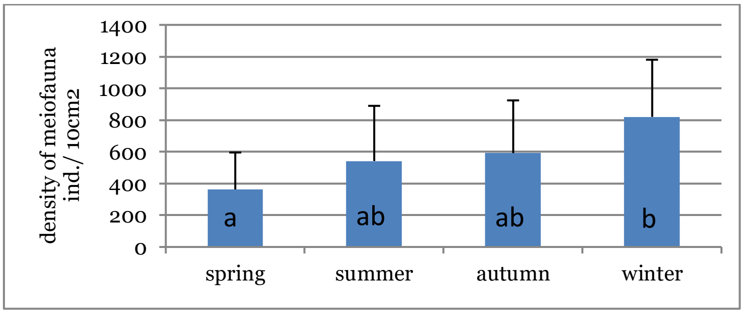

Figure 14. Density of living meiobenthos animals at different seasons (in Mazandran province).

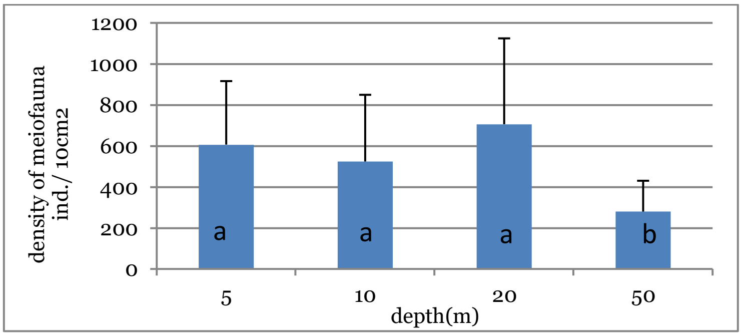

Figure 15. Density of living meiobenthos animals at different depths (in Mazandran province).

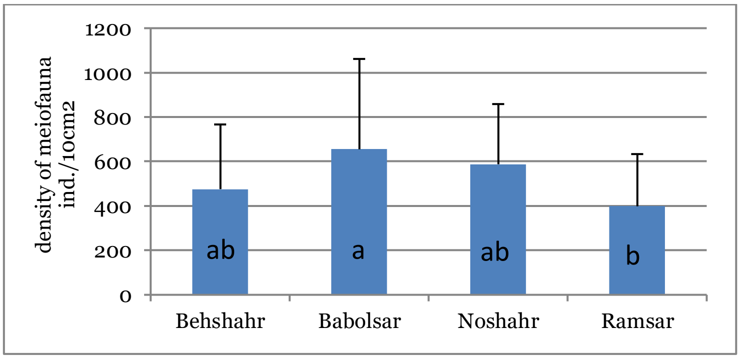

Figure 16. Density of living meiobenthos at different stations (in Mazandran province).

Discussion

The distribution and dynamics of the communities of meiobenthos in the ecosystems are strongly influenced by fluctuations of the physicochemical factors. According to the results of One Way ANOVA the density of meiofauna was significantly different with the stations, seasons and depths. Among seven parameters evaluated, the result of Pearson correlation showed that the density of meiobenthos, TOM and depth were negatively correlated. The present results indicate that all these factors affect the abundance and diversity of meiobenthic organisms in the area of the study (with low density and high diversity) characterized by coarse grain sediments and low TOMs. On the contrary, Ashraf *et al*. (2011) found that meiobenthos community of the Suez Canal and the Mediterranean Sea showed high meiobenthic density and low diversity in fine grain size and high Tom's sediments.

Grain size and the degree of sorting of the sand grains determine the available space for interstitial meiobenthos and thus their abundance. Meiobenthos assemblages are largely determined by spatial gradients in factors such as grain size, depth or organic matter contents; therefore large variations in meiobenthos abundance depending on these factors might be expected (Giere, 2009; Deudero and Vincx, 2000).

The overall higher densities in the Mediterranean are explained by the coarser and more oxygenated sands, higher meiobenthos in coarser sediments has been reported frequently (Giere, 2009). Benthic communities in brackish water have lower densities and fewer species than either pure marine or pure freshwater communities (Gheiskiere *et al.,* 2005).

In the previous study, a highly significant negative correlation was obtained between meiobenthic abundance and salinity. This is different from the trend observed in the Changjiang River (Yangtze River) Estuary (Hua *et al*., 2005) and an offshore area of the Bohai Bay, China (Zhang *et al*., 2009). However, in the present investigation the meiobenthic abundance may not have been significantly related to salinity and salinity gradient was not found. It is known that the smaller the organisms, the more fine environmental heterogeneity they could perceive. Furthermore, the short generation time of small-sized organisms causes high temporal variability of their communities (Burkovsky *et al*., 1994; Azovsky, 2000; 2002; Azovsky *et al.,* 2004).

The result of PCA showed that granulometry, TOM % and $CaCO_3$ % had an important role on the distribution of meiobenthos. And DA showed the depth of 10m is separated from the depth of 50 m. According to granolumetry (Fig. 15) the structure of sediment is different in two depths then density of meiobenthic is different. Stations Babolsar is separated from Noshhar (Fig. 4). Mean grain size did not vary significantly over the seasons. The substrate type was varied among the four depths (Fig. 12). The common substrate type consisted of coarse sand, find sand, silt and clay. The highest number of individuals and diversity was observed in depth of 5m; where substrate structure consisted of fine sand.

Therefore, it can be assumed that substrate is one of the major factors that influenced the distribution of meiobenthos. The result of PCA showed that granulometry had an important role (Table 3 and Fig. 2). The benthic communities at the study site exhibited a marked seasonal variability with maximum density and diversity were observed in winter (Table 8 and 9). We observed highest Shannon-Wiener index and high Pielou index in winter. Then Shannon-Wiener index was high despite that we had maximum richness in spring (Table 2).

In a previous study the meiobenthos, both the number of taxa and abundances were significantly higher during the winter and autumn (Meurer and Netto, 2007). The results obtained by Meurer and Netto (2007) in shallow sub-littoral Laguna estuarine (South Brazil) showed an increase of reproductive activities of macrobenthic species during spring and summer, as indicated by the highest densities of temporary meiobenthos, coincided with the lower peak of the meiobenthos densities. Moreover, the highest peak of the meiobenthos, during autumn and winter months, corresponded with the decrease of the macrobenthicrecruits. Indeed, Danovaro*et al*. (1995) showed that selective predation operated by meiobenthos on the dominant polychaete families of the temporary meiobenthosmay structure macrofaunal communities both altering density and acting selectively on a few families of macrobenthos juveniles.

Like the meiobenthos, the higher species richness and diversity of both adult and juvenils zooplankton recorded during the rainy than the dry season which are may be due to the influx of all ochtonous nutrients, reproductive and breeding activities of most aquatic animals are taking place mostly in the rainy season. Lower abundance and diversity of the planktonic juvenile stages in contrast to those of the adult zooplankton are a manifestation of predator-prey relationship.

The adult zooplankton constitutes a major group of food organisms for the juvenile stages of higher animals in the aquatic environment. The higher abundance and diversity levels recorded for adult zooplankton than the planktonic juvenile animals are therefore expected (Yakub *et al.,* 2012).

The results of experimental studies that have considered the overall effects of macrobenthos originating from processes such as predation, bioturbation and competition for food also indicate effects on meiobenthos (Ólafsson, 2003). The results of Zarghami *et al.* (2018), showed that the divergent seasonal variations of the meiofauna and macrofauna may be linked to their different life strategies, and that possible biological interactions between meiofauna and macrofauna may also play a significant role in structuring these associations.

In the present study the maximum density of meiobenthos, was observed in depth of 20m. These fluctuation in the meiobenthos were, to a large extent, be affected by variation in density of Foraminifera, which constituted more than 70% of the total meiobenthic (Fig. 13). Foraminifera was the only group present in every core sample and dominated the fauna. The cosmopolitan Foraminifera *Ammonia beccarii caspica* was the dominant species at all sampling stations and was observed at all seasons. This species was reported in earlier work in the Caspian Sea (Birshtain *et al.*, 1968). *Ammonia beccarii* is a common cosmopolitan species dwelling in littoral and neritic environments. It has been extensively studied in various aspects, such as, geographic distribution, ecology, biology, life-cycles, morphology, structure, and environmental applications from all over the world (Debenay *et al.*, 2009; Sadoogh, 2013; Zarghami *et al.*, 2014 a, b and Zarghami *et al.,* 2018). Results of previous study showed on very dynamic sandy shores, wave's and tidal currents can suspend fractions of sediment and, therefore, disturb the infauna (Murray *et al.*, 2002). Moreover, small animals which dwell in the upper few centimeters of sediment may be more affected by water movement (Negrello *et al.*, 2006). The present results indicate that following Foraminifera, the worms had the maximum density in the present region. The maximum density of nematode was 92.14% of the total worms. Highest density of nematode was observed in autumn. Nematodes usually dominate all marine meiobenthos samples in abundance and biomass occurring in each substrate and sediment in all climatic zones, where they are of considerable ecological importance (Ashraf *et al.,* 2011). Regarding abundance, nematodes showed the highest densities at '5m', where the hydrodynamic conditions are expected to be more stressful. In fact, nematodes are more tolerant to stressful conditions than most other groups (Deudero and Vincx, 2000). TOM values increased with depth. Then higher abundances at '5m' could be due to pollution events, since it is known that nematodes have a higher persistence in gradients with increasing pollution (Raffaeli and Manson, 1981).

Our results showed that the seasonal variability was highest for the univariate indices such as the Shannon–Wiener and Pielou index. These indices decreased with increasing depth and showed maximum in winter (Figs. 6, 7, 8, 9, 10 and 11). Thus in the Mediterranean protected area, Burullus Lake in Egypt exhibited maximum diversity at a depth of 5m (Mitwally and Abada, 2008) and the results showed that the diversity of meiobenthos was negatively related to grain size. This is in accordance with the present result that the lowest diversity was associated with finer grain size. We observed highest Shannon-Wiener index and a high Pielous index in Ramsar. Thus Shannon-Wiener index was high in Ramsar station despite we had maximum richness in Babolsar station.

Even though water depth has been proposed as an environmental factor that modifies meiobenthos assemblages (Deudero and Vincx, 2000), as well as grain size (Coull and Bell, 1979), there is a lack of knowledge on the relationship between these two factors. Water depth affects hydrodynamism, the deeper the profundity is, the lesser is the hydrodynamism at the bottom and therefore smaller grain size scan be found. This fact, translates into higher sedimentation and organic accumulation rates (Parenzan, 1979; Guerra-Garcíaand García-Gómez, 2005). The results of Cabria *et al.* (2015), in the sandy beaches of the western Mediterranean, showed that the combinations of environmental factors that best explain the observed meiobenthos distribution have similar correlation values in both BIO-ENV analyses.

The present results showed that depth was the main factor influencing meiobenthic assemblages in this region of the Caspian Sea. Additionally, we provide quantitative and qualitative data for future assessment of shallow communities of meiobenthos under natural or human-induced perturbations. Accordingly, our results report that maximum density and diversity of meiobenthos were observed in winter. However, several factors affect meiobenthos distribution, life strategies, competition for food sources, predatory pressure and disturbances may have different importance. Moreover, if the behavior of each component of the benthos and the interactions between them are to be understood, simultaneous observations on the different components of the benthic community should be done.

Conclusion

In summary exploring the biodiversity and distribution of meiobenthos in the sediments of the Southern Caspian Sea (Mazandaran) showed that the Foraminifera, Crustacea, Worms and Mollusca were dominant. The First major finding was that, there were 40 species (belonging to 29 genera of 25 families) were identified. Pearson correlation revealed a negative correlations between density of meiobenthos, TOM and depth. The second major finding was that the density of meiobenthos was significantly different at each station, season and depth. Shannon diversity index decreased with depth. In shallow waters, diversity was higher than in deeper water. Mean of maximum and minimum Shannon index was observed at depth of 5m and 50m (0.93 and 0.43). Account of Shannon index showed that this area is under pressure. Account of Peilou index showed that the distribution in this area was not steady. Further similar investigation into other parts of the Southern Caspian Sea coastline is strongly recommended.

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توزيع وتنوع Meiobenthos في جنوب بحر قزوين (مازندران- ايران)

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المستخلص - درس التوزيع والتنوع للأحياء القاعية meibenthos في رواسب جنوب بحر قزوين وحددت علاقتها بالعوامل البيئية. جمعت عينات الرواسب فصلياً من 12 محطة (تتراوح أعماقها ما بين 5 و 10 و 20 و 50 م) خلال عام 2012. قيست درجة الحرارة والملوحة والأوكسجين الذائب والأس الهيدروجيني أثناء جمع العينات وبجهاز CTD (التوصيلية، درجة الحرارة والعمق)، فضلاً عن قياس حجم الدقائق والمادة العضوية الكلية وكربونات الكالسيوم. تراوحت درجة حرارة الماء (9.52-23.93°م)، الأوكسجين المذاب (7.71-10.53 ملغم/لتر)، الملوحة (10.57±0.07-10.75±0.04 جزء بالألف)، الأس الهيدروجيني (7.44±0.29-7.41±0.22)، التوصيلية (17.97± 0.12-18.30±0.04 µs/cm²)، المواد الذائبة الكلية (8.92±0.04-9.14±0.02 ملغم/لتر)، المواد العضوية الكلية (5.83±1.43-6.25±0.97 %) وكربونات الكالسيوم (2.36±0.36-1.68±0.19 %). تم التعرف على 40 نوعاً ينتمون إلى 29 جنساً من 25 عائلة من المجموعات الحيوانية الأربعة : Foraminifera و Crustacea و Worms و Mollusca، وقد شوهد Ammonia beccariicaspica من الأنواع الشائعة في جميع المحطات. اعتبر العمق عاملاً مهمًا في توزيع Meibenthos. قيس الحد الأعلى والأدنى لمؤشر شانون بعمق (5 و 50 متر)، فقد تراوح بين (0.93 و 0.43). كما أظهر مؤشر شانون وبيوليو بأن هذه المنطقة ليست ثابتة.

الكلمة المفتاحية: التنوع الاحيائي، الاحياء القاعية، Meibenthos، بحر قزوين، العوامل البيئية.