Article

Effect of urban pollutants on distribution of meiofauna worms in the southern cities of Caspian Sea

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Abstract
The Caspian Sea is a large lake renowned for its diverse aquatic fauna. This study investigates recent meiofauna worms from sediment samples collected during spring, summer, autumn and winter 2012 from 12 stations (ranging in depths 5, 10, 20 and 50 meters) in the Southern Caspian Sea from Bandar Amirabad to Ramsar. The benthic environmental factors including temperature, dissolved oxygen, salinity and pH were measured by CTD during the sampling time. Associated factors includes: grain size, Total phosphate, Total nitrate, total organic matter and calcium carbonate concentration were also measured. In this research three classes of worms (Nematodes, Annelida and Platyhelminthes) were identified. The result of One Way ANOVA showed that density of Worms has been different significant with depth and stations ($P<0.05$). Result of Pearson correlation showed that between density of worms and %Silt and Clay, %TOM, depth and $\%CaCO_3$ had been negative correlation. The highest density being observed in autumn, most density of worms was observed in Babolsarstations (B1) (759.78 ind/0.1m^2). That showed a good situation for living there. Urbanization had important role in this area that increased abundance of meiofauna tolerance worms.

Keywords worms; Caspian Sea; environmental factors; Meiofauna.

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1 Introduction

Humans have always relied on the oceans and their resources, first as a food source (fishing), later for transportation of raw materials. Today, our oceans are also exploited for mineral, gas, oil, and other natural resources of great economic importance. It is noticeable that 50% of the world population lives in coastal areas or nearby regions (Sherbinin et al., 2007). Such a high population density along the coastal areas results in high environmental stress due to the multiple activities that take place there (Agardy et al., 2005).

Understanding the relationship between sediment community structure and seafloor ecological processes remains a central area of focus in current marine ecology and the growing concern of marine biodiversity loss has provided an extra impetus for experimental work aimed at ascertaining the ecological role of different benthic compartments in basic ecosystem functioning (Austen et al., 2006; Raffaelli et al., 2003; Solan et al., 2006). Seafloor ecosystem functioning can be defined as the ecological processes (such as nutrient or elemental cycling) or the flow of energy and material through the biotic and abiotic components of benthic ecosystems (Bremner et al., 2006).

Soft bottom benthic communities are key components in the functioning of coastal and marine ecosystems (Lu, 2005). These bring about considerable changes in physical and chemical composition of sediments, especially in the water-sediment interface (Gaudencio and Cabral, 2007; Shou et al., 2009). In coastal environments, the contents of contaminants and organic matter in sediment, which might be capable of damaging biota, are mainly ascribed to human activities. The discharge of municipal and agriculture effluents, for instance, may result in functional changes of coastal environments due to the entry of excessive nutrients that might stimulate the primary production and influencing food chain (Voss et al., 2011). However, when these inputs exceed the limit of the environmental consumption capacity, a bloom of phytoplankton might occur and lead to dissolved oxygen (DO) depletion and an alteration of the ecosystems structure (Diaz, 2001). Rivers, estuaries, and marine waters have mainly served for final repositories of anthropic waste both organic and inorganic (Islam and Tanaka, 2004) and where the sediment represents the final sink (Goher et al., 2014).

Thereof in coastal environments, the contents of contaminants and organic matter in sediment, which might be capable of damaging biota, are mainly ascribed to human activities (Karlson et al., 2007; Diaz and Rosenberg, 2008). Rivers, estuaries, and marine waters have mainly served for final repositories of anthropic waste both organic and inorganic and where the sediment represents the final sink (Goher et al., 2014). Sediment parameters like grain size, organic content and food availability are among the important factors affecting benthic community structure (Kari, 2002). Communities of meiofauna, as a rule, remained outside of the zone of attention though meiofauna is an important component of the marine ecosystems (Pavlyuk and Trebukhova, 2005). Polychaetes are also being used for biomonitoring program as organic pollution indicators to check the health of the marine environment (Jayaraj et al., 2007).

The Caspian is a non-tidal sea and is landlocked, the bulk of the discharged contaminants remain trapped within its basin. Sea currents transport and circulate the entrapped pollutants along the Iranian coast of the Caspian Sea. A large percentage of the more than 10 million people who reside in the Iranian coastal provinces bordering the Caspian Sea are therefore exposed to high concentrations of toxic contaminants. For instance, coastal residents regularly eat sturgeon and other fish from the Sea. The pollutants accumulating in the fish, especially the sturgeon is transferred to the human food chain. Questions have been raised as to whether the higher rates of cancer recorded in the study area could be associated with fish consumption (Agusa et al., 2004). The enclosed Caspian Sea is the world’s largest brackish water body, comprising nearly 40% of the earth’s continental surface water. One of the remarkable aspects of its fauna is the high level of endemism (Dumont, 2000).

The present study was conducted to determine the diversity and distribution of the soft bottom meiofauna worms along the south coast of Caspian Sea because meiofauna is poorly studied in Caspian Sea. Sediment characteristics were evaluated to understand their influence on worms and we used meiofauna worms for biomonitoring effect of urbanization in research area.

2 Study area and Methodology

2.1 Study site

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

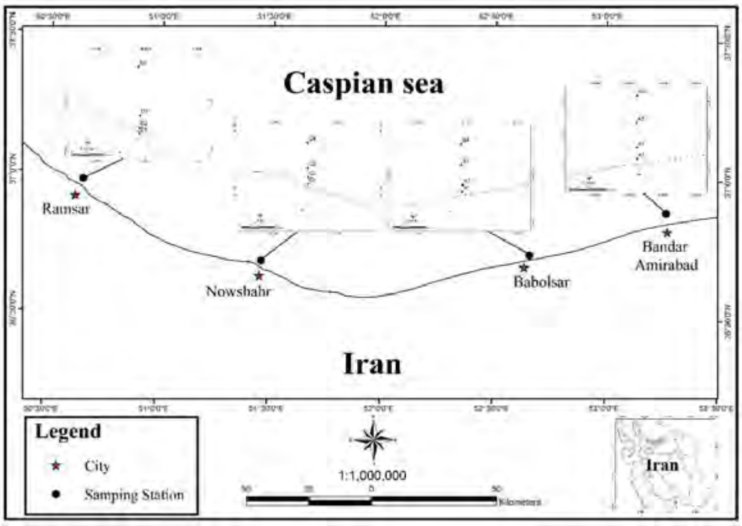

Fig. 1 Situation of sampling stations in the southern Caspian Sea.

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"

2.2 Data collection

2.2.1 Samples

Samples were collected by boat and 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 volume) was 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, Zarghami et al., 2018).

Water samples were collected to measure total phosphate and total nitrate. Samples were taken from near-bottom of the stations using a Niskin sampler. After filtering in the field, the water samples were kept in a cool place over ice until to analysis in laboratory (APHA, 2005).

2.2.2 Environmental Factors

The benthic environmental factors including temperature, dissolved oxygen, salinity and pH were measured by CTD 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 sediment (70°C, 8 h) was mixed with 250 ml of tap water and 10 ml of sodium hexametaphosphate (6.2 g/L) to disaggregate the sediment. The sediment was then stirred mechanically (15 min), allowed to soak (8 h), stirred mechanically (15 min) and dried again (70°C, 24 h). Fifty grams of dried material was 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 was removed and weighed. Finally, the percentage of each particle was calculated (Moghaddasi et al., 2009; MOOPAM, 2010).

TOM in each sample was 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 h). After removal from the oven, the sample was allowed to cool and was reweighed (A). It was then placed in a Muffle furnace (550°C – 8 h), removed, cooled and reweighed again (B). The TOM content was determined by the loss of weight on ignition at this temperature: %TOM =100(A-B) / (A-C) (Moghaddasi et al., 2009; MOOPAM, 2010)

Calcium carbonate concentration was measured based on the reaction with dilute Hydrochloric Acid (HCl). Twenty-five grams (W1) of dried sediment (7 – 8 h.) was 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 h) and reweighed again (W2).Calciumcarbonate percentage was measured by the following formula: %CaCO3= 100 (W1-W2) / W1 (Moghaddasi et al., 2009).

Total nitrogen (TN) was measured colorimetrically after oxidation with peroxodisulfate and reduction in a Cu-Cd column. Total phosphorus (TP) was determined by the molybdenum blue method after digestion with peroxodisulfade according with the APHA-standard methods digestion of samples for the determination of total nitrogen (TN, µg/l) and phosphorus (TP, µg/l) were done by the per-sulphate digestion procedure (APHA, 2005).

2.3 Data analysis

PCA was used to investigate the relationship between nine variables collected during seasonal sampling cruises in 2012 (temperature, pH, dissolved oxygen, salinity, %TOM, %$CaCO_3$, TN, TP and granulometry). One Way ANOVA was performed to test possible differences. Shannon-Wiener (H) diversity index and Peilou's Evenness Index have measured assaying species diversity and ecological assessment in this area (Marques et al., 2009).

3 Results and Discussion

3.1 Environmental factors

The temperature of the water near the bottom was nearly similar in all stations that related to a system of horizontal and vertical movements of water mass in the Caspian Sea, as well as in any other water body. The results indicated that enough oxygen presented in water near the bottom that good intermixing of water is observed in this lake, causes the bottom waters to be rich in oxygen (Aladin and Plotnikov, 2004). According to Jamshidi et al. (2009) in southern Caspian Sea, DO concentrations through the vertical and horizontal directions were not homogenously varied in this study. Our result confirmed previous study and showed that the Concentrations of DO were found to range between 8.1 and 10.5 mg/l (Table 2, 3, 4).

According to results pH was nearly equal in all stations. In summer, when the surface water temperature was highest and the strongest seasonal thermo cline existed, the maximum value for pH was observed. In this season, pH had a value of 8.43 in bottom. The results of Hajizadeh and Araghi (2009), showed that seasonal variations of pH in the southern Caspian Shelf and the coastal waters adjacent to Iran is a function of seasonal variations in water temperature, characteristics of thermo cline, local rivers chemical characteristics and discharges, and production or degradation processes.

The result of TP and TN in this study was showed in Tables 2, 3 and 4 that maximum amount of TP and TN were observed Ramsar (65.7 and 438.2 µg/l) and minimum amount of them were observed in Noshahr (54.5 and 373.1 µg/l). According results of TP and TN Behshahr and Ramsar were polluted that cause of Amir Abad port in Behshar (A) and tourism area in Ramsar (D).

The grain size analysis (Fig. 2) of the sediments showed that the structure of the sediment samples mostly consisted of sand; silt and clay that are probably related to nonexistence of rivers follows, which causes reduced the coarse grain-size in this confined. The grain size decreased with water depth, according to Duros et al. (2012), a slight decrease of grain size observed with water depth in the Whittard Canyon area (NE Atlantic

Total Organic Matter (TOM) was higher in station in stations D4 in spring Tables 2, 3 and 4 that is related to increasing silt-clay rate, because according to Moghaddasi et al. (2009), Sadough et al. (2013) and Zarghami et al. (2018), organic compounds increased in silt-clay sediments. The result of Pearson correlation showed the significantly positive correlation between depth and TOM (at $P<0.05$).

3.2 Data analysis

According PCA results, pH, DO and salinity had been important role (Table 12, Fig. 3). The result of One Way ANOVA showed that density of worms has been different significant with depth and stations ($P<0.05$). Result of Pearson correlation showed that between density of worms with %Silt and Clay, %TOM, depth and %$CaCO_3$ had been negative correlation. The result of Shannon and Peilou index was showed Table 5, 6 and 7. According the amount of this indices biodiversity was not high in this area and this area had not been good ecological situation. Highest and least of biodiversity indices was observed in order in Ramsar and Behshahr stations. That showed Ramsar had a good situation and as we expected Bandar Amirabad station for Amir Abad port had been worst situation.

3.3 Worms's identification

During the study in spring, summer, autumn and winter 2012 in Mazandaran province, from Behshar to Ramsar along the southern coast of the Caspian Sea research three classes of worms (Nematodes, Annelida and Platyhelminthes) were identified. In this 3 species, one genus and one family of meiofauna worms were found. Form Annelida two group was identified (polychaetea and oligochaeta) that polychaeta composed of (*Streblospio gynobranchiata* and *Nereis diversicolor*) and oligochaeta (*Paranais litoralis*), one genus of Platyhelminthes (*Annulovortex* sp.) and one family of nematodes (Monhysteridae) was identified. Maximum density of worms observed in spring at B1 (759.78 ind/0.1m^2) (Tables 8-11).

The present study indicates maximum density of nematode (92.14%) of total worms. The highest density of nematode was observed in autumn in A1 (583.8 individual/0.1m^2) (Tables 5, 6, 7 and 8). That result of Ashraf et al. (2011) confirmed it and showed that Nematodes usually dominate all marine meiofaunal samples in abundance and biomass occurring in each substrate and sediment in all climatic zones, where they are of considerable ecological importance.

According to the result most density of nematodes was observed in autumn and absolved significant difference between autumn in compare with other seasons (Fig. 5). In previous study at tropical and subtropical areas, nematodes show seasonal shifts that are mainly related to food availability. High densities of nematodes from northern and southern temperate sandy beaches occur during spring, summer and autumn because abundant food sources are provided due to the increase in primary production during spring and summer that persists into autumn (Hourston et al., 2005; Nicholas, 2001).

The main purpose of the study was that we can assay ecological situation according distribution of meiofauna worms. In our other study in effect of urban pollutants on distribution of benthic foraminifera in the southern of Caspian Sea the most density was observed in Babolsar station (Zarghami et al., 2019). In previous study on meiofauna (especially oligochaetes, rotifers, and some nematodes) are quite robust and can thrive in organically polluted environments (Traunspurger and Majidi, 2017). Although meiofauna appears to be very tolerant to extreme conditions, nematodes, which are the most abundant metazoans in deep-sea environments, are the most tolerant group to low oxygen, being able to penetrate deeper into hypoxic, sulphidic sediments than other meiofauna organisms (Ott et al., 2004; Vanreusel et al., 2010). Hodda and Nicholas (1985) observed that meiofaunal density decreased with increasing pollution. Our result confirmed all of previous study and showed despite this area had not been good ecological condition according biodiversity indices but we observed highest density of nematodes.

Sediment sorting is a principal factor determining meiofauna distribution (Urban-Malinga et al., 2004). In the previous study, the high variability of nematodes found in fine sediments percentage among seasons is an evidence of the extreme instability of this area. A predominance of fine sand, a higher level of organic matter, higher mean levels of oxygen and pH, and total transparency, associated with shallow water (Kapusta et al., 2006). Our results showed the highest density of worms in shallow waters because of structures of sediment and other environmental factors.

In the current study, total organic matter (TOMs) was found to play an important role in meiofaunal distribution of the investigated sites. In present study exhibited high density of nematodes and relatively low TOMs. That showed TOMs has negative effect on distribution of them because increasing of TOMs leads to bad situation for them. As Ashraf et al. (2011) mentioned the inverse relationship between TOMs content and meiofaunal densities indicated that either meiofauna are not food limiting, or TOMs does not measure food quality, or other factors might regulate density.

The obtained results indicate that all these factors affect the abundance and diversity of meiobenthic organisms in the area of study (with low density and high diversity) characterized by coarse grain sediment and low TOMs. On the contrary, themeiobenthic community found of the Suez Canal and the Mediterranean Sea showed high meiofaunal density and low diversity in fine grain size and high TOMs sediments (Ashraf et al., 2011; Mohammed, 2010).

After nematodeas, polychatea had been dominant in this area (6.27%). Taheri et al. (2005) reported that in golf of Gorgan in depth of 1, 2 and 3 m streblospiogynobranchiata increase with depth but in our result we did not observe correlation with this specimen density and depth and with adding depth TOM is adding last studied showed. The density of polychaetes was generally less at high organic carbon area except few species providing a possible indication that, high organic content adversely affect the polychaete abundance and distribution. In this research the maximum density of polychatea observed in summer because reproductive this species is high in summer and then we observed juveniles. In the autumn we observed low density because in this season the reproductive is finished and the adults are there. And another reason is grazing factor that this factor has important role in density of benthic organisms.

In the present study maximum density of worms was observed in spring at Babolsar (759.78 ind/0.1m^2). Salinity, TOM and $CaCO_3$ was at its lowest level in this season. Total mean of density showed maximum density in autumn (Fig. 5) that showed significant difference with other seasons. Since the dominant group of meiofauna worms was nematodes in this study, total mean increased in autumn. Highest density of worms were observed at Babolsar but there was no significance difference between stations (Fig. 6) and according to the previous study were stated that nematodes are known to be relatively resistant to many types of pollutants and the highest species number of nematodes even within small samples renders them good indicators for disturbance and pollution induced change. In this research A (Bandar Amirabad) station was Amirabad port and that we expect nematodes density was highest in this area. According previous studies (Mohammadizadeh, 2013) on south of Caspian Sea (Maznadarn) the highest concentrations of PAH were present in sediments collected from Amirabad-Bandar Amirabad and were a consequence of oil products transportation in this port. Bandar Amirabad region receives input primarily from oil activity; therefore, it can be inferred that the main source of PAH could be petrogenic. As we expected meiofauna worms are important bio indicator for showed environmental situation and environmental factors has important role on distribution of them. Urbanization also increased the frequency of stress-resistant taxa (Carboni et al., 2009). In our study we observed this and the highest density of worms were observed in sites with highest tourism and urbanization activities. Biodiversity and distribution of animals were affected by increasing of population due to increasing pollutants and sinking of these pollutants in the sea, therefore only resistant species remain that interrupting ecological conditions.

Table 2 The mean of temperature, salinity, DO, pH, Total Organic Matter (TOM), $CaCO_3$, TP and TN in different seasons in the southern Caspian Sea from Behshahr to Ramsar (±SD).

Factors / Season	Temperature(C0)	Salinity(ppt)	DO(mg/l)	pH	%TOM	%Caco3	TP(µg/l)	TN(µg/l)
spring	20.74±0.02^b	11.01±0.01^a	10.23±0.04^b	8.27±0.01bc	7±1^a	9±4.47a	54.9±5.52^a	391.7±48.39^a
summer	23.93±0.008^b	11.22±0.005^b	8.17±0.014^a	8.56±0.005^c	8.52±1.64^a	9.61±3.29^a	65.9±2.54^b	413.6±42.82^b
autumn	17.34±0.007^a	11.14±0.01^b	8.1±0.007^b	8.11±0.051^b	8.08±1.03^a	9.19±2.22^a	53.3±4.67^a	344.3±57.76^a
winter	9.52±0.009^c	11.39±0.02^a	10.53±0.01^b	8.41±0.01^a	8.23±1.6^a	9.72±3.92^a	70.2±1.59^b	496.6±31.21^c

Table 3 The mean of temperature, salinity, DO, pH, Total Organic Matter (TOM), $CaCO_3$, TP and TN at different depths of the southern Caspian Sea (±SD).

Factors / Depth	Temperature(C0)	Salinity(ppt)	DO(mg/l)	pH	%TOM	%Caco3	TP(µg/l)	TN(µg/l)
5	20.83±0.011^a	11.08±0.019^a	8.71±0.034^a	8.28±0.016^a	3.41±0.66^a	3.33±0.653^a	61.5±7.04^a	382.48±59.47^a
10	20.71±0.023^a	11.2±0.008^b	8.72±0.015^a	8.29±0.019^a	6.43±1.14^b	7.09±1.968^b	64.9±6.29^a	425.24±48.02^a
20	18.8±0.019^a	11.25±0.009^b	8.6±0.03^a	8.35±0.03^a	7.86±0.881^b	13.4±5.873^c	58.4±12.36^a	418±39.26^a
50	11.27±0.013^b	11.21±0.04^b	9.20±0.007^b	8.48±0.01^a	14.56±2.77^c	12.76±4.572^c	62.7±8.87^a	388.83±110.5^a

Table 4 The mean of temperature, salinity, DO, pH, Total Organic Matter (TOM), $CaCO_3$, TP and TN in different stations in the southern Caspian Sea from Bandar Amirabad to Ramsar (±SD).

Factors / Stations	Temperature (C0)	Salinity (ppt)	DO(mg/l)	pH	%TOM	%Caco3	TP(µg/l)	TN(µg/l)
A	18.52±0.34[a]	10.97±0.032[a]	8.69±0.036[a]	8.4±0.024[a]	10.59±1.88[a]	14.73±6.26[a]	63.45±3.33[ab]	419.7±42.95[a]
B	18.18±0.011[a]	11.24±0.024[a]	8.42±0.036[a]	8.3±0.033[a]	7.78±1.1[b]	7.95±2.59[b]	60.71±3.34[ab]	388.2±46.82[ab]
C	17.37±0.01[a]	11.28±0.014[b]	9.01±0.007[a]	8.43±0.013[b]	7.04±0.95[b]	7.27±1.66[b]	54.56±4.23[b]	373.17±50.96[b]
D	17.54±0.017[a]	11.24±0.01[a]	9.1±0.006[a]	8.28±0.005[a]	6.85±1.52[b]	6.63±2.544[b]	65.76±3.43[a]	438.2±39.45[a]

Table 5 Shannon and Peilou index for worms in different seasons in the southern Caspian Sea from Bandar Amirabad to Ramsar.

Season / Index	Spring	Summer	Autumn	Winter
Shannon	0.5	0.57	0.85	0.9
Peilou	0.31	0.3	0.4	0.46

Table 6 Shannon and Peilou index for worms at different depths in the southern Caspian Sea from Bandar Amirabad to Ramsar.

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

Table 7 Shannon and Peilou index for worms in different stations in the southern Caspian Sea from Bandar Amirabad to Ramsar

index / Depth(m)	Shannon (meiofauna)	Peilou (meiofauna)
Bandar Amirabad(A)	0.28	0.13
Babolsar(B)	0.88	0.43
Noshahr (C)	0.78	0.5
Ramsar (D)	0.96	0.55

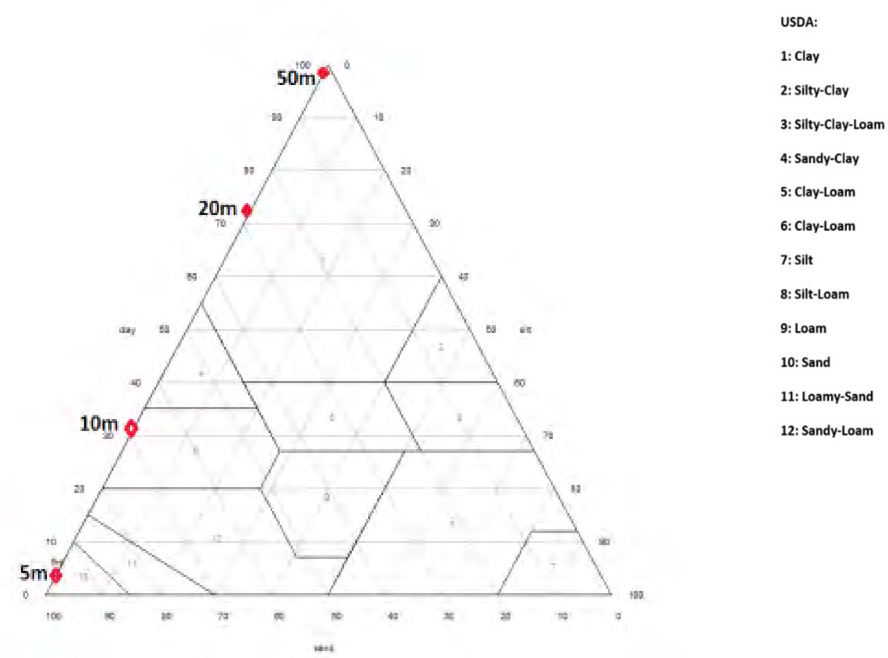

Fig. 2 Percentage of grovel, sand and silt and clay at different depth in the southern Caspian Sea from Bandar Amirabd to Ramsar.

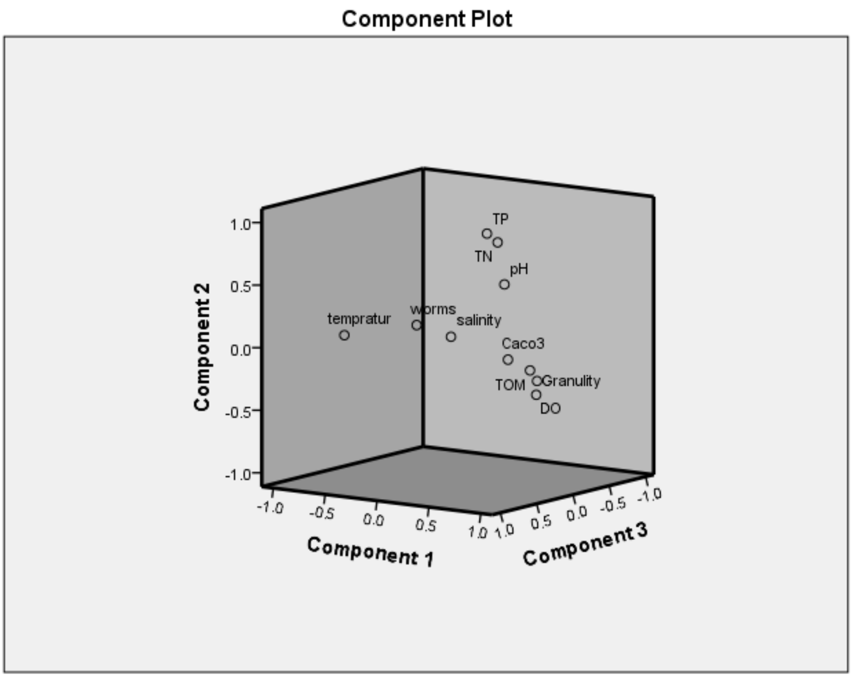

Fig. 3 PCA of environmental factors in southern Caspian Sea in the sampling period.

Table 8 Density of worms (individual /0.1m^2) of southern Caspian Sea (Mazndaran) (Spring, 2012) (±SD).

STATIONS / WORMS	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4	mean
Paranaislitoralis	2.79 ± 4.32	0	0	0	0	5.58 ± 8.65	2.79 ± 4.32	0	0	0	0	0	5.58 ± 8.65	0	0	0	**1.04**
Streblospiogynobranchiata	2.79 ± 4.32	2.79 ± 4.32	0	0	0	5.58 ± 8.65	5.58 ± 4.32	0	0	0	0	0	8.38 ± 12.98	0	0	0	**1.57**
Nereisdiversicolor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Annulovortexsp.	0	2.79 ± 4.32	0	0	0	11.17 ± 11.44	0	0	0	0	0	0	0	0	0	0	**0.87**
Nematoda	114.52 ± 60.58	53.07 ± 41.28	0	5.58 ± 8.65	759.78 ± 400.65	139.66 ± 178.84	55.86 ± 43.91	8.38 ± 12.98	0	0	0	108.94 ± 123.38	0	86.59 ± 67.59	2.79 ± 4.32	0	**76.81**
Total	120.11	58.66	0	5.58	759.78	162.01	64.24	8.38	0	0	0	108.94	13.96	86.65	2.79	0	**115.92**

Table 9 Density of worms (individual/0.1m^2) of southern Caspian Sea (Mazndaran) (Summer, 2012) (±SD).

STATION / WORMS	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4	mean
Paranaislitoralis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.58 ± 8.65	0	**0.34**
Streblospiogynobranchiata	36.31 ± 28.37	16.76 ± 14.99	2.79 ± 4.32	11.17 ± 11.44	0	8.38 ± 7.49	0	2.79 ± 4.32	0	36.31 ± 31.2	2.79 ± 4.32	2.79 ± 4.32	2.79 ± 4.32	5.58 ± 8.65	36.31 ± 24.09	2.79 ± 4.32	**10.47**
Nereisdiversicolor	0	0	0	0	2.79 ± 4.32	0	0	0	0	0	0	0	0	0	0	0	**0.17**
Annulovortexsp.	0	0	0	0	2.79± 4.32	5.58 ± 4.32	0	0	0	0	0	0	0	0	0	0	**0.52**
Nematoda	2.79 ± 4.32	0	0	16.76± 19.83	100.56 ± 81.07	212.29 ± 69.64	5.58 ± 4.83	13.96 ± 15.6	75.42 ± 52.46	53.07	2.79 ± 4.32		78.21 ± 83.57	2.79 ± 4.32	0	13.9 ± 21.63	**35.44**
Total	39.1	16.76	2.79	27.93	106.14	226.26	5.58	16.76	75.42	78.21	5.58	2.79	81	8.38	41.9	16.76	**62.61**

Table 10 Density of worms (individual /0.1m2) of southern Caspian Sea (Mazndaran) (Autumn, 2012) (±SD).

STATION / WORMS	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4	mean
Paranaislitoralis	0	0	0	0	0	0	0	0	0	0	2.79	0	0	0	0	0	**0.17**
Streblospiogynobranchiata	0	16.76 ± 12.98	8.38 ± 12.98	0	0	16.76 ± 12.98	8.38 ± 12.98	0	0	16.76 ± 12.98	2.79 ± 4.32	0	0	16.76 ± 12.98	8.38 ± 12.98	0	**6.28**
Nereisdiversicolor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
***Annulovortex*sp.**	0	5.58 ± 4.32	0	0	0	5.58 ± 4.32	0	0	0	5.58 ± 4.32	0	0	0	5.58 ± 4.32	0	0	**1.39**
Nematoda	187.15 ± 17.3	78.21 ± 82.56	11.17 ± 17.3	0	284.92 ± 140.42	94.97 ± 108.44	0	0	298.88 ± 125.94	94.97 ± 108.44	11.17 ± 17.3	0	298.88 ± 125.94	94.97 ± 108.44	8.38 ± 12.98	0	**91.48**
Total	187.15	100.56	19.55	0	284.92	117.32	8.38	0	298.88	117.32	22.34	0	298.88	117.32	16.76	0	**132.44**

Table 11 Density of worms (individual /0.1m^2) of southern Caspian Sea (Mazndaran) (Winter, 2012) (±SD).

STATION / WORMS	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4	mean
Paranaislitoralis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Streblospiogynobranchiata	5.58 ± 8.65	0	0	0	8.38 ± 12.98	22.34 ± 18.86	2.79 ± 4.32	0	19.55 ± 15.6	5.58 ± 4.32	5.58 ± 4.32	16.76 ± 7.49	0	0	8.38 ± 7.49	5.58 ± 8.65	**6.28**
Nereisdiversicolor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
***Annulovortex*sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Nematoda	583.8 ± 718.54	0	0	0	30.72 ± 47.6	5.58 ± 4.32	5.58 ± 8.65	0	304.47 ± 193.18	432.96 ± 242.45	16.76 ± 12.98	5.58 ± 8.65	170.39 ± 132.46	22.34 ± 34.61	27.93 ± 36.97	128.49 ± 99.53	**108.41**
Total	589.39	0	0	0	39.1	27.93	8.38	0	324.02	438.55	22.34	22.34	170.39	22.34	36.31	134.08	**152.93**

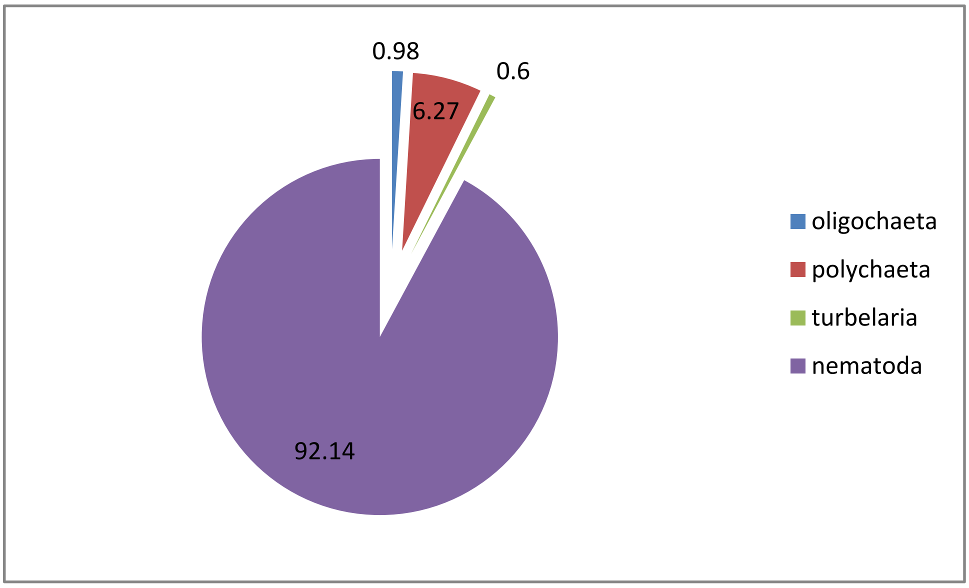

Fig. 4 Percentage of worms density (individual /0.1m^2) of southern Caspian Sea (Mazndaran).

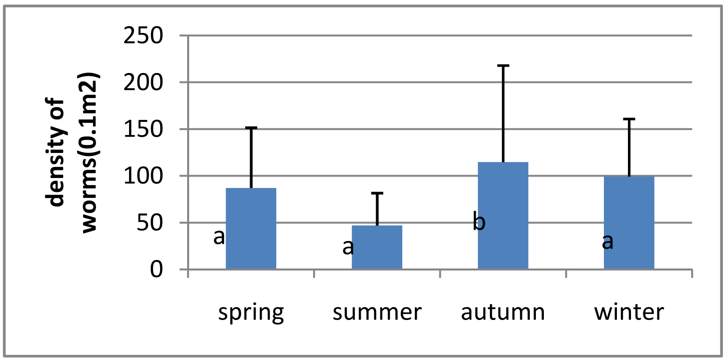

Fig. 5 Density of worms in different seasons (Mazandran province).

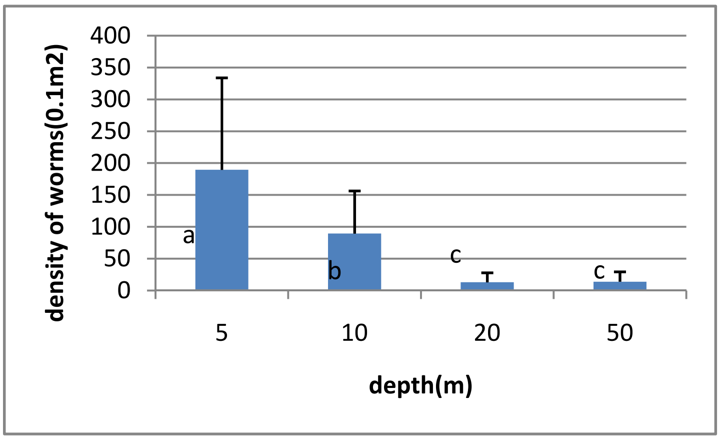

Fig. 6 Density of worms in different stations (Mazandran province).

Table 12 Component matrix (PCA).

	Component		
	1	2	3
DO	.089	-.264	-.481
pH	.099	.239	-.154
Salinity	.060	.056	.233
Tempratur	-.208	.047	.466
Granulity	.299	-.106	.112
TOM	.263	-.072	.073
$CaCO_3$	.252	-.008	.249
TP	.059	.452	-.105
TN	.084	.416	-.133
Worms	-.207	.014	-.206

Extraction Method: Principal Component Analysis

Component Scores.

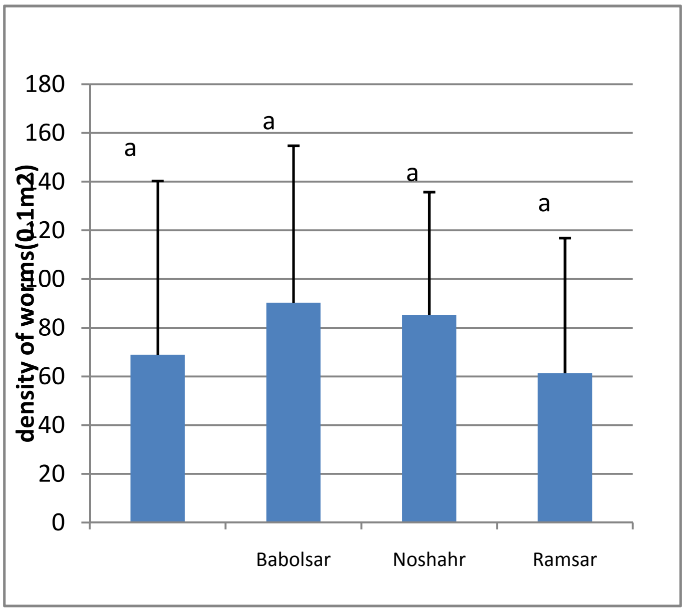

Fig. 7 Density of worms at different depths (Mazandran province).

4 Conclusions

In this research three classes of worms (Nematodes, Annelida and Platyhelminthes) were identified. From Annelida tow group was identified (polychaetea and oligochaeta) that polychaeta composed of (*Streblospio gynobranchiata* and *Nereis diversicolor*) and oligochaeta (*Paranais litoralis*), one genus of Platyhelminthes

(*Annulovortex* sp.) and one family of nematodes (Monhysteridae) were identified. Maximum density of worms observed in spring at B1 (759.78 ind/0.1m^2).

According Shannon-Wiener index this area had not good ecological condition. According our results, we can use worms as bioindicator for pollutant area that result showed the density of them increased in stations that amount of TP and TN were high and urbanization had important role in this area that increased abundance of meiofauna tolerance worms.

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