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Water quality assessment with biological indicators: Mond protected area, Iran

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Abstract

The purpose of this study is to determine the diversity and the accumulation of Macrobenthos of Mond River and assess the condition of water quality using Welch's index. Sampling was done in summer and winter seasons during 2011-2012 years. Sediment samplings were done three times for each station. Macrobenthos samples were collected using van Veen grab with 0.025 cross-section, (they were fixed using 5% buffered formalin) so were counted and identified in the laboratory. Further, physical-chemical parameters of water including temperature, pH, dissolved oxygen (DO), water salinity was measured at each station. The diversity index was examined using Shannon-Weiner formula. Dominant index was examined using Simpson formula and water quality was assessed using Welch index. The identified samples were composed of 13 genus, 11 families and 3 classes. The most identified species in stations belongs to Ceanidae, Limnaeidae and Chironomidae families. The results of the study indicated that according to the identified samples and Welch index, quality water in river Mond has poor to medium.

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Introduction

Rivers are natural habitat for very of aquatic species with individual fauna and flora. Sewage discharge (agricultural, industrial and domestic) is an important factor in changing and decreasing of the quality of these ecosystems. As in the most polluted rivers, bio communities have limitations and their resources such as local fish, algae, benthic invertebrates and their other communities are destroyed. Meanwhile, Surveying rivers as, circulatory system, is important to recognize the health and incoming possible pressure of the surrounding environment (Sioli., 1975).

In order to assess the water quality of streams and rivers, chemical analyses are not solely sufficient (Kar & Chu., 1999). Thus macro benthos (benthic) is one of the most reliable indexes to determine the effects of toxic materials on water ecosystems. The structure of macro benthic communities exactly depends on physical-chemical factors and mechanical and chemical combinations of sediments that environmental conditions like atmosphere pollution, agricultural drainage, and sewages effects on it. Moreover, macro benthos acts as a filter for waiters and are effective in water quality because they have variable food diet (Tabatabaei & Amiri., 2011)

Most macro benthos is not able to live in polluted waters and introduce as biological indicators as they respond to the available turbulence in the environment (Habit *et al.,* 1993). In a healthy river, benthic community includes sensitive species to pollution but in a polluted river only patient invertebrates are available. Most macro benthos is immobile species and can't escape from pollution. So study of macro benthic community state past and present condition of river (Fenglio *et al. , 2002*). In fact, these studies are valued in order to determine the effect of natural and human factors on rivers because of these community responses consistently to the environment conditions (Kar., 1981; Weigel & Robertson., 2007).

The effect of pollution on the macrobenthic community have been stated in various studies (Pearson & Rosenberg., 1978; Gray & Mirza., 1979; Daurin., 1982; Warwick *et al.,* 1990; Simboura *et al.,* 1995; Bllingsen., 2002; Celik., 2002; Morrisey *et al.,* 2003; Guerra-Garcia & Garcia-Gomez., 2004; Mohammadi Roozbehani *et al.,* 2010; Tabatabaei & Amiri., 2011; Mousavi Nadushan & Ramezani., 2011; Hamzavi *et al.,* 2012; Mohammadi Roozbehani *et al.,* 2013). Therefore, Mond River is the most important water supply resource in the Mond protected area, and therefore the water quality of the area depends on the water quality of the river. The purpose of this study is the detection of benthic invertebrates; survey of physical-chemical parameters also estimates biological indices and physical-chemical parameters for determining water quality in this river.

Materials and methods

Studied stations

Mond River located in Bushehr province during 2011-2012 years. The Study indicated that based on subjects of study, only two sampling periods in two warm (summer) and cold (winter) seasons are sufficient in order to have newer information on studied area. The location of study stations and location of geographical stations is shown in Fig.1. and geospatial location of sampling point presented in Table 1.

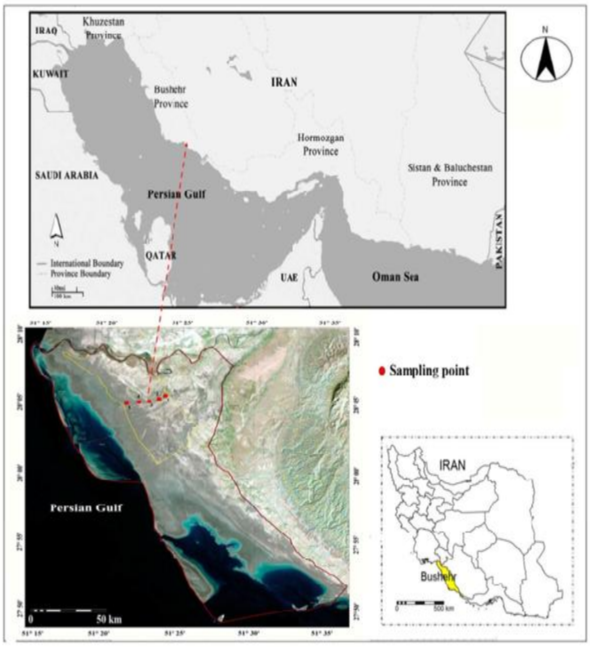


Fig. 1. Location of Mond river and sampled stations.

Table 1. Geographical location of sampling point.

Sampling point	Longitude	Latitude
1	51° 29' 58.7"	28° 26' 29.4"
2	51° 32' 00.8"	28° 10' 57.0"
3	51° 30' 13.7"	28° 08' 52.9"
4	51° 27' 44.1"	28° 08' 55.7"
5	51° 15' 57.7"	28° 15' 12.5"

Sediments sampling and determining physical-chemical parameters

Sampling of the Mond river sediments was done using van Veen grab with 0.025 cross-section in too warm (August) and cold (February) seasons in 2011-2012. In each station, first the geographical location was specified using GPS and then were sampled from sediments and water to measure physical-chemical parameters (pH, salinity, temperature, dissolved oxygen). At each station, 3 of sediment samples were taken using van Veen grab to study macrobenthos, and were sieved with 0.5 meshes. Then were planted by rose Bengal 1 gr/lit. Finally they were counted and identified. (Walton. 1974). In order to measure water physical-chemical parameters, temperature and oxygen were measured using a thermometer and DO meter respectively, and salinity by optical salinometer and pH by locally pH meter portable were measured. Moreover the measurement of each factor was repeated three times, and then they mean was recorded.

Statistical analyses

For statistical examination of the data, first the normality of the data was examined using Kolmogorov-Smirnov test and the difference between stations and seasons were determined using one-way ANOVA and T-test in SPSS®16 software environment (Zar., 1999).

Diversity indices

Shannon-Weiner diversity index was calculated through Eq. 1 (Shannon & Weaver., 1963).

$$H' = -\sum_{i=1}^{R} \rho_i \ln \rho_i \qquad [1]$$

Where, ρ_i is the relative frequency, i is in the community and R is the total number of the community.

The Simpson's diversity index it equals (Krebs., 1994):

$$\lambda = -\sum_{i=1}^{R} {\rho_i}^2 \qquad [2]$$

Where, ρ_i is relative frequency. i is in the community, and R is the total number of the community.

Determination of water quality of the area

After determining diversity indices to determine the water quality of the area Welch index was used (Welch., 1992).

Results

Physical-chemical parameters

Based on the performed examinations, it was specified that there are no significant differences between the mean temperature, dissolved oxygen, Salinity, and pH in 5 stations (Table 2.), but the mean temperature between 2 seasons had significant differences ($P<0.05$). The most temperature degree recorded in 35.4°C temperature in station number 5 in summer and the least temperature degree was recorded with 16.7°C temperature on station number 1 in winter (Fig.2.(a)). According to the performed examinations it was specified that there were no significant differences between the mean dissolved oxygen of the five sampled stations ($P=0.99$) and also dissolved oxygen in both warm and cold seasons ($P=0.46$). The most rate of oxygen was recorded as

7.87 mg/l in station number 3 in winter and the least rate of oxygen was recorded as 6.13 mg/l in station number 4 in summer season (Fig.2.(b)). According to the performed examinations it was specified that there are no significant differences between the average salinity of the five sampled stations (P=0.29). Further, no significant differences were observed between the salinity rate in both winter and summer seasons (P=0.55) (Fig.2.(c)). The performed examinations it was specified that there are no significant differences between the mean pH in stations (P=0.80) and the sampling seasons (P=0.064). The mean pH was recorded as 8.17 for cold season and 8.36 for warm season respectively (Fig.2.(d)).

Table 2. Mean (SD) changes of physical-chemicalin sampling point in cold and warm seasons.

Stations	Season	T (°C)	DO (mg/lit)	Salinity (ppt)	pH
					Mean±SD
1	Cold	16.70±0.4	7.37±0.1	2.43±0.3	8.24±0.42
	Warm	30.93±0.6	7.20±0.05	3.30±0.5	8.31±0.31
2	Cold	17.43±0.3	7.20±0.2	2.73±0.02	8.14±0.21
	Warm	34.20±0.9	7.37±0.5	2.83±0.04	8.25±0.02
3	Cold	18.40±0.3	7.47±0.02	3.20±0.2	8.16±0.41
	Warm	33.40±0.7	7.87±0.04	4.03±0.1	8.22±0.04
4	Cold	18.60±0.2	6.90±0.03	3.30±0.03	8.13±0.11
	Warm	33.22±0.8	6.13±0.05	6.13±0.04	8.59±0.3
5	Cold	20.03±0.6	6.67±0.06	4.13±0.2	8.20±0.25
	Warm	35.40±0.9	7.03±0.1	6.77±0.1	8.47±0.21

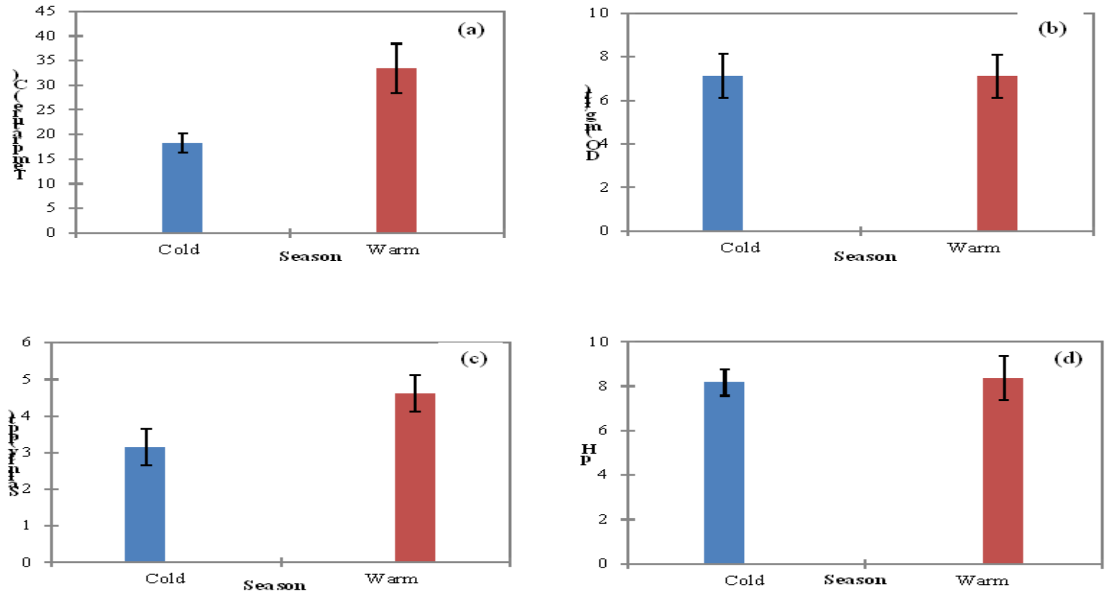


Fig. 2. Comparison of seasonal changes in physical- chemical parameters.

Accumulation and dispersion of benthic invertebrates

13 genera from 11 families of benthic invertebrates were identified altogether during the sampling period (Table 3.) that the frequency results of benthos groups in both cold and warm seasons are presented separately. The results indicate that the frequency and diversity of macro benthos in warm season have an increase in comparison with the cold season. Fig. 3. shows the coarse frequency changes of counting benthic invertebrates in different stations. According to the results of T-test (P=0.01) there were significant differences between frequency changes in both cold and warm seasons.

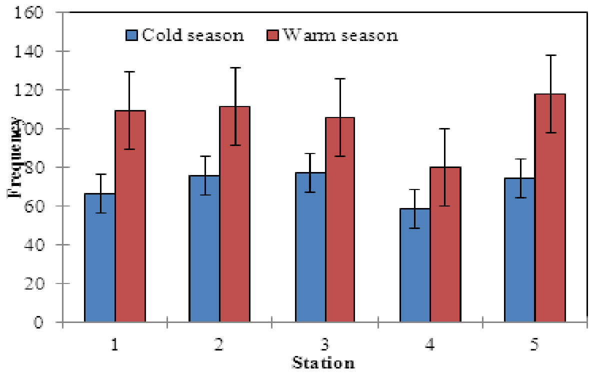


Fig. 3. Frequency changes of Macrobenthos in sampling point in both cold and warm seasons.

Table 3. Macrobenthic faunal communities during cold and warm seasons.

Class	Family	Genus
Crustacea	Daphnidae	Daphnia
	Gammaridae	Gammarus
Gastropoda	Viviparidae	Viviparus
	Limnaeidae	Lymnaea
Insecta	Ceanidae	Ceanis
	Ephemerellidae	Ephemerella
	Habrophlebiidae	Habrophlebia
	Heptogonidae	Heptogonia
	Leptophlebiidae	Leptophlebia
		Paraleptophlebia
	Nemouridae	Nemoura
	Chironomidae	Chironomous
		Spaniotoma

Shannon index

According to the results of ANOVA (P=0.74) no significant differences have been observed between the mean Shannon index in sampled stations. But significant differences were observed between the mean Shannon index in sampling seasons (P=0.02) (Fig.4.).

Simpson index

According to the results of ANOVA no significant differences have been observed between the mean Simpson index, between sampling seasons (P=0.47) and also in sampled stations (P=0.49) (Fig.4.).

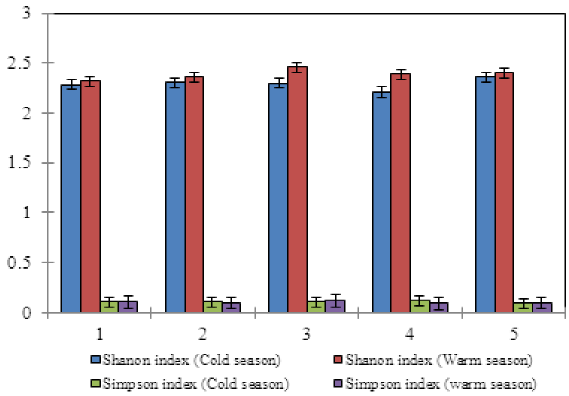


Fig. 4. Shanon and simpson index changes among stations and in cold and warm seasons.

Determination of water quality of the region

Welch index was used in order to determine the water quality. In this index, based on the rate of Shannon diversity index changes, water quality is determined in each station (Table 4.). Water quality in this river has generally an average level (Table 5.).

Table 4. Assessment pattern of the region pollution.

Water quality class	Welch index
Low pollution	3-5
Average pollution	1-3
High pollution	1>

Table 5. Determination of the conditions of the stations.

Stations		1	2	3	4	5
Welch index	Cold season	2.281	2.304	2.300	2.210	2.360
	Warm season	2.319	2.362	2.455	2.390	2.400

Discussion

According to the results of this study it can be concluded that macro benthos are a good index to assess the ecological conditions of rivers that correspond to the results of the study Anbuchezhian *et al.* (Anbuchezhian *et al.*, 2009) and Mooraki *et al.* (Mooraki *et al.*, 2009).

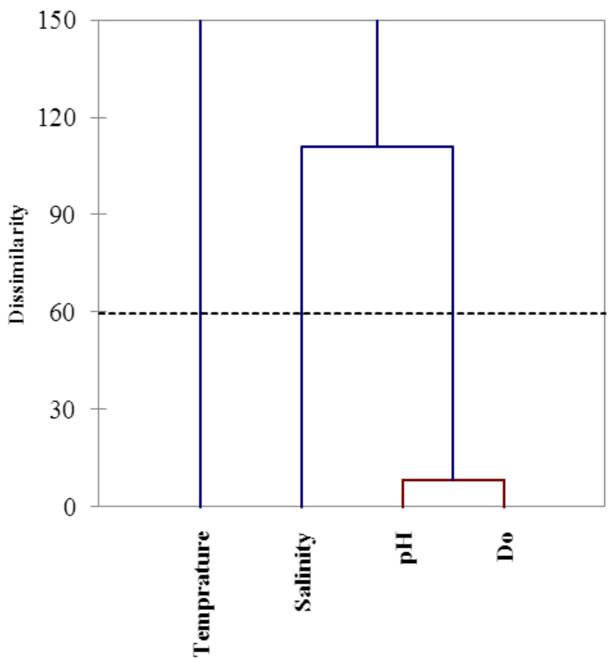
The obtained results of the Welch index (Welch., 1992) indicated that water quality in this river has generally an average level. Based on this index in both Cold and warm seasons, all stations have an average quality. The most frequent group of identified macro benthos in the river includes Chironomidae, Limnaeidae, Ceanidae. The cause of the frequency of these groups in both seasons can be due to the existence of suitable environmental conditions for life and reproduction of this species. Since these species are rather resistant to the pollution, it can be stated that the studied stations don't have desirable conditions qualitatively. Based on Shannon index, biodiversity is higher in summer than winter. This will be justified as suitability of the environment conditions and the existence of nutrients in summer season cause the creation of desirable conditions for the life of more species.

According to the research of Saunders *et al.* (Saunders *et al.,* 2007) an increase in pollution causes a decrease in diversity and frequency of coarse species of benthic invertebrates while in these polluted region's opportunist species of polycheates which are an index for showing pollution become dominant. Moreover, the study of Carvalho *et al.* (Carvalho *et al.,* 2006) showed that an increase in pollution degree causes the domination of the opportunist species.

Abu-Hilal *et al.* (Abu-Hilal *et al.,* 1994) and El-Sammak (El-Sammak., 2001) studied the pollution conditions in Dubai estuary by studying benthos. Their study results showed that in the studied stations, the coarse diversity of benthic invertebrates' decreases as pollution increase. Environmental factors which interfere in accumulation or dispersion of benthic creatures in a small ecosystem consist of chemical and physical factors including the size of composing particles of sediments, dissolved oxygen levels in sediments (Johanson., 1997) and the rate of sediment pollution and biological factors including the way of feeding banthos, the effects of feeding benthic creatures on the other smaller species and the effects of biological turbulence in environment bed (Gray., 1981).

The results of physical-chemical factors shows that there are no differences in water quality of the river in winter and summer seasons and the quality are the same in both seasons. The results of cluster analyses of the examined parameters are given in Fig. 5. Based on the similarity percentage 60% parameters are divided into three groups. Group A includes temperature, group B includes salinity and group C includes DO and pH.

Fig. 5. Results of cluster analyses among physical-chemical parameters in this examination.



In small scales, it was specified that the distribution pattern of macro benthos has a direct interaction with physical-chemical parameters of the environment and the dispersion pattern also changes with the changes to these parameters (Barry & Daytom., 1991; Thrus *et al.,* 1996; Inglis & Kross., 2000; Chapman., 2002; Mikac *et al.,* 2007). In the study of Mooraki *et al.* (Mooraki *et al.,* 2009) it is stated that there is a direct interaction among the diversity of species and physical-chemical parameters of the environment including salinity, dissolved oxygen, pH and temperature. Further, according to Celik' research (Celik., 2002) and Mohammadi Roozbehani *et al.* (Mohammadi Roozbehani *et al.,* 2013) the diversity of the existing species has a direct interaction with physical-chemical parameters.

Human activities cause changes in the environment variables cause changes in the combination and the species diversity of macro benthos (Warwick & Clarke., 1993). Therefore, according to this fact that the only pollutant source of this river is agricultural activities, which are done at this river's edgeit can be concluded that the main factor of the pollution of the studied river is the agricultural drainage arising from these activities.

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