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Study of Macrofaunal Communities as Indicators of Sewage Pollution in Intertidal Ecosystems: A Case Study in Bushehr (Iran)

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Abstract: Sewage disposal into intertidal zone is generally regarded as one of the most widespread anthropogenic disturbances for marine benthic communities and a primary cause of habitat change in benthic environments. In order to ecological assessment of intertidal ecosystems with respect to their responding to different volume of sewage disposal in Bushehr, sediment sampling was carried out four stations (including a control and three affected). Ecological indices of infaunal macrobentic assemblages and the physical and chemical variables of their habitats were measured and calculated during four seasons (2009-10). Ecosystems showed a characteristic seasonal variation pattern. However, the comparison of different ecological biotope and biocenose variables indicated severe environmental impacts on the studied ecosystem locating in the sites of sewage release. Among the all environmental factors, pH, TOM and BOD_5 signified to be influenced by the mentioned event. Investigation of community structure of three identified taxa (polycheates, mollusks and crustaceans) revealed that polychaete individuals constituted higher proportion of overall population in Shoghab and Jofreh as disturbed ecosystems. Airforce, however, seem to be in the earlier stages of completely being affected by sewage originated pollution. On the other hands, Heleileh with its lack of access to direct contaminants demonstrated the best ecological quality than other stations. Examination of different variables' correlation suggested that ecosystem stability in the study area is being ferociously threatened by this source of pollution. It is necessary to prevent destruction of these ecosystems and some appropriate policies should be made to maintain the function of undisturbed ones.

Key words: Intertidal ecosystems % Macrofauna % Ecological indices % Sewage pollution % Bushehr

INTRODUCTION

The Persian Gulf's environment has being subjected to rapid changes; some of which are derived from major developments in the coastal zone [1]. Intertidal ecosystems with their vulnerability and direct access of anthropogenic pollutants seem to be sensitive land-sea interface. Sewage effluent is considered one of the most common anthropogenic disturbances of marine benthic communities and has long been recognized as one of the principal causes of faunal change in near-shore benthic environments [2]. Macrobenthic communities are good indicators of anthropogenic and natural stressors in these ecosystems [3]. They possess life history traits and functions which lead to a relatively rapid response to a multitude of stressors. Many indicators and indices have been proposed to summarize the response of benthic fauna to pollution gradients [4]. Benthic invertebrate assemblages are amongst the useful bio-indicators of ecological quality in coastal and estuarine environments. They are relatively sedentary and cannot avoid deteriorating conditions of their habitats. In addition, benthic communities systematically consist of a variety of species that exhibit a wide range of physiological tolerances for stress, feeding guilds and trophic interactions [5-7]. Following disturbances, they typically undergo a period of changes often referred to as succession [8], which ends with a return to the pre-impacted state or can also be interrupted by additional disturbance events [9,10]. The natural tendency of systems to return to a preimpacted state forms the basis to recover from anthropogenic impacts [11, 12]. Therefore, the benthic communities provide an integrative measure of the system health [13].

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Among the all indices and indicators of ecosystem health, some of the try to assess the environmental stress effects accounting for the ecological strategies followed by different organisms. Polychaete/Amphipod ratio index was formerly designed to measure the effects of crude oil pollution [14]. Its application to estimate the ecological status of intertidal ecosystems, however, has been well documented [15]. Diversity is the other mostly used concept, focusing on the fact that the relationship between diversity and disturbances can be seen as a decrease in the diversity when disturbances increase. Shannon-Wiener diversity Index, Pielou Evenness Index, Margalef species richness Index and Simpson dominance Index are categorized as these indices [14].

Several studies have addressed the indication of intertidal ecological quality by benthic communities with reference to macrofauna [3, 16 -19]. Although some related academic studies have formerly been carried out in Bushehr coastal zone [20 -23], the main objectives of this study was to assess the ecological status of intertidal ecosystems of Bushehr whose stability seem to be threatened especially by sewage pollution released in that vulnerable and ecologically valuable portion of coastal zone. Ecological indices and also examination of correlation between biotope and biocenose variables are utilized as the effective tools to assess the mentioned anthropologically important and environmentally vital concept.

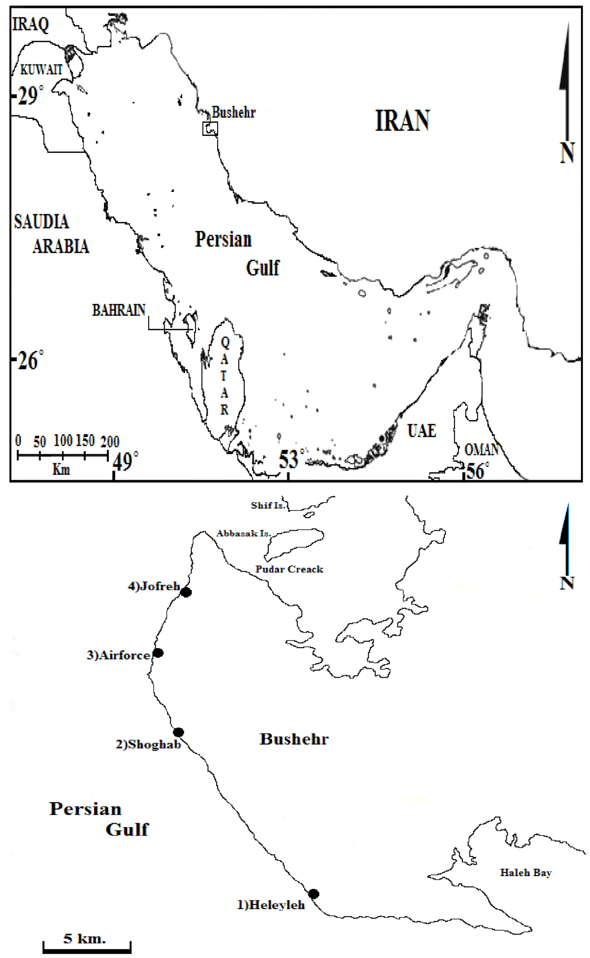

Fig. 1: Position of Bushehr in Persian Gulf and sampling stations

MATERIALS AND METHODS

Bushehr is a peninsula whose intertidal zone has different geomorphologic characteristics. While its two southern (around Haleh bay) and northern (around Pudar creack) parts are exposed to mixed semidiurnal tidal cycle constituting wide tidal mudflats, coastal rocks and boulders are distributed between the two extremes of the overall sandy shoreline (Figure1).

Macrofaunal samples were randomly collected with the least handling of natural microhabitats along Heleileh as control station which is not directly in contact with any anthropogenic activity and also Shoghab, Airforce and Jofreh. Indeed the latter three stations are the main sites of sewage disposals in the study area. It should be noted that the third station (Airforce) has been recently considered as a site where these pollutants release. Furthermore, in addition to sewage disposal, Jofreh has long been adjacent to fishing port activities and establishments. Samples were collected using a 10cm depth×5cm diameter core sampler (for sandy portions) and a 50×50 cm quadrate (for rocky substrates) during spring, summer and autumn 2009 and also winter 2009-10. Macrofaunal individuals were fixed in buffered formalin (5% solution diluted by local sea water with sodium tetraborate) [24]. A mixture of 70% ethanol and 5% glycerin was also used for permanent storage in the laboratory [25]. Rose Bengal vital staining was selected to separation of detritus and animals [26]. Environmental variables (temperature, salinity, pH and dissolved oxygen) were simultaneously measured using German Wisseschaflich-Technische Werkstatten GmbH sets. In addition, analyses of BOD_5 and Total Organic Matter (TOM) related to water body and sediments of all sampling points were carried out according to standard methods [26, 27].

After taxonomic identification of benthic faunal communities down to species level [28 -31] the ecological indices including Shannon-Wiener diversity Index

(*H'*) [32], Polychaetes/Amphipods Index (*P/A*) [14], Pielou Evenness Index (*J'*) [33], Margalef species richness Index (*M*) [34] and Simpson dominance Index (*D*) [35] were calculated for all stations during four seasons using Biological Diversity Professional Beta (BDPro), 1997 software. After examining the distribution of all variables by Kolmogrov-Smirnov test of normality, Parametric (One way ANOVA, Tukey Post Hoc) and Non-parametric (Kruskal-Waliis and Mann-Whitney U) tests were performed in order to determine the would be differences between stations during single seasons and finally correlation between variables (Pearson and Spearman tests) were investigated. SPSS 16.00 for Windows software was used for all the tests in 0.05 confidence level.

RESULTS

As it can be seen from the tables 1 and 2, among the all measured environmental factors, One Way ANOVA revealed that there was no significant difference ($P<0.05$) between temperature and salinity of almost all the stations during each of four sampling seasons. However, results of Tukey Post Hoc indicated that mentioned variables in Shoghab significantly differed from the other stations during summer. Conversely, One Way ANOVA indicated significant differences ($P<0.05$) between pH and dissolved oxygen during different seasons. Tables 1 and 2 show the results of Tukey Post Hoc ($P<0.05$) for the latter factors. Examining the differences between Non normal distributed biotope variables (TOM and BOD_5) of all stations during each season, Kruskal-Waliis test showed significant results. In that way, Mann-Whitney U determined that Heleileh was the only station whose content of TOM and BOD_5 significantly ($P<0.05$) differed from other stations which in turn did not show significant difference with each other ($P<0.05$).

Taking a glance on the abundances of three taxa of macrobenthic animals (Tables 1 and 2), Polychaetes were the most populated group of animals throughout the study area. However, partial proportion of them within the population during the entire study period was relatively so much less in Heleileh though. According to One Way ANOVA there was a significant difference ($P<0.05$) between stations during each season.

Tukey Post Hoc determined that Shoghab, Airforce and Jofreh were the stations whose Mollusks' abundances were significantly differed ($P<0.05$) from Heleileh. As it has been pointed out in the tables 1 and 2, there was no significant difference between the abundances of former stations in different seasons.

Kruskal-Waliis and Mann-Whitney U tests also showed the identical results ($P<0.05$) about the two other groups of animals in the spatiotemporal scale. Tables 4-6 introduce the identified taxa of the mentioned groups of animals.

Table 1: Mean±standard error of biotope and biocenose variables of four sampling stations during spring* and summer** 2009

Station	1)Heleileh*	2) Shoghab*	3)Airforce*	4) Jofreh*	1)Heleileh**	2) Shoghab**	3)Airforce**	4) Jofreh**
Temperature(°C)	26.5±2.029^{1a}	25.00±1.820^{a}	34.5±2.770^{a}	34.00±3.001^{a}	34.72±2.321^{a}	39.21±2.021^{b}	35.53±3.327^{a}	34.00±2.841^{a}
Salinity(psu)	37.41±3.214^{a}	37.50±2.137^{a}	37.41±3.341^{a}	39.21±5.000^{a}	40.02±4.114^{a}	44.2±4.217^{b}	40.27±4.772^{a}	39.21±5.429^{a}
pH	8.31±0.523^{a}	7.50±0.410^{b}	7.41±0.119^{b}	7.29±0.401^{b}	8.27±0.643^{a}	7.27±0.529^{b}	7.50±0.219^{b}	7.29±0.301^{b}
DO($mg.l^{-1}$)	9.72±0.101^{a}	3.50±0.060^{b}	5.50±0.048^{b}	2.46±0.027^{b}	8.72±0.071^{a}	3.50±0.028^{b}	4.27±0.033^{b}	2.46±0.031^{b}
BOD_5	3.00±0.215^{a}	220.00±12.819^{b}	200.00±11.900^{b}	280.00±16.666^{b}	5.00±0.241^{a}	240.00±11.119^{b}	230.00±16.447^{b}	280.00±19.724^{b}
TOM%	14.02±2.403^{a}	47.30±8.641^{b}	34.66±6.216^{b}	56.22±9.733^{b}	15.27±1.961^{a}	52.09±7.704^{b}	42.21±5.280^{b}	66.07±8.212^{b}
Mollusks($Ind.m^{-2}$)	64.91±4.427^{a}	20.44±3.628^{b}	13.84±1.207^{b}	17.61±1.980^{b}	73.21±6.217^{a}	4.36±0.272^{b}	9.18±1.601^{b}	17.61±2.314^{b}
Polychaetes($Ind.m^{-2}$)	72.05±7.261^{a}	9.84±1.409^{b}	10.16±1.968^{b}	13.45±2.004^{b}	55.67±5.771^{a}	10.59±1.20b^{b}	20.29±2.054^{b}	13.45±2.406^{b}
Crustaceans($Ind.m^{-2}$)	84.97±8.909^{a}	4.40±0.121^{b}	1.63±0.040^{b}	1.50±1.036^{b}	87.41±6.911^{a}	3.50±0.024^{b}	9.09±0.023^{b}	1.50±1.027^{b}

1. Dissimilar superscripts indicate significant differences.

Table 2: Mean±standard error of biotope and biocenose variables of four sampling stations during autumn 2009* and winter2009-10**

Station	1)Heleileh*	2) Shoghab*	3)Airforce*	4) Jofreh*	1)Heleileh**	2) Shoghab**	3)Airforce**	4) Jofreh**
Temperature(°C)	27.50±2.562^{1a}	28.50±1.820^{a}	28.40±2.770^{a}	30.00±3.001^{a}	17.25±2.321^{a}	18.51±2.021^{a}	17.44±3.327^{a}	15.20±2.841^{a}
Salinity(psu)	41.52±3.061^{a}	40.02±2.137^{a}	39.72±3.341^{a}	41.27±5.000^{a}	34.28±4.114^{a}	34.28±4.217^{a}	35.00±4.772^{a}	40.0±5.429^{a}
pH	8.20±0.323^{a}	6.26±0.410^{b}	7.50±0.119^{b}	7.41±0.401^{b}	8.30±0.643^{a}	7.79±0.529^{b}	7.21±0.219^{b}	7.29±0.301^{b}
DO($mg.l^{-1}$)	10.25±0.321^{a}	3.72±0.060^{b}	4.74±0.048^{b}	4.75±0.027^{b}	10.00±0.071^{a}	4.50±0.028^{b}	5.78±0.033^{b}	2.46±0.031^{b}
BOD_5	3.50±0.715^{a}	230.00±12.819^{b}	230.00±11.900^{b}	210.00±16.666^{b}	2.00±0.241^{a}	200.00±11.119^{b}	220.00±16.447^{b}	280.000±19.724^{b}
TOM%	12.91±2.171^{a}	39.67±3.796^{b}	22.83±3.414^{b}	39.44±4.906^{b}	16.13±3.200^{a}	49.35±7.818^{b}	41.29±4.501^{b}	53.11±7.121^{b}
Mollusks($Ind.m^{-2}$)	71.25±6.037^{a}	18.88±3.628^{b}	9.87±1.207^{b}	0.00±1.980^{b}	68.88±6.217^{a}	18.80±0.272^{b}	11.54±1.601^{b}	17.61±2.314^{b}
Polychaetes($Ind.m^{-2}$)	60.42±6.456^{a}	15.85±1.409^{b}	9.05±1.968^{b}	14.68±2.004^{b}	70.75±5.771^{a}	11.89±1.20b^{b}	7.49±2.054^{b}	13.45±2.406^{b}
Crustaceans($Ind.m^{-2}$)	95.26±9.403^{a}	1.29±0.121^{b}	2.16±0.040^{b}	1.29±1.036^{b}	92.22±6.911^{a}	6.23±0.024^{b}	5.12±0.023^{b}	1.50±1.027^{b}

1. Dissimilar superscripts indicate significant differences.

Table 3: Correlation between different biotope and biocenose variables of the study area (0.05* and 0.01** confidence levels)

	Temperature	Salinity	pH	DO	BOD_5	TOM	Mollusks	Polychaetes	Crustaceans
Temperature	1.00	0.681**	0.321	- 0.444*	- 0.319*	0.282	0.029	- 0.127	- 0.630
Salinity		1.00	0.382	- 0.331	0.510	- 0.316	0.139	- 0.357	- 0.317
pH			1.00	0.601	- 0.212**	- 0.092	- 0.173*	0.290*	- 0.041*
DO				1.00	- 0.661**	0.349*	0.314**	- 0.308**	0.420**
BOD_5					1.00	0.628**	- 0.287**	0.469**	- 0.768**
TOM						1.00	- 0.0246*	0.311*	- 0.396*
Mollusks							1.00	- 0.627**	0.592*
Polychaetes								1.00	- 0.869**
Crustaceans									1.00

Table 4: Identified macrofaunal species of the tree taxa: A) Polychaeta, B) Molluska and C) Crustacea Figure 2) Shannon- Wiener diversity Index measured from different stations during four seasons.

A)Family	Species
1) Aphrodite	Lepidonotus carinulat
2) Ariciidae	Arabella irricolor
3) Capitellidae	Capitella capitata
4) Cirratulidae	Cirriformica tentaculata
5) Dorvillidae	Scoloplos chevaleiriNainereis laevigata
6) Eunicidae	Eunicidae siciliensisLycidice collarisArabella irricolor
7) Glyceridae	Glycera convulataGoniadopsis incerta
8) Nereidae	Platynereis dumeriliiPerinereis kuwaitiensis
	P. nigropunctatusP.nuntiaP.vancauricaP. cultiferaCeratoneris erythroensis
9) Ophelidae	Armmansia lanceolataAmmotrypane aulogaster
10) Owenidae	Owenia fusiformis
11) Phyllodocidae	Eulalia viridis
12) Sabellidae	Sabella fusca
13) Serpulidae	Pomatoleios krussi
14) Syllidae	Syllis spongicolaS.gracilis
15) Terebellidae	Sprionospio pinnataP.rotalisPseudopolydora antennataAonidex.
	sp.Scoloplos chevaleiri

B)Family	Species
1) Acmaeidae	Acmaea profunda
2) Acteonidae	Pupa affinis
3) Arcidae	Anadara ehrenbergiBarbatia fuscaB.obliquata
4) Bullidae	Bulla ampulla
5) Chitonidae	Acanthopleura haddoniChiton lamyi
6) Columbellidae	Anachis miseraMitrella blandaM. misera
7) Cymatiidae	Cymatium aquatile
8) Nassariidae	Nassarius deshayesianaN.arcularius plicatus
9) Naticidae	Neverita didyma
10) Neritidae	Nerita adenesisN.textile
11) Osteridae	Saccostrea cucullata
12) Planaxidae	Planaxis sulcatus
13) Potamididae	Cerithidea cingulata
14) Psammobiidae	Asaphis deflora ta
15) Siphonariidae	Siphonaria tenuicostulato
16) Thaidiae	Thais mutabilisT.savignyi
16) Thaidiae	
17) Triphoridae	Triphora perversa
18) Trochidae	Umbonium vestiariumEuchelus asperTrochus radiatusT. erythraeus
19) Turbinidae	Turbo radiatusT.coronatus
20) Turitellidae	Turitella fultoni

Table 4: Continued

C)Family	Species
1) Alpheidae	Alephus djiddensisA.lobidens
2) Apanthuridae	Apanthura sandalensis
3) Maeridae	Elasmopus pectenicrus
4) Grapsidae	Metopograpsus messor Ilygrapsus paludicola
	Nanosesarma minutum Sesarma plicatum
5) Ligiidae	Ligia exotica
6) Orchestiidae	Talorchestia martenicrus
	Orchestia platensis
7) Paguridae	Pagururistes perspicax
	Diogenes avarus
	Clibanarius singnatus
8) Porcellanidae	Pacheles natalensis
	Pterolisthes indicus
	P. rufescens
9) Sphaeromidae	Sphaeroma annadalei
	Cymodoce sp
10) Urothoeidae	Urothoe grimaldi
11) Xanthidae	Medaea granulosus
	Actaea savignyi
	Eurycarcinus orientalis
	Pilimneopeus vaguelini

Results of Pearson and Spearman bivariate correlation tests on the different biotope and biocenose variables related to all over the period of study have been given in Table 3. As it could be interpreted from the table, salinity was not significantly correlated with any variable except for temperature (positively, $P<0.01$) which in turn was correlated negatively with dissolved oxygen and BOD_5 ($P<0.05$). The latter variable which showed a significant negative correlation with pH ($P<0.01$).

Were not the only variable that correlated with it. Furthermore the abundances of mollusks and crustaceans were the other variables whose correlations were negatively significant with pH ($P<0.05$). While polychaetes' abundance correlated positively with that variable in the same confidence level. Dissolved oxygen, on the other hand showed a positive correlation ($P<0.01$) with the abundances of Table 4) Identified Polychaete species in the study area both mollusks and crustaceans and a negative one with polychaetes ($P<0.01$). TOM and BOD_5 were the other variables showed a significant positive ($P<0.05$) and negative ($P<0.01$) correlation with dissolved oxygen. BOD_5 indicate a negative (with TOM and polychaetes' abundance, $P<0.01$) and positive (with the abundances of mollusks and crustaceans, $P<0.01$) significant correlation.

TOM was also showed similarly correlated with the abundances of different taxonomic groups. While mollusks and crustaceans were positively correlated with each other, the abundances of both taxa were in a negative significant correlation with polychaetes' abundance ($P<0.01$).During all seasons higher values of Shannon-Wiener diversity index (*H'*) were measured for Heleileh. The highest diversity in this station occurred in winter (2.89). Jofreh had got the least diversity value in summer (0.168). As it can clearly be interpreted from the figure2, although *H'* indices of Airforce were relatively higher than Shoghab and Jofreh, all of the latter stations' diversities were considerably lower than Heleileh all the study period long. Comparison of stations' evenness during seasons showed similar pattern with what obtained from the diversity index. Pielou Index in Heleileh showed higher values (the highest one was for winter, 0.968) within all the seasons. Similarly the least record of *J'* belonged to Jofreh in summer. The considerable difference observed among the stations' diversity was clearly distinguished for the Pielou evenness index. The results of this index are illustrated in term of season in figure 3. In contrast, Simpson dominance index gave the controversial values. Heleileh has got the least values of this index compared with other stations during all the seasons.

Similarly that was Jofreh whose species dominance was higher. All the stations except for Heleileh were dominated as almost well as each other. The maximum and minimum values of *D* were gotten from Jofreh (0.828) in summer and Heleileh (0.071) in spring respectively (Figure 4).

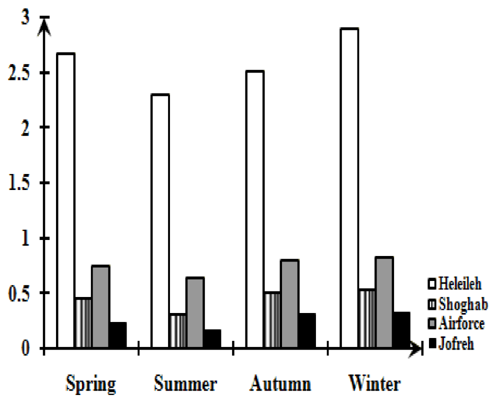

Fig. 2: Shannon- Wiener diversity Index measured from different stations during four seasons.

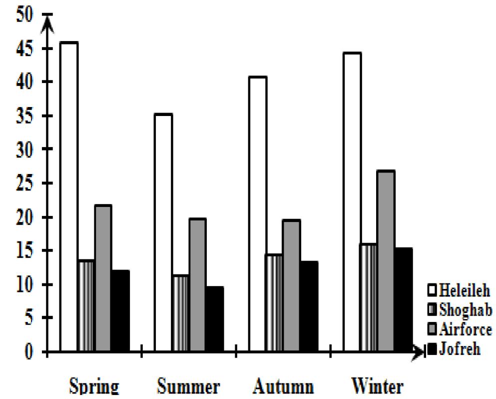

Fig. 5: Margalef species richness Index measured from different stations during four seasons

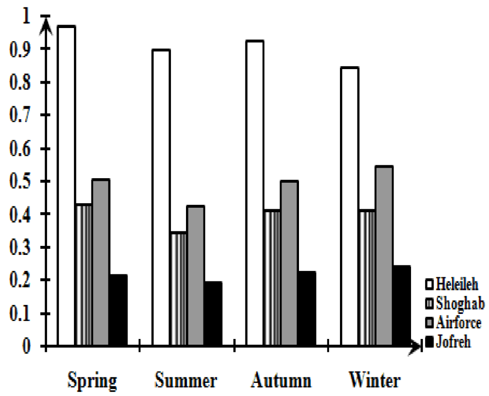

Fig. 3: Pielou evenness Index measured from different stations during four seasons.

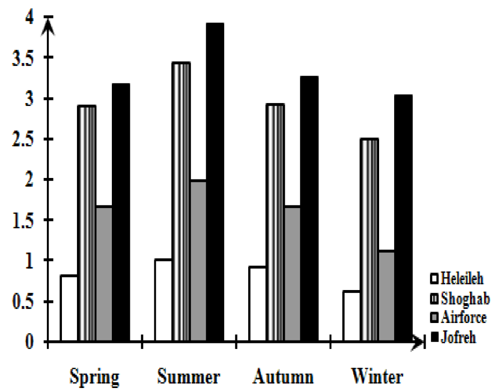

Fig. 5: Polychaetes/Amphipods index measured from different stations during four seasons

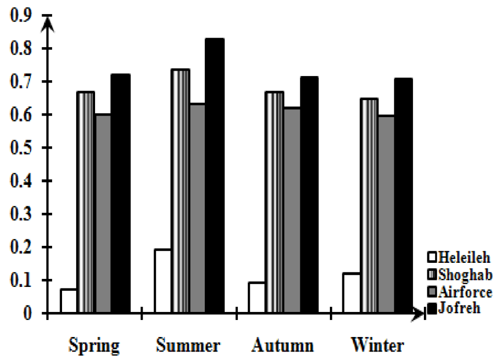

Fig. 4: Simpson dominance Index measured from different stations during four seasons.

Margalef index revealed that species richness in Heleileh was far beyond the other stations. It had the maximum species richness in spring (45.81), whilst the minimum value for this index measured again in summer for Jofreh. Airforce station showed the higher richness than Shoghab and Jofreh. Figure 5 demonstrates the variation of Margalef index in all stations during four seasons.

Results of Polychaetes/Amphipods index is illustrated in Figure 6. It is evident that the highest values of the index during all seasons belonged to Jofreh (maximum was calculated in summer, 3.688).

The only station whose P/A indices all year long did not exceed 1 was Heleileh (its minimum was 0.601 in winter). While the amounts of the index in Shoghab were close to those of Jofreh, Airforce showed relatively lower values during each season. However its values of this index were always more than 1.

DISCUSSION

Despite the fact that summarizing complex ecological variables and information to a single value may lead to some disadvantages and it might be difficult to consider the combination of chemical, physical and biological elements when monitoring marine benthic environments and thus impacts may not always be reliably attributed to anthropogenic stressors [36], the indices provide a simple means for communicating complex information to managers and for correlating benthic responses with stressor data and environmental factors [37, 38]. In this study two season dependent variables (temperature and salinity) did not show any significant differences between Heleileh (Control) and other assuming polluted station. In spite of temperature and salinity gradients in intertidal zone, sea water provides inhabitant assemblages with a buffered environment against salinity and temperature fluctuations [39]. It seems to be (an) other factor(s) influencing on these substantial difference in the community structure and ecological indices of macrofaunal organisms. Controversial status of seasonal changes of all other biotope variables revealed that sewage pollution in intertidal zone of this city might be the main cause of these spectacular variations. Remarkable differentiation in pH of control versus other stations could substantiate the impacts of sewage on chemical characteristics of intertidal body of sea water. The spatial extraordinary changes in pH would occur in unusual events such as release of extensive contents of pollutants [40]. All other studies on Bushehr undisturbed intertidal ecosystems did not report any significant differences pH within seasonal and spatial scales [21-24]. The impacts of sewage disposal on physical and chemical properties of intertidal environment is also reflected in the significant differences between content of dissolved oxygen as a very important biotope characteristic influencing on the coastal marine environment [41] between Heleileh and other polluted stations. Notion was already mentioned in other reports of the study area [21, 22].

The much more organic matter involved the more productive ecosystems. But this notion is only held for the natural and undisturbed ones. With the intention that organic enrichment is considered as a major disturbance in natural coastal habitats [41], it is suggested that the main cause of the high percentages of organic matter in sediment budget of Shoghab, Airforce and Jofreh could be the input of sewage to their intertidal areas. It should not be forgotten that the highest amounts of this variable in Jofreh may be related to other sources of pollution such as oil contaminants released in the Jofreh fishing harbor. Comparison of different taxa suggested that polychaetes as the tolerant and also opportunistic species possessed higher proportion of individuals in stations more influenced by sewage release. While some of mollusks and especially crustaceans whose tolerance to pollution is fairly lower than polychaetes had the best presence opportunity in Heleileh. Regarding correlation of the abundances of these two more sensitive groups of animals with dissolved oxygen compared to such other variables as pH, TOM and BOD_5 this assumption can be confirmed. In the light of ecological indices it could be interpreted that Heleileh (with its higher species diversity, evenness and richness and lower dominance) possess the best environmental condition for inhabitation of sensitive species. By contrast, the ecosystem stability of intertidal zone of Shoghab, Airforce and especially Jofreh have violently been threatened by irresponsible release of sewage into the natural ecosystems. Previous study carried out on a special taxonomic group of crustacean organisms in the study area indicates almost the same results. [22]. It can be understood by the results of the ecological indices that Airforce intertidal ecosystem is in the earlier stage of deterioration. Following some environmental considerations and strategies here may lead to prevent the degradation of these ecosystems here. As it was mentioned before Jofreh harbor and related activities could cause some disturbances which the worst ecological status can be estimated along this part of Bushehr in consequence. Although the abundance of polychaete individuals during the all seasons was more than amphipods, higher Polychates/Amphipods Index in more polluted ecosystems indicated the results of other ecological indices. Large number of *Capitella capitata* as an indicator of intense pollution [13] in Jofreh necessitates the environmental consideration to improve ecosystem function and maintain its stability there. Although the sewage disposal seem to be higher than permitted limits, ecosystem based management in this area and other station such as Shoghab could provide the macrofaunal inhabitants with the condition of returning the preimpacted ecological status.

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