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Short Communication

Using polychaetes as an assessment tool for health status of Jafari Creek, North-West of the Persian Gulf

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Marine ecosystems and their adjacent coastal habitats, especially estuaries are important because of maintaining the coastal biota, including a diverse array of organism's (Currier and Small, 2005). However, these ecosystems are being impacted by the anthropogenic activities through urbanization and industrialization developments. For evaluating the degree of alteration occurring in these valuable ecosystems, scientists have conducted several methodologies based on chemical assays (i.e. directly measured abiotic parameters of the environment) and use of ecological indices. Which are mainly based on benthic communities (Engle, 2000).

During the last two decades, there has been a growing interest in the use of biotic indices. It is noteworthy that the use of these indices relies on the fact that biological communities are affected by the ambient factors, and each community has different optimum habitat condition and pollution and disturbance tolerance (Pinto *et al*., 2008). In this regard, many researchers have shown that alterations in the macrobenthic assemblages and their distribution patterns is a valuable sign in interpretation of the environmental condition affected by stressors (Ysebaert *et al*., 2002; Ysebaert and Herman, 2002; Morrisey *et al*., 2003; Currier and Small, 2005).

Use of the whole community including relations, correlations, and responses can be informative, but problems can occur in some types of habitats, which are affected by various kinds of pollutants. Meanwhile, the results may not be distinct enough because of the multiplicity of direct and indirect effects. To integrate all the phenomena some researchers act selectively and try to focus on a single species or individual which is also more cost and time effective (Miller *et al*., 2007). Among the macrobenthos assemblages, polychaetes were tried to be introduced as an effective component in analyzing the health status of the sampling sites (Papageorgiou *et al.,* 2006; Dean, 2008). The use of polychaetes as indicators of environmental conditions of estuaries were previously applied by several researchers (Reish and Gerlinger, 1997; Dean, 2007, 2008).

During the last two decades, Mahshahr Creeks in Musa Bay has become one of the main economic assets of the north-west coast of the Persian Gulf, serving a variety of industrial activities. Some early endeavors have generally focused on identifying estuarine macroinvertebrate assemblages to the higher taxonomic levels, including polychaetes and also their spatial variation (Nabavy, 1992; Dehghan *et al.,* 2008; Mooraki *et al*., 2009). Jafari Creek, as one of the constituents of Mahshahr Creek, has been subjected to anthropogenic activities since 1993. From this year onward, the construction of Petrochemical Special Economic Zone (PETZONE) in an area of about 17 km^2, followed by the inception of petrochemical activities of the complexes situated in this zone, affected Jafari Creek. In this regard, the present paper was prepared to evaluate the health status of Jafari Creek using polychaetes as indicators and to compare the results with the previous evaluation which had been done through tracing the spatial distribution of the whole macrobenthic assemblages and chemical assay of the ambient factors (Mooraki *et al*., 2009) in this area. Accordingly, the primary objective of this research is to introduce the status of polychaetes assemblage of Jafari Creek and furthermore provide answer to this question if analysis of the polychaete fraction of the macrobenthic community of the creek can be a useful key in interpretation of the effects of industrialization.

This study was undertaken at Jafari Creek located in Mahshahr Creeks, which is connected to the Musa Bay, north-west of the Persian Gulf (Fig. 1). Jafari Creek, with an area of about 5.1 km^2, is a subtropical tidal creek with the tidal range of 0.8-5.1m surrounded by a vast muddy expanse (Niyyati and Maraghei, 2002). This creek receives irregular fresh water following the seasonal precipitation of about 100-300 mm per annum occurring mainly from November to February (Niyyati and Maraghei, 2002). In 1993, an area of about 1.22 km^2 of the Jafari Creek was isolated and 0.8 km^2 of which was drained off for construction of PETZONE. The remaining area (0.41km^2) is used as sewage and post treatment waste receptor. Sewage and post treatment waste runs into the main body of the creek through a connective canal which is opened only during low tide (Fig. 1).

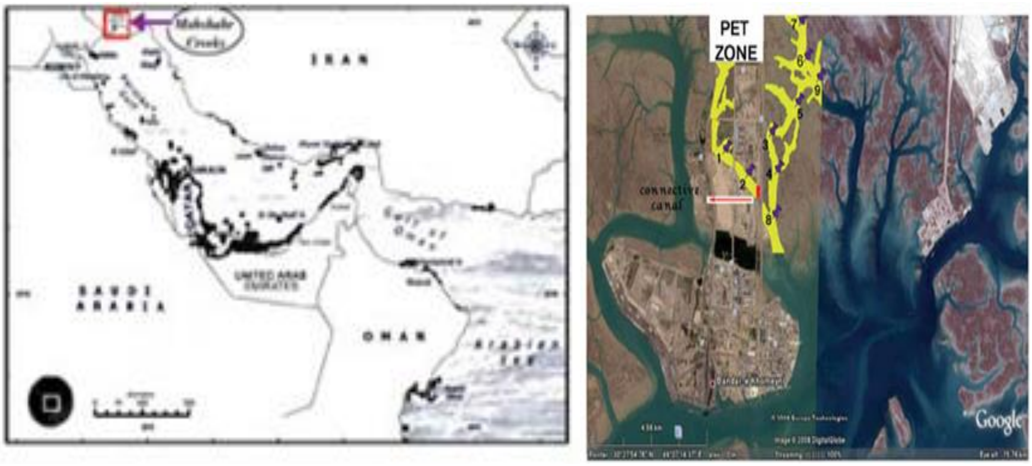

Figure 1: (a)The location of Mahshahr Creeks, (b) the location of the sampling sites and connective canal in Jafari Creek and PETZONE, north-west of the Persian Gulf. 1,50000.

Samples in submerged depositional substrates of Jafari Creek were collected from nine sites. The sites were selected in a way to encompass the entire area with similar characteristics in terms of general appearance and sediment particle size distribution. Moreover, the choice of sites was also influenced by accessibility, logistics and safety considerations.

Sites 1 and 2 were placed inside the PETZONE boundaries with 1.85 and 1 kilometer distance away from the connective canal. Sites 3, 4 and 8 were situated 0.8, 1.5, and 1.25 km from the connective canal, out of the PETZONE boundaries, respectively. Sites 5, 6, 7 and 9 were located out of the PETZONE far from connective canal. The distance of the aforementioned sites is respectively 2, 3.1, 3.25 and 3.5 km away from the canal (Fig. 1). Sampling was conducted from September 2006 to January 2008 every 50 days within two hours after the high tide using an Eckman grab with an area of 225 cm^2. The sampler collects a piece of sediment with a thickness of 5-15 cm weighing about 600-2000 grams. The number of replications of sediment samples collected for biota analysis was determined by a pilot study that revealed three replications provided means with acceptable precision (i.e. standard error/mean≤0.1 (Andrew and Mapstone, 1987)) for species richness. Accordingly, three sediment samples were taken from each of the nine sites for macro invertebrate analyses. Collected sediments were sieved through a 0.5 mm mesh and the retained macro invertebrates were preserved in 7 percent formalin buffered in sea water, followed by 70 percent ethanol with rose Bengal for sorting (Martin *et al*., 2006). Samples were sorted under a dissecting microscope using 16 × magnification, and all macro invertebrates were identified to the lowest possible taxonomic level, often to family level, using systematic and classification keys (Ponder, 2000; Martin and Davis, 2001; Todd, 2001; Glasby, 2002).

Data analyses were undertaken using PRIMER version 6 (Plymouth Marine Laboratories, Clarke and Warwick, 2001) and SPSS version 13. The contribution of specific taxa to the differences in macro invertebrate assemblages among sites was examined using SIMPER analysis. The Mean abundance of macro invertebrates was 4th root transformed to reduce the influence of very abundant species. The total abundance, taxonomic richness, and Shannon-Wiener diversity index were measured using Diverse Routine in PRIMER.

A total of 227745 macro invertebrates were sampled, representing three phyla, five classes and 32 families. Polychaetes were the most diverse class with 16 families mainly dominated by Glyceridae followed by Cossuridae, Eunicidae, Nereidae and Onuphidae (Table 1). Polychaetes comprised 62.12 percent of the total number of individuals, followed by Bivalvia (18.00%), crustaceans (12.20%) and gastropoda (7.73%).

Table 1: Mean number of individuals of each of the taxonomic groups, per square meter in Jafari Creek, north-west of Persian Gulf.

Phylum	Class	Mean number of taxa
Annelidae	**Polychaeta**	Glyceridae 4526
		Cossuridae 3521
		Eunicidae 2929
		Nereidae 2105
		Onuphidae 1390
		Serpulidae 868
		Aphroditidae 418
		Nephtyidae 239
		Lumbrinereidae 81
		Spionidae 69
		Sternapsidae 38
		Capitelidae 35
		Pectinaridae 30
		Terbelidae 10
		Hesionidae 7
		Centrodrilidae 2
Mollusca	**Bivalvia**	Yoldiidae 1659
		Veneridae 1009
		Solenidae 209
		Ostreidae 163
		Larva 1196
	Gastropoda	Postamididae 1339
		Barleeidae 376
		Columellidae 71
		Planorbidae 20
		Turbinidae 10
		Truncatellidae 7
Arthropoda	**Malacostraca**	Ampithoidae 752
	Isopoda (Order)	Alpheidae 38
	Tanaidacea (Order)	Gonodactylidae 41
	Cumaceae(Order)	Grapsidae 632
	Ostracoda	Ocypodidae 33
		Tanaidacea 876
	Maxilliopoda	Isopoda 345
	Cirripedi (Infraclass)	Cumaceae242
		Ostracoda 12
		Cirripedi 12

A significant difference was found in invertebrate assemblages among sites, as in sites 1 and 2, situated in the surrounding area, no macro invertebrate individual was found during the sampling period, and the other seven sites showed a variable composition of macrobenthic communities (Table 2).

Table 2: Summery of One-way ANOSIM of total macro invertebrate abundance comparison between outer sites in Jafari Creek, north-west of Persian Gulf.

Comparisons	Pairwise R		
Site3 vs Site4	-0.00	Site3 vs Site5	0.02
Site3 vs Site6	0.01	Site3 vs Site7	0.02
Site3 vs Site8	0.00*	Site3 vs Site9	0.00*
Site4 vs Site5	0.07	Site4 vs Site6	0.03
Site4 vs Site7	0.01	Site4 vs Site8	0.00*
Site4 vs Site9	0.00*		
Site5 vs Site6	0.01	Site5 vs Site7	0.02
Site5 vs Site8	0.00*	Site5 vs Site9	0.00*
Site6 vs Site7	0.09	Site6 vs Site8	0.00*
Site6 vs Site9	0.00*		
Site7 vs Site8	0.00*	Site7 vs Site9	0.00*
Site8 vs Site9	0.01		

*: Significant level $p<0.001$ (Global R= 0.386, p= 0.001).

The sites situated out of the PETZONE boundaries (i.e. sites 3 to 9) were dominated by the polychaetes followed by molluscs. Faunal assemblages in sites 8 and 9 were distinguished by high densities of Veneridae and Postamididae (molluscs), followed by Tanaidacae (Crustacean) and Eunicidae (Polychaete), respectively. Whereas the remaining five sites are dominated by polychaetes. Such a break down in spatial pattern of macrobenthos is largely controlled by the abundant number of polychaetes and few numbers of molluscs.

The dominated presence of polychaetes in comparison with bivalves, gastropods and crustaceans is not only supported by conducting SIMPER routine, but also by calculation of average density, species richness, Shannon-Wiener diversity indices for each sampling site, which is presented in Table 3. Domination of one taxa results into the increase of mean density but has an adverse effect on species richness.

Table 3: The mean value (±S.D) of four measured indices in nine sites in Jafari Creek, north-west of Persian Gulf.

Station	Density (No. ind.m^{-2})	Diversity(H´)	Evenness (J´)	Species richness
1	0	0	0	0
2	0	0	0	0
3	1015.25±645.00	1.79±0.74	0.9±0.10	1.76±0.69
4	816.2±290.77	1.68±0.77	0.9±0.09	1.47±0.65
5	624.84±220.60	1.91±0.43	0.94±0.02	1.67±0.41
6	1275.66±384.55	1.98±0.66	0.93±0.01	1.83±0.34
7	636.17±262.44	1.67±0.60	0.93±0.03	1.41±0.41
8	582.46±281.36	1.77±0.74	0.88±0.14	1.69±0.53
9	889±230.25	2.17±0.72	0.93±0.01	2.32±0.37

As it is obvious from the results, the first four dominant families among the whole community of macrobenthic organisms in Jafari Creek belonged to polychaetes. This is not unexpected since the studied areas were contaminated, to some extent, (Mooraki *et al*., 2009). However, unlike previous studies, which stressed on polychaetes and usually members of Capitellids (Mendez *et al*., 1998; Belan, 2003; Rivero *et al*., 2005), Spionids (Dix *et al*., 2005), Nereid (Bailey-Brock *et al*., 2002) and Cirratulidae (Rygg, 1985) as indicator of polluted environment, in the present study the positive pollution indicators seem to be Glycerides, Cossurids, Eunicids, and Nereids considering their mean abundance, respectively.

The result of the present study is not only in agreement with findings of Bailey-Brock and his colleagues (2002), but also with the results of Belan (2003), Olsgard *et al*. (2003), and Rosenberg (1976) which introduced Lumbrinerids and Terebellids as negative indicators of poor benthic conditions and stressed environments. In this regard, their absence or probably their low abundance in the community is a symptom of poor environmental condition. It should be mentioned that the presence of small numbers of Terebellids did not correlate with the degree of pollution of the area, as this taxa was not common in the studied area. For this reason, supplementary macrobenthic samplings should be conducted in a longer period to define whether this taxa is common in this region. Although Dehghan *et al*. (2008) did not refer to Terebellids during the sampling procedure in eight creeks of Musa Bay.

On the other hand, with regards to finding of and Rosenberg (1976) Onuphidae family was expected to be a negative indicator but in the present study, Onuphidae was placed in the sixth position in the list of more abundant taxa. The low abundance of Spionidae in Jafari Creek was similar to the condition of this taxa in Mediterranean waters of Barcelona, Spain evaluated by Mendez *et al*.

(1998), so it could be introduced as a negative indicator; which is also in agreement with Pocklington and Wells (1992). The eight position of Nephtidae in the list of more abundant taxa is accordant with the findings of Rivero *et al*. (2005) introducing this taxa as an indicator of the healthy environments.

Moreover, with regards to findings of Mendez *et al*. (1998), Belan (2003), Rivero *et al*. (2005) about the tolerance of Capitellids in the poor environmental conditions, the mean abundance and contribution percentage of this taxa were very low in the studied area. This could be explained by the results which represented by Grassle and Grassle (1976) and Christie (1985), that although Capitellids are known as cosmopolitan and also their presence maybe a symptom of environmental degradation, but this taxa was distinguished as groups of morphologically distinct or sibling species differing in their life cycle traits. Meanwhile, the result of this study on Capitellids at the level of family was not enough for any further discussion. Thus, if the objective of a study is to detect the effects associated with anthropogenic disturbances based on this fact that Polychaetes are commonly a major component of any benthic community and the analysis of their assemblage structure could mirror the alterations, the level of taxonomic resolution should be more precise near the species and also sub-species level especially for *Capitella capitata*. The other possible explanation for low mean abundance of Capitellidae family in Jafari Creek and in eight creeks of Musa Bay (i.e. Ghannam, Doragh, Ghazaleh, Ahmady, Patil, Darvish, Bihad, Zangy) for which Dehghan *et al*. (2008) explored their macrobenthic community, in six stations (Genaveh, Farakeh, Bandargah, Rostami, Asalouyeh) along the coastal border of Bushehr Province, which was sampled by Safahieh *et al*. (2012) and as well in Nayband Bay, North west of the Persian Gulf (Mooraki, *et al*., unpublished) could be due to the fact that some of the species belonging to this family are found in clear non polluted environments and maybe the Capitellid species which are distributed in the studied areas are adapted to the non-polluted environments. This could be an avenue for future work to identify the *C. capitata* species complex in muddy estuaries of the Persian Gulf, and also study why the abundance of this taxa has been recorded low despite the presence of fine particle size substrate with significant content of total organic matter Dehghan *et al*. (2008), Mooraki *et al*. (2009), Mooraki *et al*. (unpublished).

Analyzing the polychaetes community for evaluating the health status of the whole benthic assemblage and their habitat, seems to be usual in many conditions while some single species or groups of species have been introduced as either negative or positive bioindicators. Moreover, before making any conclusion, it should be taken into account that each region is inhabited by specific groups of species, which will respond to environmental alterations in a specific way; and also the fact that numerically dominant species may change temporally, especially in dynamic systems as estuaries. According to this statement, some have espoused the use of higher taxonomic levels of polychaetes (families, orders) as indicators of the health status of the environment (Dean, 2008), which could be true for Jafari Creek as well. In this regard, the taxa which have been recognized as bioindicators should be viewed as specific for the studied area, Jafari Creek. As it is obvious, the members of Glyceridae, Cossuridae, Eunicidae and Nereidae could be introduced as positive bioindicators and Centrolidae, Hesionidae, Terebellidae could be representative of negative bioindicators in the studied region due to their mean abundance during the sampling procedure. Hopefully, this article will stimulate the analysis of the coastal areas of the Persian Gulf to recognize the native members of polychaete taxa and positive and negative bioindicators among them with regards to the nature of the probable pollutants which enter the environment.

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