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Full Length Research Paper

Taxonomic identification and distribution of biofouling organisms in Deilam port in Iran

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In this research, sampling was done from the biofouling organisms of piles of Deilam port from Autumn 2009 to Spring 2010. Two stations were chosen and samples were taken from three zones: super tidal zone, inertial zone and sub-tidal zone in 1 × 1 m^2. At the same time, the environmental factors (pH, salinity, conductivity, temperature) were measured. Ecological indices such as Shanon, species richness, Simpson and evenness were calculated. Results showed that biofoulings belong to 4 phyla, 5 classes, 9 orders, 9 families, and 10 genera. The identified species are as follows: *Palletoida profunda*, *Barbatia obliguata*, *Serpula* sp., *Nereis* sp., *Saccostrea cucullata*, *Thais mutabilis*, *Balanus amphitrite*, *Trochus radiatus*, *Natica vitelius*, *Antopleura* sp. Barnacle (*B. amphytrit*) was the dominant species in all 3 tidal zones. Results of variation analysis between diversity and environmental factors were significant only for temperature (-0.349).

Key words: Biofouling organisms, taxonomic identification, ecological indices, Deilam port.

INTRODUCTION

Biofouling is commonly used to distinguish the assemblages of animals and plants that grow on artificial structures from those occurring on natural objects (Abdul Azis, 2000). There are numerous ways by which man-made objects enter into the marine environment. Accidental introductions occur through shipwrecks, unintentional overboard discards or losses of subsurface equipment. Deliberate introductions range from intertidal or subsurface coastal defences, moored or floating exploitation platforms, pontoons and moorings, boats and ships, pipelines and cables as well as artificial habitats and man-made reefs. Many of these man-made introductions and the research associated with the introduction are reviewed in Jensen et al. (2000). On introduction, the artificial surfaces will attract biological settlement or 'biofoul' at rates that are determined by the biotic and abiotic characteristics of the receiving environment. Over 2000 species of fouling organisms are considered to be potential settlers on the surfaces of artificial structures and until recently, most biofouling research has concentrated on investigating methods of control (Brown and Eaton, 2001).

In the past few years, however, there has been increasing interest in developing methods to promote the growth of biofouling on artificial structures, such as artificial reefs. The rationale is that the biofouling would enhance the productivity of the marine environment (Steimle et al., 2002; Qui et al., 2003), mitigate the loss of marine habitat caused by anthropogenic activities (Burton et al., 2002) and reduce the organic enrichment caused by net-cage fish farming (Angel and Spanier, 2002). Ships show a 10% higher fuel consumption caused by increased drag and frictional resistance resulting from hull and propeller fouling (Denys and Guenther, 2009). Biofouling also promotes corrosion of materials (Dobrevsky et al., 2000). The money and material needed for fouling protection measures are indeed great. It is estimated that the marine industry incurs an expenditure of 10 billion sterling pounds a year to combat the situations arising from biofouling worldwide (Faille et al., 1999). Some biofouling investigations were done in Persian gulf (Mohammad, 1975; Stachowitsch, 2002). But a few research efforts have been devoted to understand the fundamental ecology and biology of fouling environments, organisms, and communities in diverse settings in Iran. The first aim of this work was identification of biofouling and the second objective of this

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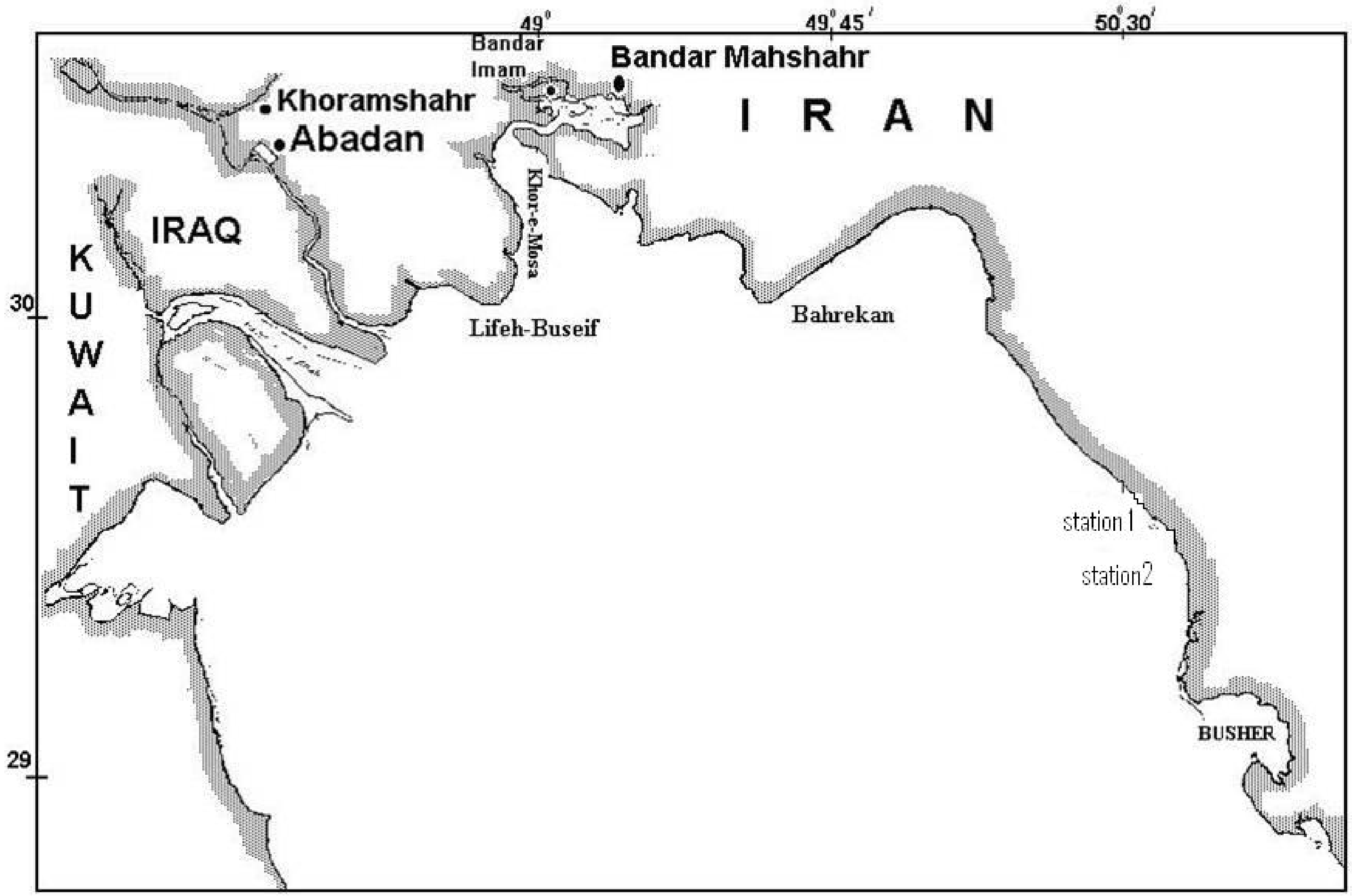

Figure 1. Map of stations in Deilam port.

work was distribution of biofouling in Deilam port.

MATERIALS AND METHODS

In this research, biofouling organisms were collected from piles of Deilam port from Autumn 2009 to Spring 2010. Two stations (Figure 1) were chosen and samples were taken from three zones: super tidal zone, inertial zone and sub tidal zone by quadrate that covered 1m^2. Samples were taken during a low tide. The biofouling were preserved in 5% formaldehyde. Samples were washed by 0/5 mm mesh size number sieve and were identified to species (Anderw, 1993; Janqueira, 2003) and were counted. The numbers of biofouling in each station were converted to density numbers (m^2). Seawater samples were collected from the surface of water in the sub tidal zone using a clean plastic bucket. Water temperature was measured using a mercury thermometer with an accuracy of 1°C. Conductivity was measured using a conductivity meter (Yellow Springs Instr. Co., USA) and pH, using a pH meter (Fisher, USA). Salinity was measured using a salinity meter (). Associations between environmental variables and indices diversity were assessed by calculating Pearson's rank correlation coefficient. Indices diversity for species was calculated with ecological methodology software. Total analysis was measured with SPSS17 and Excel softwares.

RESULTS

Results showed that biofouling belong to 4 phyla, 5 classes, 9 orders, 9 families, and 10 genera. The identified species are as follows: *Palletoida profunda, Barbatia obliguata, Serpula sp., Nereis sp., Saccostrea cucullata, Thais mutabilis, Balanus amphitrite, Trochus radiates, Natica vitelius, Antopleura* sp. Barnacle (*B. amphitrite*) was the dominant species in all stations. Abundance of biofouling in different seasons and stations are shown in Figure 2. Results of temperature, salinity, conductivity and pH are presented in Table 1. Seasonal variation of biofouling in Deilam port has been shown in Table 2.

Classification of identified biofouling in Deilam port is shown in Table 3. Results of variation analysis between indices diversity and environmental factors were significant only for temperature. Temperature was the only factor which had significant effect on diversity of biofouling organisms (-0.349) and other factors had no significant effects (Table 4). Moreover, the results showed that the increase in temperature causes decreases in

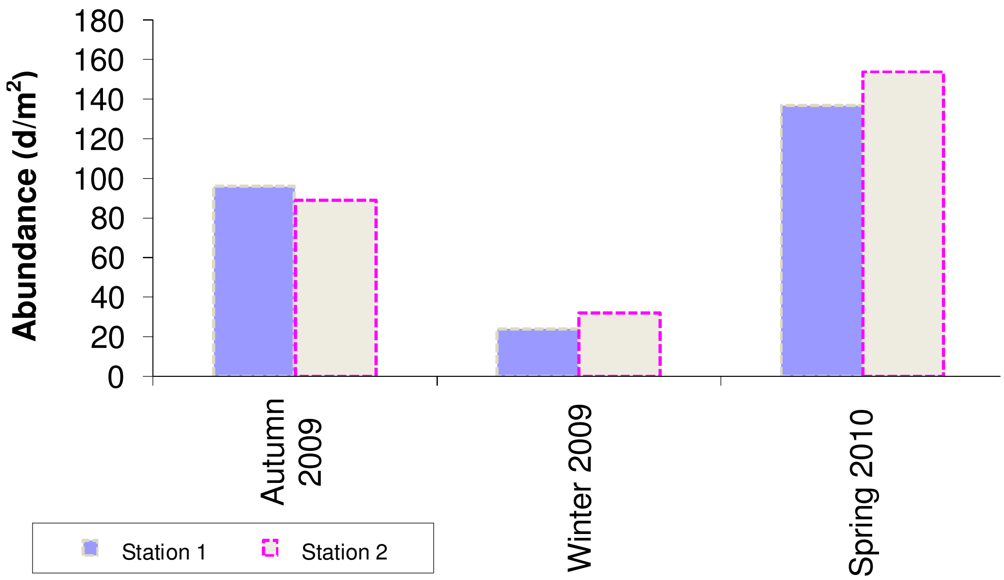

Figure 2. Abundance of biofouling in different seasons and stations in Deilam port.

Table 1. Sea water parameters in Dilam port.

Parameter	Stations	Seasons		
		Autumn	Winter	Summer
Temperature(°C)	Station 1	17	16	28/5
	Station 2	16	15	28
pH	Station 1	7/9	8/1	8/6
	Station 2	8	8/2	8/7
Conductivity (ms/cm)	Station 1	59	58	61
	Station 2	59	59	60
Salinity(‰)	Station 1	39	38	41
	Station 2	38	37	40

biodiversity but it increases the richness. On the other hand, the results revealed a positive correlation between temperature and Simpson index (0.380) and negative correlation between temperature and Shanon, evenness and species richness indices.

DISCUSSION

The most important members of the macrofouling community were the Annelida, Crustacea and Bivalvia, also Anthozoa settled on this port. Altogether, 10 genera of biofouling were present in the Deilam port. There were seasonal differences in species abundance, but overall, Barnacle (*B. amphitrite*) was the most abundant species in Deilam port. Barnacles and mollusks (bivalve) were the major hard foulers. Biofoulings were comprised of six faunal groups namely: Protozoa, Crustacea, Annelida, Nematoda, Mollusca, and Chordata in Saudi Arabia in Persian gulf (Al-Nomazi, 2008). Literature reviews and field sampling during 2005 to 2006 identified 21 species as present in Imam Khomeini port (Khodabakhsh, 2006). Bivalvia in the biofouling community were represented by two genera: *Barbatia* and *Saccostrea*. *Barbatia* and *Saccostrea* only were observed in station 2. The reason for this is concerned about substratum type; substratum type was concrete in station 2 whereas it was fiberglass in station 2. Anderson and Underwood (1994) found that many species, including the oyster *Saccostrea commercialis* and the barnacles *Hexaminius* sp., *B.*

Table 2. Seasonal variation of biofouling in Deilam port.

Species	Autumn		Winter		Spring	
	Station1	Station2	Station1	Station2	Station1	Station2
Palletoida profunda	+	-	+	-	-	+
Anthopleura sp.	+	-	-	-	-	-
Barbatia obliguata	-	+	-	+	-	+
Balanus amphitrite	-	+	-	+	-	+
Serpula sp.	-	+	-	-	-	+
Nereis sp.	-	+	-	+	-	-
Saccostrea cucullata	-	+	-	+	-	+
Thais mutabilis	+	-	+	-	+	-
Trochus radiatus	+	-	+	-	+	-
Natica vitclius	+	-	-	+	-	-

Table 3. Classification of identified biofouling in Deilam port.

Phylum	Class	Order	Family	Genus	Species
Molluscs	Gastropoda	1) Archaeogastropoda	Lotiidae	*Palletoida*	*Palletoida profunda*
			Trochidae	*Trochus*	*Trochus radiatus*
		2) Mesogastropoda	Littorinimorpha	*Natica*	*Natica vitclius*
		3) Neogastropoda	Muricidae	*Thais*	*Thais mutabilis*
	Bivalvia	1) Arcoida	Arcidae	*Barbatia*	*Barbatia obliguata*
		2) Pterioida	Ostreidae	*Saccostrea*	*Saccostrea cucullata*
Cnidaria	Anthozoa	Actinaria	Actiniidae	*Anthopleura sp.*	
Annelida	Polychaeta	1) Aciculata	Nereididae	*Nereis sp.*	
		2) Sabellida	Serpulidae	*Serpula sp.*	
Anthropoda	Maxillopoda	Sessilia	Balanidae	*Balanus*	*Balanus amphitrite*

amphitrite and *Balanus variegatus*, recruited in higher numbers onto substratum consisting of concrete or plywood than onto fiberglass or aluminium (Anderson and Underwood, 1994). The abundance of fouling organisms was subject to geographical and seasonal variation, being considerably higher in station 2 and throughout the spring. There was an inter-annual variation that was presumably caused by seasonal variation in the environmental features of Deilam port. Settlements of the biofouling was maximum in spring.

However, during winter, the settlement was poor. Presumably due to temperature variation that occurs towards the end of the winter. Several studies have shown marked decreases in fouling with decreasing temperature and increasing depth (Costlow, 1967).

Parameters such as temperature, conductivity, pH and salinity showed seasonal fluctuations in the Deilam port. The pH of the seawater ranged from 7.9 to 8.7 indicating that the variations in seawater pH remained within narrow limits. The sea surface conductivity ranged from 58 to 61 ms/cm in the Deilam port. The lowest value for conductivity was recorded in winter whereas the highest was in summer. Salinity ranged from 37 to 41 (‰). The lowest salinity was in winter and highest salinity was in summer. Patterns of colonisation and succession in biofouling communities within sub tropical regions are highly affected by seasonality. This seasonality is reflected in changes in both the quantity of biofouling and species composition of these communities (Railkin, 2004). Fouling community development lessens during winter because of reductions in light levels, water temperature and a reduction in the settlement of macrofouling organisms on substrates (Railkin, 2004). Temperature of water plays a very significant role in the settlement of organisms (Desai et al., 2006). The effect of temperature and salinity on the attachment, growth and

Table 4. Correlation between indices diversity and physicochemical factors.

	TEMPER	pH	DO	SALINITY	SIMPSON	SHANON	EVENNESS	RICHNESS
TEMPER	1.000							
pH	0.288	1.000						
DO	-0.370	-0.590	1.000	1.000				
SALINITY	0.443	-0.010	-0.177	-0.123				
SIMPSON	0.380	0.058	-0.176	0.255	1.000			
SHANON	-0.349	-0.081	0.197	0.065	-0.913	1.000		
EVENNESS	-0.304	0.008	0.007	0.040	-0.950	0.821	1.000	
RICHNESS	-0.601	-0.191	0.144	0.040	-0.702	0.677	0.598	1.000

breeding of the major macrofouling fauna (e.g. barnacles, mussels and bryozoans) is well documented. For example, the reproductive cycles of seven species of barnacles in Japan was studied. Four of the seven species could only breed at a limited range of temperature (Iwaka, 1981). Adult barnacles fed artemia were maintained at 20, 25 and 30°C (Desai et al., 2006).

The barnacle *B. amphitrite* is a dominant fouling organism found in warm and temperate waters throughout the world (Desai et al., 2006). The results showed that increase in temperature causes decreases in biodiversity but it increases richness. On the other hand, the results revealed a positive correlation between temperature and Simpson index (0.380) and negative correlation between temperature and Shanon, evenness and species richness indices. Also, a negative correlation between Simpson with Shanon, evenness, and richness indices was observed. In brief, the results indicated that increases in species dominance was joint with decreasing biodiversity and species richness. In general, the local environmental habitat conditions temperature, light intensity, hydrodynamics, sedimentation rate, turbidity, substratum stability geographical condition and distance from coast are the most important factors on seasonal variation of biofoulings that were reported in a previous study (Gomez de Saravia et al., 2001).

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