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Oil-related Contamination in the Sediment and Water of Khark Island, Persian Gulf

[1,2]*Javad Kazemzadeh Khoei,*
[2]*Afshin AbdiBastami and* [2]*S. Farmohammadi*

[1]Department of Microbiology, Faculty of Biology, Baku State University, Azarbayejan, Iran
[2]Iranian Academic Center for Education, Culture and Research (ACECR)

Abstract: In the present study the concentrations of oil-related heavy metals (Ni, V and Pb) and PAHs (naphthalene, acenaphthene, pyrene and benzo(a)pyrene) were determined in the water and sediment of Khark Island. A flame atomic absorption spectrometer and an HPLCwere used to measure the levels of heavy metals and PAH compounds in the samples respectively. The results showed that pyrene largely predominated in water and sediment. The highest levels of total PAH in water (70.72 ng/g) and sediment (607.76ng/g) were observed in S1. The accumulation order of heavy metals in the water and sediment samples was Ni > V > Pb >. The comparison among stations indicated that S1 had the highest levels of Ni (126.97 µg/g), V (28.65 µg/g) and Pb (12.64 µg/g) in sediment.

Key words: PAH · Heavy metal · Khark Island · Persian Gulf · Sediment

INTRODUCTION

The Persian Gulf is a very important industrial area. It is a shallow area with a depth ranging between 10-100 m and a surface of $2.39x10^5$ km^2. The salinity of this sea ranging between 37.0-40.0%0 and the surface temperature ranging between 10-36°C during winter and. summer seasons respectively[1].The Persian Gulf represents a stressed ecosystem due to its location within the richest oil province in the world hosting more than 67% of the world oil reserve. Oil-related activities that range from exploration to exportation result in a wide range of adverse effects that cause significant damages to the components of the ecosystem such as coral reefs, algal mats, mangrove and other habitats[2]. It is well known that some heavy metals such as Ni, V and Pb and some PAHs such naphthalene (NAP), acenaphthene (ACE), pyrene (PYR) and benzo(a)pyrene (BaP) are resulted from oil contamination in the Persian Gulf [3].

PAHs and heavy metals are considered toxic for aquatic organisms, such as fish [4], shrimp and bivalve mollusks [5]. PAHs have been included in the Agency of Toxic Substances and Disease Register (ATSDR), the International Agency for Research on Cancer (IARC), in the European Community (EC) and in the Environmental Protection Agency (EPA) priority pollutant lists, due to their mutagenic and carcinogenic properties. In 1984, the United States Environmental Protection Agency (USEPA) designated 16 PAHs as compounds of interest under a suggested procedure for reporting test measurement results [6]. Heavy metals are regarded as serious pollutants of the aquatic environment because of their environmental persistence and tendency to be concentrated in aquatic organisms. Heavy metal and PAHs are toxic contaminants and has serious effects on brain and nervous system of contaminated organisms [4].

In the present study, we examined the accumulation of oil-related PAHs, including naphthalene (NAP), acenaphthene (ACE), pyrene (PYR) and benzo(a)pyrene (BaP) and oil-related heavy metals, including Ni, V and Pb in the sediment and water of Khark Island, which characterized by remarkable oil pollution.

MATERIALS AND METHODS

Sediment and water samples were collected from three different stations along Khark Islans, including, station 1 (S1), station 2 (S2) and station 3 (S3) (Fig. 1) in February 2012. Water samples were collected by Nansen Sampler 0.5 m below the water surface in bottles, acidified by

Correspond Author: Afshin AbdiBastami, Department of Microbiology, Faculty of Biology, Baku State University, Azarbayejan, Iran, Tel: +989122905125.

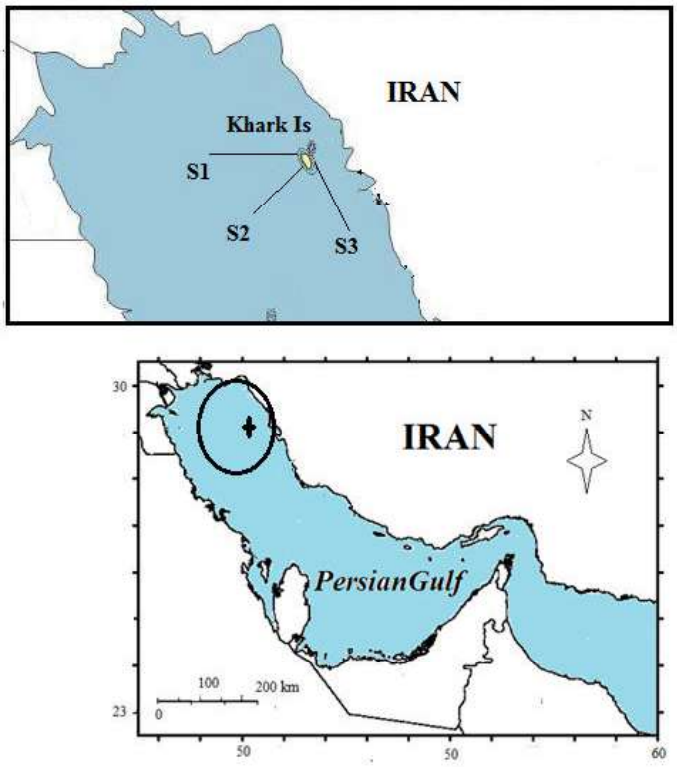

Fig. 1: A map showing of Khark Is and the stations

adding 0.5% concentrated nitric acid and were filtered through micropore membrane filter. Sediment samples were collected using stainless steel Van Veen Grab. The samples were transferred to the laboratory using icebox and were kept frozen at -20 °C until dissection.

Before analysis, sediment samples were thawed at room temperature, oven-dried for 24 h at 105 °C, powdered in an agate mortar and then sieved through a 63-µm mesh [7]. The extraction of PAH compound were performed using the method described by Schneider *et al*. (2001). The method described by Abdolahpur Monikh *et al*., (2012) was used in order to determine metal concentration in the samples.

All reagents used were of analytical grade. All the glassware were soaked in 10% nitric acid for 24 h and rinsed three times with double distilled water before use. Standard reference material SRM 1645 (National Bureau of Standards) was used to check the analysis accuracy of metal determination. The result showed good agreement with the certified values. For quality control of PAHs extraction, internal standard mixture (d10-2-methylnaphthalene,D10-fluorene, d10-fluoranthene, d12-perylene) was added to the samples. The blanks were prepared in a similar manner without samples to avoid samples contamination. In order to determine the concentrations of PAHs in the fish samples, an HPLC (model KANUER) equipped with a UV detector system was used. A GBC (Savant AA?, Australia) Flame Atomic Absorption Spectrometer was employed to determine Ni, V and Pb in samples.

All data were tested for normal distribution with Shapiro-wilk normality test. Significant differences between heavy metals and PAHs concentration in the samples of various stations were determined using one-way analysis of variance (ANOVA) fallowed by Duncan post hoc test. The level of significance was set at α= 0.05.

RESULTS AND DISCUSSION

The concentrations of PAH compounds and Heavy metals in water and sediment samples collected from Khark Island are given in Tables 1 and 2 respectively. In water samples, PYR and BaP are abundant in all stations. The predominant components of PAHs in the sediment of all stations were PYR and BaP (Table 1).This findings indicate that the contamination of PAH in all Khark Island coasts originate from the same sources. The concentration of total PAHs in sediment were significantly higher than that in water. This is not surprising because of the ability of bottom sediment to act

Table 1: The levels (mean) of PAH compounds in sediment and water samples from Khark Island (ng/g d. w) and guideline

	S1		S2		S3			
PAH	Water	Sediment	Water	Sediment	Water	Sediment	ERL	ERM
NAP	1.87 ± 0.23^{c}	17.56 ± 4.31^{c}	0.54 ± 0.1^{b}	12.33 ± 3.14^{b}	0.32± 0.1^{a}	6.11± 2.15^{a}	160	2100
ACE	0.43 ± 0.1^{b}	3.99 ± 0.55^{c}	0.12 ± 0.1^{a}	1.34 ± 0.4^{b}	0.13± 0.03^{a}	0.67± 0.2^{a}	16	500
PYR	41.98 ± 6.4^{c}	368.21 ± 63.42^{c}	30.94 ± 3.88^{b}	246.1 ± 62^{b}	15.09± 4.19^{a}	177.31± 39.72^{a}	665	2600
BaP	26.44 ± 5.21^{c}	218 ± 28.37^{c}	16.27 ± 5.86^{b}	120.21 ± 26.3^{b}	9.83± 3^{a}	88.42± 27.92^{a}	430	1600
Total PAH	70.72 ± 17.64^{c}	607.76 ± 52.94^{c}	47.87 ± 13.83^{b}	379.98 ± 72.14^{b}	25.37± 6.33^{a}	272.51± 46.52^{a}		

ERL, Effect Range Low. ERM, Effect Range Median. abc Different letters show significant differences of PAHs concentrations between stations

Table 2: The levels (mean) of heavy metals in sediment and water samples from Khark Island (µg/g d. w) and guideline

	S1		S2		S3			
Metal	Water	Sediment	Water	Sediment	Water	Sediment	ERL	ERM
Ni	21.66 ± 4.8^{b}	126.97 ± 42.9^{b}	19.32 ± 5.92^{b}	124.86 ± 52.13^{b}	14.74± 3.8^{a}	112.31± 37^{a}	21	52
V	3.77 ± 1.03^{c}	28.65 ± 6.72^{c}	2.23 ± 0.6^{b}	21.07 ± 4.92^{b}	1.41± 0.34^{a}	15.92± 4.98^{a}		
Pb	1.48 ± 0.34^{c}	12.64 ± 2.45^{b}	0.87 ± 0.2^{b}	11.43 ± 2.56^{b}	0.37± 0.1^{a}	8.32± 3.88^{a}	47	218

ERL, Effect Range Low. ERM, Effect Range Median. abc Different letters show significant differences of metals concentrations between stations

as a trap for entered contaminations [8]. Nonpolar organic chemicals, such as PAHs, because of their low affinity for the water phase, tend to have a strong affinity for phase boundaries, such as the surface sediment of the marine ecosystems and the surface of particles [9].The tendency for PAHs in solution to adsorb to suspended or deposited particles can be expressed as a sediment/water partition coefficient (K_p) [9].

In water samples, Ni in the highest and Pb in the lowest concentration were observed in Khark Island. The accumulation order of heavy metals in the water samples was Ni > V > Pb >. Also, in sediment; Ni was found in higher concentrations than other heavy metals. As also indicated by Abdolahpur Monikh *et al*. (2013), the highest concentrations of Ni in the water of the Persian Gulf may be attributed to oil pollution in the region. Safahieh *et al*. (2011) also reported Ni to be found in the highest accumulation in the sediment of Musa estuary, Persian Gulf. These finding are consistent to our results.

The concentration of the heavy metals and PAH compounds varies significantly among stations. The highest concentration of Total PAHs, Ni, V and Pb was recorded at S1. Khark Islan is the biggest Iranian oil terminals in the Persian Gulf. High concentration of the studied metals and PAHs, possibly due to direct contamination of the water by oil and petrochemical related discharges. Such an assumption gives evidence that the heavy metal and PAHs pollution in Khark Island originate from anthropogenic affect.A comparison between our results and those of previous studies in the Persian Gulf and elsewhere in the world was done. The concentration of V, Ni and Pb obtained in this study are generally higher than those reported in Jebel Ali (UAE) and Askar (Bahrain) along the south Persian Gulf [10]. The concentration of Pb in Akkah Beach [10] was extremely higher than those reported in this study. The concentration of heavy metals in the northewest part of the Persian Gulf [11] was considerably greater than those observed in the present study.The concentrations of total PAH in this study were higher than those reported by Hosseini*et al*. (2012)in Water of the north Persian Gulf.

To understand the magnitude of heavy metals and PAHs concentration in the sediment of Khark Island, the levels recorded in this study were compared with standard guidelines (Table 1 and 2). Generally, the concentrations of naphthalene, acenaphthene, pyrene and benzo(a)pyrene measured in current study do not exceed ERL and ERM, the guidelines that established by Canadian SQG and NOAA [11]. However, the elevated Ni level, particularly in S1, exceeds maximum concentration of Ni reported by the sediment quality guidelines.

CONCLUSION

This study provides new information on the levels of oil-related PAHs and heavy metals in Khark Island. According to the results, pyrene was the dominant compounds of PAHs. S1 had the highest levels of the studied contaminant, however, except for Ni; the concentrations of the other contaminants do not exceed ERL and ERM.

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