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Ecological Risk Assessment of Polycyclic Aromatic Hydrocarbons in the Northwest of the Persian Gulf

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Abstract**—**This study investigated the presence of polycyclic aromatic hydrocarbons (PAHs) in the sediments of the Musa Bay (around the PETZONE coastal area) from Feb 2010 to Jun 2010. Concentrations of PAHs recorded in the Musa Bay sediments ranged from 537.89 to 26,659.06 ng/g dry weight with a mean value of 3990.74 ng/g. the highest concentration of PAHs was observed at station 4, which is located near the aromatic outlet of Imam Khomeini petrochemical company (station 4: BI-PC Aromatic effluent outlet) in which its concentration level was more than the NOAA sediment quality guideline value (ERL= 4022 ng/g dry weight). Owing to the concentration of PAHs in the study area, its concentration level was still meet the NOAA sediment quality guideline value (ERL: 4022 ng/g dry weight); however, according to the PELq factor, slightly adverse biological effects are associated with the exposure to PAHs levels in the study area (0.1< PELq= 0.24 > 0.5).

Keywords**—**Musa Bay, PAHs, PETZONE, NOAA, PELq.

I. Introduction

As defined by the Environmental Protection Agency (EPA), ecological assessment is a process that investigates the harmful and inappropriate or adverse ecological effects that result from the exposure of an environment to one or more stresses [1].

Although the limited portions of marine environments especially seashore areas , were defined as a marine protected areas (because controlling and protecting the condition of seashores is easier and more feasible) , but these areas cannot be isolated from the effects of different environmental variables, thus the current viewpoint of most marine protection experts is to recognize the main resources of stress and endangers in marine ecosystems and reservoirs and create management plans to decrease or eliminate stress-producing factors [2].

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Marine contamination not only affects the world of fishing industries but may also significantly affect the natural resources which are subjected to overfishing and natural habitat destruction [3]. Coastal sediments may act as a temporary or long-term reservoir of contaminants accompanied by natural origin compounds. Aliphatic and polycyclic aromatic hydrocarbon compounds and also heavy metals and trace elements are omnipresent components of coastal sediments and derive from natural and anthropogenic sources. The natural concentration of chemical compounds is characterized as a base and background for identifying the portion of anthropogenic sources [4-6]. An important category of petroleum pollution is groups of chemical compounds include of two or more fused benzene rings called polycyclic aromatic hydrocarbons (PAHs) that are carcinogenic, mutagenic and toxic [7].

The objectives of the present study are the following: to estimate concentration of Polycyclic Aromatic Hydrocarbons (PAHs) in surface sediment to distinguish vulnerable stations and to evaluate ecologic risk to assess adverse biological effects in the northwest of the Persian Gulf. Because, according to the IMO declaration, the Gulf area is the most sensitive area in the world [8] and based on the scientific reports, 49% of the world’s oil production comes from the Gulf States and passes through this old waterway.

Several studies showed that the Persian Gulf is the most oil-polluted marine area in the world, even before the Gulf war and the Gulf oil pollution is about 48 times that of any other similar area on the earth [8-11]. Department of Environment of Iran has reported that, the Musa Bay (northwest of the Persian Gulf) is considered as the most sensitive marine area in Iran and the Gulf area. Therefore, Musa Bay is important for the whole northwestern coast of the Persian Gulf [8].

II. Experimental Section

In this present study, sediment samples from Musa Bay were collected from 10 stations located in the coastal area of the PETZONE were monitored from Feb 2010 to June 2010, by using an Ekman-Birge grab sampler 225 cm^2. All the sampling stations were determined based on the suggestions of the experts of PETZONE environmental office. Sampling stations were in the proximity of PETZONE wastewater discharge points and make another sampling point whit 700 m apart on each transect. In general, sampling stations were monitored and they are represented as Table I and Fig. 1.

The study area is covered with fine-grained sediments and the top surface sediment 0-5 or 0-10 cm from each grab samples. Then, sediment samples were stored in aluminum foils and placed on compartment ice after sampling, immediately transported to the laboratory and kept in the refrigerator at -20 °C until further analysis for measuring organic contaminants (PAHs). This follows the methodologies by Paul et al. (1992) and MOOPAM (1999) [12-13].

TABLE I
SAMPLING STATIONS OF MUSA BAY

No.	*E*	*N*
1	49° 6'48.50"E	30°26'53.50"N
1-J	49° 7'29.49"E	30°26'36.12"N
2	49° 7'12.44"E	30°26'17.34"N
2-BI	49° 7'40.01"E	30°25'59.60"N
3	49° 7'0.47"E	30°25'50.09"N
3-BI	49° 7'28.11"E	30°25'28.77"N
4	49° 6'26.87"E	30°25'37.39"N
4-BI	49° 6'45.47"E	30°25'11.46"N
5	49° 6'2.06"E	30°25'29.16"N
5-R	49° 6'12.26"E	30°25'1.02"N

Each sample was analyzed by gas chromatography mass spectrometry (GC-MS; GC, Agilent, 6890N, MS: Agilent, 5973N) for PAHs [13-14]. Finally, the concentration of the following PAHs were determined: Naphthalene (Na), Acenaphthylene (Acpy), Acenaphthene (Acp), Fluorene (Flur), Phenanthrene (Phen) and Anthracene (Ant), Fluoranthene (Flu), Pyrene (Py), Benzo (a) anthracene (BaA), Chrysene (Chr), Benzo (b) fluoranthene (BbF), Benzo(k) fluoranthene (BkF), Benzo (a) pyrene (BaP), Dibenzo(a,h)anthracene (DbahA), Benzo (g,h,i) perylene (BghiP), Indeno (1,2,3-cd) pyrene (IP) [15-18].

In this study, the ecological risk was assessed based on the concentration of PAHs in the sediments and the sediment quality guidelines (SQGs) were used to assess adverse biological effect in this area [19, 20].

This (SQGs) method indicates that the relationship between the concentrations of contaminants in sediment samples and adverse biological effects is based on the specific values of effect range low or threshold effect level (TEL) and effect range medium or probable effects level (PEL). The TEL value has been estimated as the concentration of contaminants with a relatively low effect on biological communities, and PEL is a concentration of contaminants with high toxic effects. Occasional toxic effects are expected to occur from contaminates Concentrations between TEL and PEL occasional toxic effect are expected [19, 21-22].

The PELq factor is the average of the ratios between the concentration of these parameters the sediment sample and the related PEL value [23, 24]. This factor describes contamination effect on biological organisms in sediment which range as non-adverse effect (PELq < 0.1), slightly adverse effect (0.1< PELq > 0.5), moderately adverse effect (0.5< PELq > 1.5) and heavily adverse effect (PELq > 1.5) [25].

Fig. 1 Sampling stations in the Musa Bay

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III. Result

The average concentrations of PAHs obtained in the sampling sediments of Musa Bay are shown in Table II.

TABLE II
PAHS CONCENTRATIONS IN THE SAMPLING SEDIMENTS OF MUSA BAY (NG/G, DRY WT.)

Station name	**1**	**1-J**	**2**	**2-BI**	**3**	**PEL**
Σ PAHs	646.37	454.3	1312.38	537.89	2713.33	
Station name	**3-BI**	**4**	**4-BI**	**5**	**5-R**	16770
Σ PAHs	1875.17	26659.06	2160.42	1410.46	2138.09	

PEL: Probable Effects Level

Most values were exceptionally low, except for the sediments near the station 4, which is located near the aromatic outlet of Imam Khomeini petrochemical company (station 4: BI-PC Aromatic effluent outlet) in which its concentration level was more than the NOAA sediment quality guideline value (ERL= 4022 ng/g dry weight) [21].

The cluster analysis of total PAH showed that this factor can be classified into two groups and classified station 4 significantly different from other stations (Fig. 2).

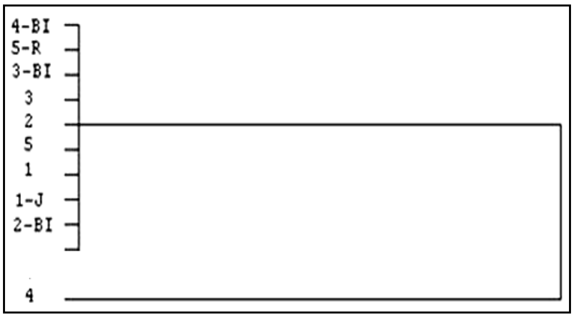

Fig. 2 A dendrogram representation of a hierarchical cluster analysis of the PAHs in the Bay

PAHs in sampling sediments from the Musa Bay ranged from 537.89 to 26,659.06 ng/g dry weight with a mean value of 3990.74 ng/g.

The PELq factor was calculated and the results are shown in Table III.

TABLE III
THE VALUE OF PELQ IN EACH SAMPLING STATION BASED ON THE CONCENTRATION OF PAHS IN MUSA BAY

Station name	**Σ PAHs**	PELq
1	646.37	0.04
1-J	454.30	0.03
2	1312.38	0.08
2-BI	537.89	0.03
3	2713.33	0.16
3-BI	1875.17	0.11
4	26659.06	1.59
4-BI	2160.42	0.13
5	1410.46	0.08
5-R	2138.09	0.13
Σ PAHs	3990.75	0.24

Ecological risk assessment based on the sediment quality guidelines showed that, most of the stations can be categorized as non-adverse effects (PELq < 0.1) except stations, 3-BI, 4-BI and 5-R which are categorized as slightly adverse effects (0.1< PELq > 0.5), and the station 4 which is classified as heavily adverse effects (PELq > 1.5).

IV. Discussion

Ecological assessment of PAHs compounds in this study Highlighted via two main problems, first of all, the scarcity of information on the PAHs concentrations in the sediments, and no background was available. The second problem was related to the biological effects and guidelines, as no SQGs were available to coastal water of Iran.

Owing to the concentration of PAHs in the study area, its concentration level was still meet the NOAA sediment quality guideline value (ERL= 4022 ng/g dry weight); however, according to the PELq factor, the study area can be categorized as slightly ecological adverse effect (0.1< PELq= 0.24 > 0.5).

V. Conclusion

In conclusion, average concentration of PAHs in the sampling sediments of the Musa Bay was lower than the guideline value. Thus, according to the above discussion, it may be concluded that PAHs, are not the main pollutants of potential concern in the study area. Also, in the present study highlighted that slightly adverse biological effects are associated with the exposure to PAHs levels in the Bay.

The unusual results may be related to the deposition of finer sediments along the Iranian eastern side and northwest area, which is associated with the counter-clockwise circulation from the Indian Ocean, deposition of eolian sediments, also the North wind which can cause water turbulence and self-purification in the Gulf area, probably the effects of tidal currents [26, 27].

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