Baseline

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Baseline of polycyclic aromatic hydrocarbons in the surface sediment and sea cucumbers (*Holothuria leucospilota* and *Stichopus hermanni*) in the northern parts of Persian Gulf

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ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) were determined in the surface sediments and in the sea cucumbers (*Holothuria leucospilota* and *Stichopus hermanni*) from around six Islands in the northern parts of Persian Gulf. The ranges of the average concentrations of PAHs in surface sediments, *H. leucospilota* and *S. hermanni* were 10.33–186.16 ng g^{-1} dw, 12.49–505.44 ng g^{-1} dw and 8.08–389.39 ng g^{-1} dw, respectively. The spatial distribution of PAHs reveals that pollutant concentration is relatively higher at the western parts of Persian Gulf. International sedimentary quality guidelines (TEL-PEL) indicated a low probability of harmful effects to benthic organisms. PAH source identification showed that the PAHs in the sediments come from pyrogenic and mixed origin.

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Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous environmental contaminants derived mainly from pyrogenic, petrogenic and diagenetic origin. PAHs are a large group of organic compounds with two or more fused aromatic rings. The composition of PAH assemblages in sediments varies widely depending on the sources of the PAH. Source determination of PAH in the marine environment seems to be difficult, because they are produced by three major processes: pyrogenic PAH, petrogenic PAH and diagenic PAH (Neff, 1979). They are globally distributed environmental contaminants with issues related to their known toxic and bio accumulative characteristics (Menzie et al., 1992). Several of them have been found to induce a number of adverse effects such as immunotoxicity, genotoxicity, mutagenicity and carcinogenicity (Neff, 1979; USEPA, 1993).

Sea cucumbers are one of the Echinodermata belonging to the class of Holothuroidea that appeared during the evolutionary period, 540 million years ago in the oceans. At present, 1400 species of sea cucumbers have been identified and reported in the seas of the world (Conand, 2006).

The dominant genus present in the northern parts of Persian Gulf is *Holothuria*, where twenty-five species of sea cucumbers have already been recorded from the Iranian coast of the Persian Gulf (Afkhami et al., 2015).

Sea cucumbers are aquatic creatures with many important and useful properties known for human health. In recent years different studies have been done on the Persian Gulf sea cucumbers including body wall composition (Salarzadeh et al., 2012), fatty acid profile (Yahyavi et al., 2012), antibacterial, antifungal and cytotoxic effects (Mohammadizadeh et al., 2013) and some new species were recorded (Afkhami et al., 2012a, 2012b, 2012c; Bastami et al., 2012; Ehsanpour et al., 2012).

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Fig. 1. Sampling sites from six islands of the Persian Gulf.

The Persian Gulf is a semi-enclosed and shallow basin which is connected to Gulf of Oman through Strait of Hormuz. The circulation in the Persian Gulf is driven by wind-stress, surface buoyancy fluxes, fresh water runoff, water exchange through the Strait of Hormuz and tides. The Persian Gulf area has about two-thirds of the world's oil sources therefore problems associated with oil pollution appear to be of greater significance in the Persian Gulf compared with other regions. Consequently, a combination of tanker traffic, accidental spills, Urbanization, industrialization, port areas and refineries are major sources of pollution in the marine environment.

Very little information is available on extend of PAHs pollution in the sea cucumber of Persian Gulf. Therefore the objective of the present paper was to investigate the levels of PAHs in *Holothuria leucospilota* and *Stichopus hermanni* and sediment samples collected from Persian Gulf.

Fresh samples of *H. leucospilota* (n = 10 in each sampling site) and *S. hermanni* (n = 10 in each sampling site) have been caught from six Islands (Kharg Island: St1, Lavan Island: St2, Hendourabi Island: St3, Farour Island: St4, Hengam Island: St5, and Larak Island: St6) of Persian Gulf, Iran by SCUBA diving in July 2013 (Fig. 1). Tissue samples have been wrapped in pre-cleaned aluminium foil and kept frozen (−20 °C) until analysis. For extraction and purification procedure of PAHs in sea cucumber tissues, we followed the method by Perugini et al. (2007) with some slight modifications. After thawing, assay sample (2 g dw) was placed into a 100 ml round-bottomed flask with 10 ml of 1 M KOH in an ethanolic solution. The mixture was placed for 3 h in 80 °C in a reflux system. The liquid phases were transferred to a separation funnel and extracted with 10 ml cyclohexane under rigorous shaking for 30 min. The cyclohexane KOH phase was drained and discarded.

Table 1

Concentrations of polycyclic aromatic hydrocarbons in sediment (ng g^{-1} dw) of sampling sites. Mean concentrations and standard deviation (±SD).

PAHs	Sampling sites					
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Naphthalene	19.063 ± 0.20	13.7 ± 1.49	7.303 ± 0.09	2.25 ± 0.91	10.473 ± 0.41	11.1 ± 1.3
Acenaphthylene	16.81 ± 0.55	11.1 ± 6.40	2.8 ± 1.61	0.54 ± 0.43	7.82 ± 1.30	7.146 ± 0.21
Acenaphthene	ND	27.65 ± 0.60	11.61 ± 0.18	3.98 ± 0.30	6.203 ± 1.07	3.203 ± 0.94
Fluorene	ND	30.33 ± 1.24	1.85 ± 1.60	0.26 ± 0.45	ND	ND
Phenantherene	11.47 ± 0.49	3.83 ± 0.25	2.36 ± 0.58	0.75 ± 0.083	11.08 ± 0.24	8.14 ± 0.34
Anthracene	6.03 ± 0.34	2.68 ± 0.46	0.85 ± 0.31	0.32 ± 0.007	3.28 ± 0.135	ND
Fluoranthene	24.6 ± 0.77	14.87 ± 0.40	2.21 ± 0.08	0.85 ± 0.30	17.74 ± 0.4	14.12 ± 1.68
Pyrene	35.48 ± 3.27	17.82 ± 0.41	1.49 ± 0.28	0.59 ± 0.135	13.6 ± 1.15	4.21 ± 0.61
Benzo[*a*]anthracene	6.43 ± 0.10	3.79 ± 0.52	ND	0.08 ± 0.144	7.206 ± 1.05	6.99 ± 0.67
Chrysene	18.49 ± 0.19	13.37 ± 0.35	0.49 ± 0.06	0.21 ± 0.015	5.263 ± 0.12	4.50 ± 0.26
Benzo[*b*]fluoranthene	12.47 ± 0.39	9.78 ± 0.33	ND	ND	13.36 ± 0.19	10.2 ± 1.24
Benzo[*k*]fluoranthene	16.30 ± 0.95	11.76 ± 0.54	ND	0.38 ± 0.65	12.89 ± 0.42	7.69 ± 0.405
Benzo[*a*]pyrene	12.51 ± 0.19	11.3 ± 0.04	ND	ND	8.81 ± 0.2	5.73 ± 0.51
Indeno[1,2,3-*cd*]pyrene	ND	ND	ND	ND	ND	ND
Dibenz[*a,h*]anthracene	ND	ND	0.64 ± 0.032	0.11 ± 0.098	3.246 ± 0.032	ND
Benzo[*ghi*]pyrene	6.48 ± 5.61	2.1 ± 1.21	ND	ND	9.37 ± 0.35	7.52 ± 0.506
ΣPAHs	186.16 ± 10.05	174.17 ± 9.022	31.63 ± 3.172	10.33 ± 1.05	130.36 ± 5.039	90.57 ± 4.29

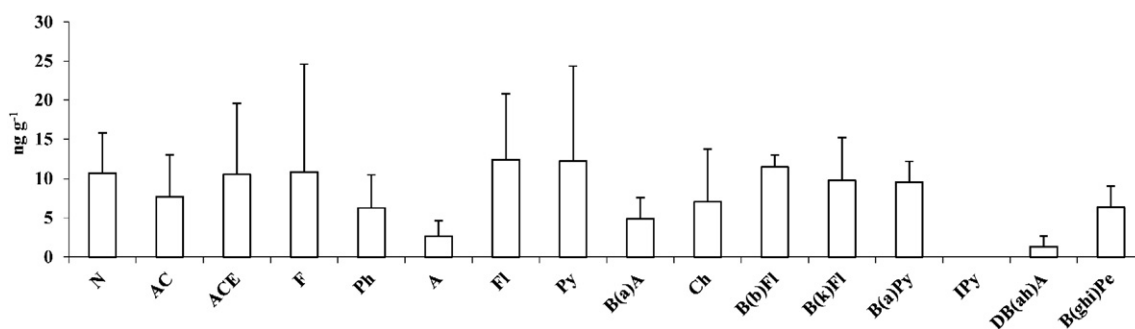ΣPAHs = sum of detected PAHs.
ND = not detected.

Fig. 2. Average ($\pm$ SD) individual PAH in sediment (ng g^{-1} dw) of Persian Gulf.

Table 2
Comparison of ΣPAHs levels (ng g^{-1} dw) in the sediment of northern parts of Persian Gulf with other locations.

Sites	Range	Reference
Persian Gulf	10.33–186.16	This study
Hormuz strait, Persian Gulf	72.17–277.77	Rahmanpoor et al. (2013)
Gorgan Bay	107.87–516.18	Eghtesadi Araghi et al. (2014)
Northern Persian Gulf	42.29–228.9	Bastami et al. (2013)
Northern Persian Gulf	24–1374	Eghtesadi et al. (2002)
Persian Gulf	400–790	Badawy et al. (1993)
Laizhou Bay, China	97.2–204.8	Hu et al. (2010)
San Diego Bay, USA	80–20,000	Anderson et al. (1996)
Masan Bay, Korea	9.1–1400	Kim et al. (1999)
Liaodong Bay, China	144.5–291.7	Ningjing et al. (2010)
Daya Bay, China	42.5–158.2	Yan et al. (2009)

Thereafter the liquid phases were rinsed twice again with 10 ml cyclohexane. Samples were allowed passing through anhydrous sodium sulfate column. The organic phase was concentrated in a rotary evaporator (Model Buchi B-490) to a volume of 5 ml under reduced pressure. Samples were allowed to pass through a column filled with florisil and concentrated in the rotary evaporator (30 °C, 19–21 kPa) to volume of 1 ml. Extracts were evaporated to about 1 ml at room temperature with a gentle stream of nitrogen and reconstituted in 1 ml of acetonitrile.

All sediment samples (top 5 cm) were taken by using a Van-Veen grab sampler from locations within sea cucumber collection sites. All samples were taken from locations corresponding to the areas of sea cucumber collection. Sediment sample was placed in a Teflon-lined amber vial on ice until it could be stored at −20 °C waiting for PAHs analysis (ICES, 1997). Extraction and purification of PAHs in sediment was carried out according to following method. Before the assessments, sediment samples obtained from one location was mixed and a composite sample was prepared. These three sediment samples (200 g of sediment) were freeze dried (freeze-drier Model: OPR-FDB-5503, Korea) at −40 °C for 24 h to a constant weight.

10 g of each sample were mixed with 250 ml of n-hexane and dichloromethane mixture (1:1 ratio). The mixture was placed for 8 h in Soxhlet. The combined extracts were evaporated on a rotary vacuum evaporator until 15 ml was left. To eliminate sulfur and their

compounds, 3 g of active copper was added to the mixture and allowed to pass through a folded filter paper (Whatman GF/C, 24 μm) for 24 h. The mixture was concentrated in a rotary (Buchi B-490) to a volume of 5 ml. Samples were allowed to pass through a column containing 10 g silica gel in n-hexane, 1–2 g anhydrous sodium sulfate and 10 ml alumina. Then, 30 ml of n-hexane and dichloromethane mixture (9:1 ratio) were added to the column. Samples were concentrated again in a rotary evaporator to a volume of 5 ml. The concentrated extract was dried under nitrogen steam (N-E VAP 112, USA). The residue was dissolved in 1 ml of acetonitrile (MOOPAM, 1999). Replicate samples, certified reference materials and procedural blanks were used as quality control procedures. All the obtained values for PAHs in CRM were in the reported range.

The sixteen most toxic PAHs listed by the EPA were assessed in sediments. The abbreviations used for the investigated PAHs are: naphthalene, N; acenaphthylene, AC; acenaphthene, ACE; fluorene, F; phenanthrene, Ph; anthracene, A; fluoranthene, Fl; pyrene, Py; benzo(a)anthracene, B(a)A; chrysene, Ch; benzo(b)fluoranthene, B(b)Fl; benzo(k)fluoranthene, B(k)Fl; benzo(a)pyrene, B(a)Py; indeno(1,2,3-c,d)pyrene, IPy; dibenz(a,h)anthracene, DB(ah)A; benzo(ghi)perylene, B(ghi)Pe.

Statistical analysis was done using the SPSS software (version 11.5). The data were tested to check for the normality. Also, mean comparison of PAHs levels in different sampling sites between two species was conducted by t-test.

The descriptive characteristics of PAHs concentration in the surface sediment sample are summarized in Table 1. The concentration of ΣPAHs ranges 10.33–186.16 ng g^{-1} dry weight with an average value of 103.87 $\pm$ 72.88 ng g^{-1} dry weight.

The highest concentration of individual PAH was fluoranthene (4-ring), while dibenz[a,h]anthracene (5-ring) showed the lowest concentration in the sediment of studied areas (Fig 2). Indeno[1,2,3-cd]pyrene was not detected in sediments of any sample.

The level of ΣPAHs contamination in this study was compared with previously reported ΣPAH level in Persian Gulf and different regions (Table 2). Concentrations of the ΣPAHs in this study were lower than those found in the Persian Gulf (400–790 ng g^{-1} dw; Badawy et al., 1993), the Northern Persian Gulf (59–330 ng g^{-1} dw; Eghtesadi et al.,

Table 3
Comparison of the sediments PAHs from sediment of Persian Gulf with standard pollution criteria (ng g^{-1} dw).

	N	AC	ACE	F	Ph	A	Fl	Py	B(a)A	Ch	B(a)Py	DB(ah)A
TEL*	34.57	5.87	6.71	21.2	86.7	469	112.82	153	74.8	108	88.8	6.22
PEL**	391	128	88.9	144	544	245	1494	1398	693	846	763	135
1	19.063	**16.81**	ND	ND	11.47	6.03	24.6	35.48	6.43	18.49	12.51	ND
2	13.7	**11.1**	**27.65**	30.33	3.83	2.68	14.87	17.82	3.79	13.37	11.3	ND
3	7.303	2.8	**11.61**	1.85	2.36	0.85	2.21	1.49	ND	0.49	ND	0.64
4	2.25	0.54	3.98	0.26	0.75	0.32	0.85	0.59	0.08	0.21	ND	0.11
5	10.473	**7.82**	6.203	ND	11.08	3.28	17.74	13.6	7.206	5.263	8.81	3.246
6	11.1	**7.146**	3.203	ND	8.14	ND	14.12	4.21	6.99	4.5	5.73	ND

* Threshold effect levels (TEL) and ** probable effect levels (PEL) (data from MacDonald et al. (1996)).
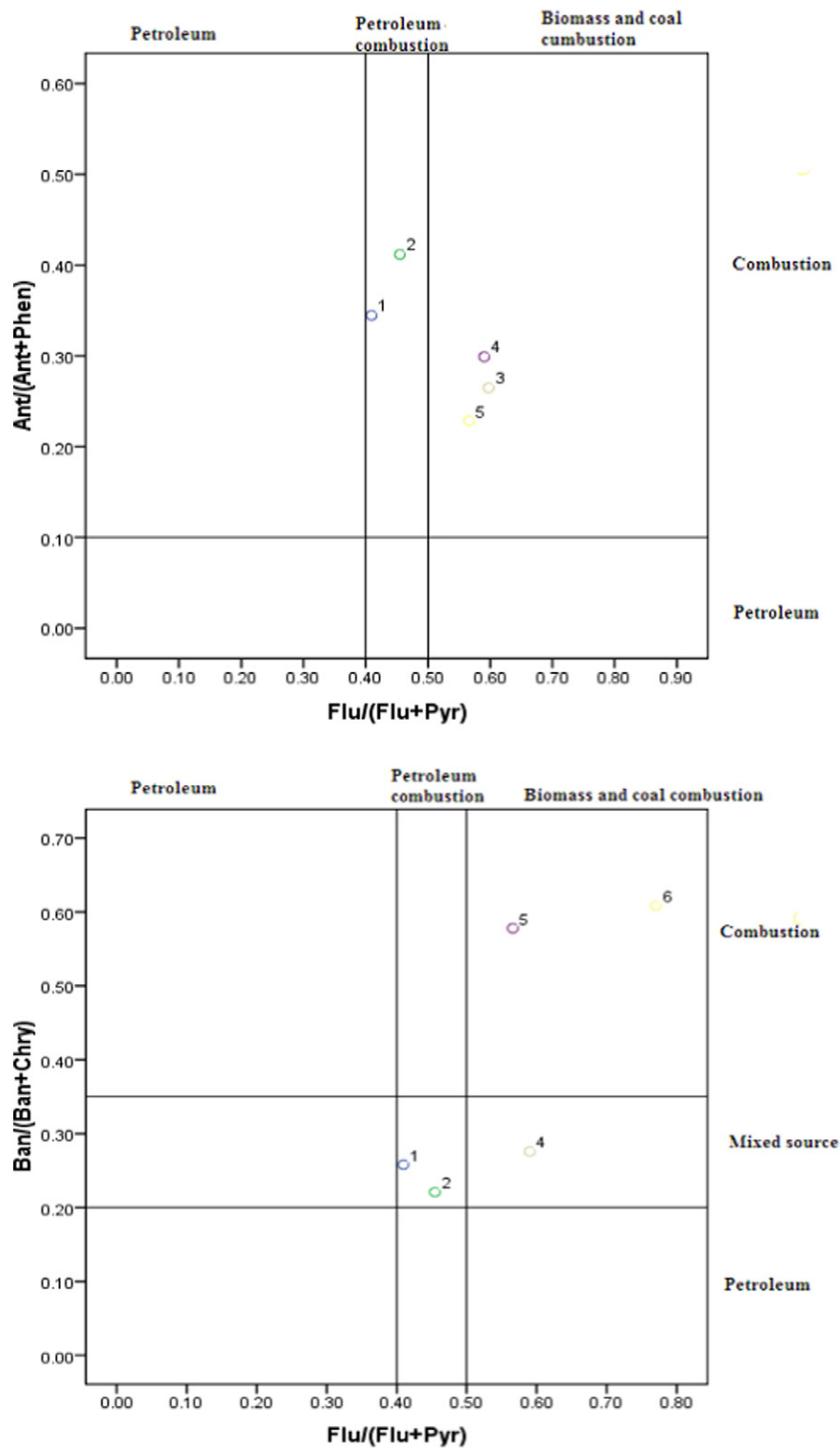
Fig. 3. Isomer ratio plots of PAH in sediment of Persian Gulf.

2002), the San Diego Bay, USA (80–20,000 ng g^{-1} dw; Anderson et al., 1996), the Masan Bay, Korea (9.1–1400 ng g^{-1} dw; Kim et al., 1999), the Liaodong Bay, China (144.5–291.7 ng g^{-1} dw; Ningjing et al., 2010), the Northern Persian Gulf (42.29–228.9 ng g^{-1} dw; Bastami et al., 2013), Hormuz strait, Persian Gulf (72.17–277.77 ng g^{-1} dw; Rahmanpoor et al., 2013), Daya Bay, China (42.5–158.2 ng g^{-1} dw ;Yan et al., 2009), Gorgan Bay 107.87–516.18 ng g^{-1} dw; Eghtesadi Araghi et al., 2014) and the Laizhou Bay, China (97.2–204.8 ng g^{-1} dw; Hu et al., 2010).

According to Baumard et al. (1998), PAH pollution levels can be characterized as low, moderate, high, and very high when the total PAHs concentrations are 0–100 ng g^{-1} dry weight, 100–1000 ng g^{-1} dry weight, 1000–5000 ng g^{-1} dry weight, and >5000 ng g^{-1} dry weight, respectively. Based on this classification, sediments from sampling sites could be considered as low to moderately polluted with PAHs.

In this study, two sets of sediment quality guidelines (SQGs), including: (a) the ERL/ERM and (b) the TEL/PEL values were applied to assess

Table 4
Concentrations of polycyclic aromatic hydrocarbons (ng g^{-1} dw) in *H. leucospilota* and *S. hermanni* of sampling sites. Mean concentrations and standard deviation ($\pm$SD).

PAHs	Sampling sites					
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
H. leucospilota						
Naphthalene	ND	2.65 ± 1.52	ND	1.11 ± 0.64	8.93 ± 1.22	1.19 ± 1.03
Acenaphthylene	49.01 ± 2.16	25.42 ± 2.80	ND	0.15 ± 0.08	3.83 ± 0.50	2.86 ± 1.65
Acenaphthene	57.81 ± 13.76	23.61 ± 3.46	7.21 ± 1.34	1.72 ± 1.11	2.61 ± 1.86	3.59 ± 3.12
Fluorene	28.89 ± 10.01	18.62 ± 3.81	7.43 ± 1.66	0.71 ± 0.33	1.2 ± 0.69	3.59 ± 1.56
Phenantherene	87.17 ± 6.38	39.49 ± 6.78	9.67 ± 1.49	2.78 ± 0.56	5.48 ± 2.68	10.91 ± 3.08
Anthracene	39.95 ± 11.28	20.36 ± 5.52	4.67 ± 1.46	1.38 ± 0.47	2.86 ± 1.60	6.55 ± 3.78
Fluoranthene	37.91 ± 2.78	18.74 ± 3.302	7.42 ± 1.47	1.29 ± 0.24	10.32 ± 2.52	9.54 ± 2.11
Pyrene	73.23 ± 32.18	19.42 ± 1.16	5.25 ± 2.27	1.11 ± 0.95	8.17 ± 0.42	7.5 ± 1.58
Benzo[*a*]anthracene	36.73 ± 14.35	17.043 ± 1.95	2.096 ± 0.27	0.95 ± 0.36	3.385 ± 0.37	4.67 ± 0.83
Chrysene	20.13 ± 2.02	8.73 ± 1.6	1.02 ± 0.33	0.17 ± 0.02	2.03 ± 1.29	2.68 ± 0.48
Benzo[*b*] fluoranthene	ND	2.34 ± 1.35	ND	ND	7.64 ± 4.41	ND
Benzo[*k*]fluoranthene	32.98 ± 2.24	13.94 ± 1.59	2.75 ± 0.37	0.85 ± 0.28	2.89 ± 0.32	7.11 ± 0.98
Benzo[*a*]pyrene	38.5 ± 19.37	ND	ND	ND	0.02 ± 0.01	ND
Indeno[1,2,3-*cd*]pyrene	3.1 ± 1.78	ND	ND	ND	ND	ND
Dibenz[*a,h*]anthracene	ND	ND	ND	0.23 ± 0.132	0.155 ± 0.021	ND
Benzo[*ghi*]pyrene	ND	ND	ND	ND	ND	ND
ΣPAHs	505.44 ± 26.56	210.39 ± 11.72	47.54 ± 3.43	12.49 ± 0.78	59.55 ± 3.41	60.22 ± 3.63
S. hermanni						
Naphthalene	ND	ND	ND	1.14 ± 1.06	2.58 ± 1.07	1.12 ± 0.16
Acenaphthylene	36.93 ± 2.205	ND	2.20 ± 0.86	0.18 ± 0.10	2.22 ± 1.38	ND
Acenaphthene	43.42 ± 5.104	14.18 ± 2.37	3.103 ± 0.61	0.85 ± 0.45	1.37 ± 0.77	0.65 ± 0.14
Fluorene	22.37 ± 3.24	10.48 ± 2.41	0.71 ± 0.55	0.50 ± 0.52	ND	0.96 ± 0.59
Phenantherene	87.01 ± 11.08	22.83 ± 2.51	3.76 ± 1.25	1.04 ± 1.59	3.003 ± 0.39	1.66 ± 0.65
Anthracene	31.29 ± 3.39	10.85 ± 4.85	0.28 ± 0.01	2.41 ± 1.68	2.31 ± 0.45	0.15 ± 0.01
Fluoranthene	27.51 ± 5.43	15.84 ± 6.22	2.17 ± 0.72	0.33 ± 1.12	11.34 ± 1.79	3.32 ± 2.04
Pyrene	49.36 ± 14.63	19.52 ± 10.47	0.92 ± 0.27	0.30 ± 0.23	6.72 ± 2.39	0.80 ± 0.39
Benzo[*a*]anthracene	26.05 ± 6.74	6.28 ± 1.69	0.33 ± 0.22	0.35 ± 0.06	0.97 ± 0.32	1.46 ± 0.73
Chrysene	22.99 ± 3.79	5.43 ± 2.29	0.15 ± 0.005	0.09 ± 0.05	1.17 ± 0.19	0.70 ± 0.10
Benzo[*b*] fluoranthene	ND	ND	1.69 ± 0.32	ND	ND	2.16 ± 1.24
Benzo[*k*]fluoranthene	18.395 ± 4.108	10.38 ± 2.14	0.18 ± 0.10	0.82 ± 0.47	4.85 ± 2.8	2.295 ± 1.36
Benzo[*a*]pyrene	21.3 ± 2.54	ND	3.8 ± 2.19	ND	ND	ND
Indeno[1,2,3-*cd*]pyrene	2.75 ± 1.58	ND	ND	ND	ND	ND
Dibenz[*a,h*]anthracene	ND	ND	ND	0.08 ± 0.07	1.67 ± 0.16	ND
Benzo[*ghi*]pyrene	ND	ND	1.83 ± 1.05	ND	ND	1.36 ± 1.10
ΣPAHs	389.39 ± 22.97	115.83 ± 7.83	19.94 ± 1.36	8.08 ± 0.63	38.24 ± 3.04	16.66 ± 0.97

ΣPAHs = sum of detected PAHs.
ND = not detected.
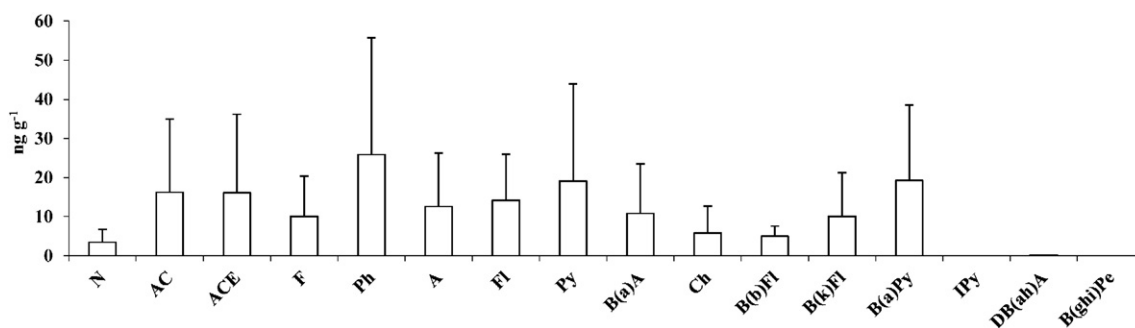
Fig. 4. Average ($\pm$SD) individual PAH in *H. leucospilota* (ng g^{-1} dw) of Persian Gulf.
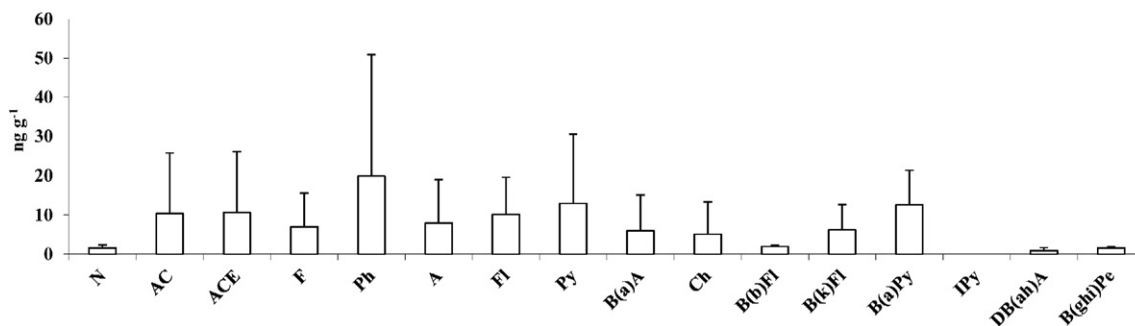
Fig. 5. Average ($\pm$SD) individual PAH in *S. hermanni* (ng g^{-1} dw) of Persian Gulf.
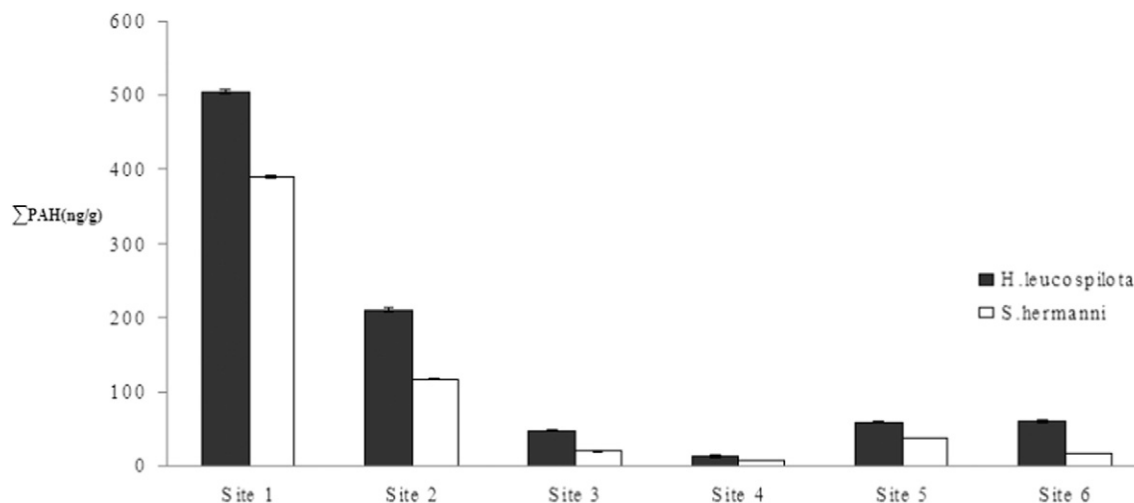
Fig. 6. Comparison of Σ PAH levels in *H. leucospilota* and *S. hermanni* from Persian Gulf.

the ecological toxicity of individual PAH concentrations in sediments (Long et al., 1995). According to SQGs adverse biological effects are expected rarely (<ERL/TEL), occasionally (≥ERL/TEL and <ERM/PEL), and frequently (≥ERM/PEL) (Long et al., 1995; Ningjing et al., 2010). Existing sediment quality guidelines (SQGs) for PAHs in marine sediments are presented in Table 3. Based on the SQG, concentrations of acenaphthylene in sediment were above the TEL at sites 1, 2, 5, and 6, while at all sites concentrations of acenaphthylene was below PEL. Concentrations of acenaphthene in sediment were above the TEL at sites 2 and 3. Also, concentrations of fluorine in sediment were above the TEL at site 2. These results indicate that negative eco-risk effects rarely occur in some sites.

Diagnostic ratios of PAHs, such as Ant / (Ant + Phen), BaA / (BaA + Chry), and Flu / (Flu + Pyre), have been developed to identify the possible sources of PAHs (Yunker et al., 2002; Liu et al., 2008). In general, a ratio of Ant / (Ant + Phen) < 0.1 suggests pollution of petroleum origin, while a ratio > 0.1 indicates a dominance of combustion (Yunker et al., 2002; Liu et al., 2008). Yunker et al. (2002) suggested that BaA / (BaA + Chry) ratio < 0.2 indicates petrogenic sources, a ratio between 0.2 and 0.35 indicates a mixed origin, and a ratio > 0.35 implies pyrogenic sources. A ratio of Flu / (Flu + Pyren) < 0.4 is consistent with petroleum inputs; a value between 0.4 and 0.5 indicates liquid fossil fuel (vehicle and crude oil) combustion; and a ratio > 0.5 implies grass, wood, or coal combustion. To distinguish samples containing petrogenic or pyrogenic PAH, the ratios of anthracene / (anthracene + phenanthrene), benzo[a]anthracene / (benzo[a]anthracene + chrysene) and fluoranthene / (fluoranthene + pyrene) were used and the results for all sites appear in Fig 3.

In this study, BaA / BaA + Chry ratio in surface sediment at sites 1, 2 and 4 were between 0.2 and 0.35, indicating mixed sources of PAH.

Ratio of Ant / Ant + Phen was higher than 0.1 in all sampling sites, suggesting pyrolytic sources of PAHs. Range of Flu / Flu + Pyre ratio was above 0.5 in sites 3, 4, 5 and 6 demonstrating biomass and coal combustion sources of PAHs.

These findings suggest that the sources of PAHs in the surface sediments of sampling sites could arise from mixed sources, with pyrogenic-related contamination as the dominant source.

As a result of the 1991 war, Persian Gulf environment was subjected to an estimated six million barrels of crude oil and in this way coastal and estuarine sediment of the region are exposed by the associated contaminants. Additionally over half of the world oil supply is transported from the Persian Gulf and offshore oil exploitation in this area is considered the most extensive in the world. Also, combustion of coal, wood, vehicle fuel and waste tire are pyrogenic source of PAH in this area.

PAHs concentrations in the body wall of two species of sea cucumber *H. leucospilota* and *S. hermanni* collected at different sites are indicated in Table 4.

The highest concentrations of PAHs in two species were measured at site 1 while lowest concentrations of PAHs in two species were measured at site 4. The concentration of ΣPAHs of *H. leucospilota* at sites 1, 2, 3, 4, 5 and 6 were 505.44 ± 26.56, 210.39 ± 11.72, 47.54 ± 3.43, 12.49 ± 0.78, 59.55 ± 3.41 and 60.22 ± 3.63 ng g^{-1} dry weight, respectively. Also, the concentration of ΣPAHs of *S. hermanni* at sites 1, 2, 3, 4, 5 and 6 were 389.39 ± 22.97, 115.83 ± 7.83, 19.94 ± 1.36, 8.08 ± 0.63, 38.24 ± 3.04 and 16.66 ± 0.97 ng g^{-1} dry weight, respectively.

The highest concentration of individual PAH was phenanthrene (3-ring), while dibenz[a,h]anthracene (5-ring) showed the lowest concentration in two sea cucumber species (Figs. 4 and 5).

PAHs are bioavailable to marine organisms through the food chain, as water borne compounds and from contaminated sediments. Those uptakes depend on their bioavailability as well as the physiology of the organisms (Meador et al., 1995). Such compounds have adverse effects on health (carcinogenic and/or mutagenic activity) and ecosystem (Long et al., 1995). In this study, concentration of ΣPAHs in *H. leucospilota* at all sampling sites was higher than concentration of ΣPAHs in *S. hermanni* (Fig 6).

The present work reported the detailed study of the distribution and the origin of PAHs in sediments and two sea cucumber species from northern parts of Persian Gulf. ΣPAH concentrations in all sediments collected from Persian Gulf were below published sediment toxicity guidelines for PAHs (PEL), but some individual PAHs (acenaphthylene, acenaphthene and fluorine) have exceeded the TEL. Source analysis by isomer ratio revealed that the grass, wood, or coal combustion as well as mixed source were both significant.

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