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Distribution and Sources of Aliphatic and Polycyclic Aromatic Hydrocarbons in Surface Sediments, Fish and Bivalves of Abu Qir Bay (Egyptian Mediterranean Sea)

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Abstract Polycyclic aromatic hydrocarbons (PAHs) were detected and quantified in recent marine sediments and selected species from fishes, bivalves and crustaceans of Abu Qir Bay during the period January–October 2004. Nineteen sampling stations were chosen to collect sediment samples covering almost the Bay area. Total PAHs found in the surficial bottom sediments of the Bay were identified in moderate values ranging between 69 and 1,464 ng/g dry weights. The distribution pattern of these compounds showed the availability of most di, tri- and tetra aromatics in the Bay area in addition to their alkyl derivatives. High molecular weight aromatic hydrocarbons of five or more ring were detected everywhere in the Bay sediments. Certain number of pairs of isomer PAH concentrations are used for five origin molecular indices to identify the PAH concentration sources in the sediments of the Bay: Fluo/Py, Fluo/[Fluo + Py], LMW/HMW, BbF/BaP and BkF/BaP. Abu Qir Bay sediment samples were contaminated mainly by pyrolytic and petrogenic contaminations with strong pyrolytic inputs in the southwestern basin, while the northeastern area of the Bay is contaminated mainly by petrogenic PAHs. The studied biota samples of the Bay revealed levels of moderately contaminated specimens with total PAHs, while the carcinogenic PAH, benzo(a)pyrene were detected in most biological samples in levels ranged between 30.3 and 358 ng/g with an average of 152.4 ng/g should be taken into consideration.

Keywords PAHs · Sediment · Biota · Origin molecular indices · Sources

Polycyclic aromatic hydrocarbons (PAHs) are of special concern because they are widely distributed in the environment and many of them have toxic and carcinogenic properties (Pruell and Quinn 1985). They can be generated and introduced into the environment by various processes: incomplete combustion at higher temperatures of recent and fossil organic matter (pyrolytic origin), slow maturation of organic materials under the geochemical gradient conditions (high temperatures and pressure, petrogenic origin) and short-term digenetic degradation of biogenic precursors (digenesis), (McElory et al. 1989). Terrestrial plant waxes, marine phytoplankton, volcanic eruptions, biomass combustion and natural oil seeps contribute natural inputs of hydrocarbons, including aliphatic and PAHs (Saliot 1981).

The present study used 19 stations to evaluate the concentrations of aliphatic and PAHs fractions in sediment samples and selected species from fish, bivalves and crustaceans from Abu Qir Bay. The lack of investigation and available data on hydrocarbons of the Bay area gives up priority to follow up and evaluate the present condition of contamination. The list of tested PAHs is recommended by US EPA (1993) as priority pollutants. In addition, our objective was to get more information on the origin of different hydrocarbon fractions considering anthropogenic sources.

Materials and Methods

Abu Qir Bay was known to be one of the most important fishery grounds in Egypt (Fig. 1). It is considered as an

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Estuary, lies between 30°50′ and 30°22′E and 31°16′ and 31°28′N (El-Rayis et al. 1993). It extends for about 63 km from El-Montazah in the west to Rosetta mouth of the Nile River in the east. On the other hand, it extends northward to about 40 km in the open Mediterranean Sea. The maximum depth of the Bay reaches 16 m, while the surface area is about 360 km^2 (Said et al. 1995). The Bay receives different pollutants contributing to various waste source categories. They discharge through three main opening namely; El-Tabia pumping station, the outlet of Lake Edku (Boughaz El-Maddya) and Rosetta mouth of the Nile River. Near El-Tabia pumping station, various industrial wastes (for about 22 factories) are discharged into the bay (Hassan 1999). Nineteen surface sediment samples were collected in June 2004 (Fig. 1). Sediments were collected utilizing a stainless-steel grab. Six grabs were taken from each location from which the top 3 cm were scooped into pre-cleaned wide-mouth glass bottle, frozen and transported to the laboratory and stored at –20°C until analysis.

The boat was moved up to 4–6 m between grabs so that the samples would be representative of the area from which they were taken. The samples were analyzed for aliphatic and PAHs following well established techniques (UNEP/IOC/IAEA 1992). Biota samples were collected during winter (February 2004). They were four groups: Bivalves (*Donax trunculus*), Crustaceans (*Peneaus japonicus*), and bottom-dwelling fish (*Solea solea*) and pelagic fish (*Diplodus vulgaris*). Group 1: with lengths ranged from 16 to 18 cm and a mean weight of 35.4 g for *Solea solea*; Group 2: with lengths ranged from 1.7 to 2.2 cm with a mean weight of 0.52 g for *Donax trunculus*; Group 3: with lengths from 6.4 to 8.12 cm and a mean weight of 2.42 g for *Peneaus japonicus* and Group 4: with lengths from 11 to 20 cm with a mean weight of 75 g for *Diplodus vulgaris*. All the samples were collected fresh from the fishermen working in the area of study, not more than two hours after catching. They kept frozen in the laboratory, biometric measurements were done; every species was grouped into size groups according to length and weight of the individuals. Biological specimens were dissected and their tissues were kept frozen until extraction. Before chemical treatment, individual samples were removed from the refrigerator and allowed to thaw at room temperature for about 5 h. Each sample was then thoroughly mixed and 30 g of the sediment was mixed with 90 g of anhydrous sodium sulfate. Duplicates were taken from each sediment sample. The sediment sample was then sonicated in an ultrasonic bath with 2 × 100 ml hexane for 30 min each, followed by third extraction with 100 ml dichloromethane. The three extracts were then combined and desulphurized through activated copper powder and then concentrated to a few millimeters in a rotary evaporator at low temperature (~35°C), followed by concentration with nitrogen gas stream down to a volume 1 ml.

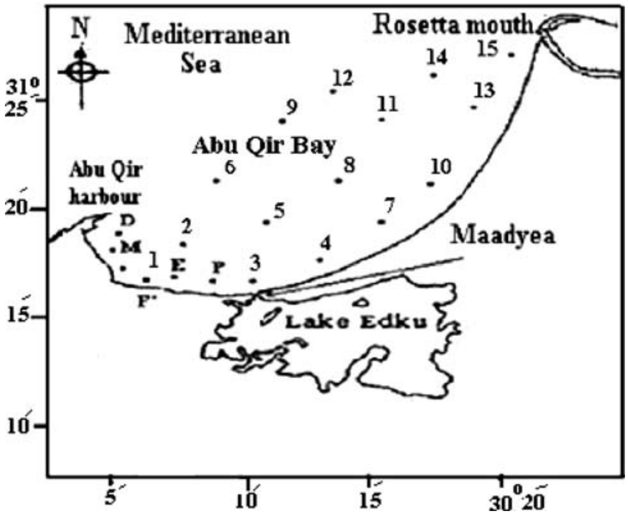

Fig. 1 Sampling stations in Abu Qir Bay

Ten gram of biota tissue (wet weight) was treated with 30 g of anhydrous sodium sulfate and the mixture was blended at high speed for 5 min. Then the mixture was extracted with a Soxhlet extractor with 200 ml of methanol for 8h (UNEP/IOC/IAEA 1992). Then 0.7 M KOH (20 ml) and distilled water (30 ml) were added to the flask and the reflux was continued for 2 h to saponify the lipids. The content of the extraction flask was extracted three times in a separating funnel with 80 ml hexane. Then the extracts were combined, dried with anhydrous sodium sulfate and filtered through glass wool. The hexane fraction was concentrated with a rotary evaporator down to about 15 ml at 30°C followed by concentration with nitrogen gas stream down to a volume of 1 ml. Clean-up an fractionation was performed by passing the concentrated extract through a silica/aluminum oxide column. The chromatography column was prepared by slurry packing 20 ml (10 g) of silica, followed by 10 ml (10 g) of aluminum oxide and finally 1 g of anhydrous sodium sulfate. The extract (1 ml) was sequentially eluted from the column with 25 ml of hexane for the saturated aliphatic fraction (F1). Then 60 ml of hexane and dichloromethane (80:20) for the unsaturated aromatic fraction (F2). F1 and F2 were concentrated by using gentle stream of nitrogen for instrumental analysis.

To control analytical reliability and assure recovery efficiency and accuracy of the results, 6 analyses were conducted on PAH reference materials, HS-5 (sediment) provided by NRC-IMB of Canada and SRM 2974 (freeze-dried mussel tissue; *Mytilus edulis*) provided by NIST of USA as well as sediment samples of known PAH levels spiked with a mixture consisting of 2 μg each of PAHs were analyzed as above to validate the analytical method used in this study. The laboratory results showed recovery efficiency ranged from 90% to 110% for HS-5, 85%–97% for SRM-2974 and 94%–102% for the spiked samples. All solvents were pesticide grade purchased from Merck. Blanks of 1,000-fold concentration were analyzed by gas chromatography with a flame ionization detector. All samples were analyzed by a Hewlett Packard HP 5890 series II GC gas chromatograph equipped with a flame ionization detector (FID). The instrument was operated in split less mode (3 μL split less injection) with the injection port maintained at 290°C and the detector maintained at 300°C. Samples were analyzed on a fused silica capillary column HP-1; 100% dimethyl polysiloxane (30 m length, 0.32 mm i.d., 0.17 μm film thickness). The oven temperature was programmed from 60 to 290°C, changing at a rate of 3°C/min and maintained at 290°C for 25 min. The carrier gas was nitrogen flowing at 1.2 ml/min. The detection limit was 0.04, 0.01, 0.01, 0.01, 0.02, 0.01, 0.03, 0.03, 0.04, 0.04, 0.05, 0.05, 0.05, 0.06, 0.08 and 0.10 μg/ml for naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k) fluoranthene, dibenzo(a,h)anthracene, benzo(ghi)perylene and indeno(1,2,3-cd)pyrene, respectively. In addition, data analysis was done on the correlation matrix using SPSS-10.

Results and Discussion

Table 1 gives the total concentrations of the aliphatic hydrocarbons from C10 to C34, with values varied from 6.0 to 565.2 ng/g (dry weight). The concentrations below their limits of detection were given a value of zero for the calculation. Higher concentrations occurred at sites D, 1 and 2. Lower concentrations were found for samples from sites P and 10. The recorded concentrations of the present study, were lower than the recorded for urban sites in Scotland, UK; ranged from 400 to 7,100 ng/g with an average value of 3,000 ng/g (Mackie et al. 1980). In addition, the recorded level for Black Sea ranged from 1,200 to 24,000 ng/g of sediment (Readman et al. 2002). The isoprenoid hydrocarbons, pristine (2,6,10,14-tetramethylpentadecane) and phytane (2,6,10,14-tetramethylhexadecane), are products of geological alteration of phytol and other isoprenoidyl natural products, and are not primary constituents of most terrestrial biota (Peters and Moldowan 1993). Pristane and phytane are presented in most petroleum oils in a ratio of pristine/phytane (Pr/Ph) < 1, so the detection of these two components is often used as good indicators of petroleum contamination. However, a high concentration of pristane alone can be derived from zooplankton. In uncontaminated sediments, the ratio Pr/Ph is >1, typically between 3 and 5 (Steinhauer and Boehm 1992). Table 1 indicates that Pr/Ph was <1 for stations: F, E and 15 indicating mainly petrogenic hydrocarbon inputs. However, high Pr/Ph ratio was >1 for stations: D, 1 and 2 reflecting biogenic origins.

The maximum concentration of total PAH was recorded in sediments collected from station D (Table 1). The average concentrations of PAHs in the present study is lower than those recorded in the Egyptian Mediterranean coast with 88–6,338 ng/g; dry weight (El Nemr et al. 2007), and than those observed by Baumard et al. (1998) in Barcelona; Spain with 1,700 ng/g; dry weight and Port Vendres; France with 6,900 ng/g; dry weight. Most sampling sites in Abu Qir Bay were contaminated in the range 146–1,447 ng/g (dry weight) except at station E, in front of the Electric Power Station (EPS) with 95 ng/g (dry weight), which may be due to thermal pollution resulted from cooling water of the EPS station. It has been demonstrated that the concentrations of PAHs in sediments were affected by chemical composition of the sediments such as organic matter and clay content (Kim et al. 1999). In addition, sediments with high organic carbon content were characterized with high values of PAHs (Yang 2000). However a low correlation was found between total PAHs and TOC concentrations in the present Abu Qir sediments with $r = 0.27$. This may be suggesting that both of direct input and type of sediment found locally would determine the distribution and concentrations of PAHs in sediments. Moreover, Simpson et al. (1998) showed that the relationship between total PAHs and organic carbon was only significant for highly contaminated sites where total PAHs was greater than 2,000 ng/g; dry weight. In this study, all sediment samples have total PAHs concentrations lower than 2,000 ng/g (dry weight). In addition, PAHs concentrations recorded in the present study were lower than the effective range low (ERL) value (4,022 ng/g) suggested by Long et al. (1995). They reported that the concentrations below the ERL value represent a minimal-effect range, i.e., adverse biological effect would rarely be observed below the ERL. The individual PAH concentrations in this study were also lower than the national sediment quality criteria proposed by US EPA (1993) for fluoranthene (3,000 ng/g), acenaphthylene (2,400 ng/g) and phenanthrene (2,400 ng/g). BaP was ranged from non-detected at stations 9 and 10–686 ng/g at station D with mean value of 99.6 ng/g, in the concentration range between rural and urban areas as given by Menzie and Potocki (1992). PAH concentration patterns differ according to the emission sources (Wang et al. 1999). Various PAH concentration diagnostic ratios have been used to identify and quantify the contribution of each source of pollution to the specified environmental regions (Kavouras et al. 2001), Fluoranthene/pyrene (Fluo/Pyr) ratio indicated the origin of PAHs. Sicre et al. (1987) suggested that a Fluo/Pyr ratio <1 was attributed to petrogenic sources and values >1, were obviously related to

Table 1 Aliphatic and PAHs (ns/s), TOC (mate) dry weight and PAH diagnostic concentration ratios in sediments of Abu Oir Bay, 2004

Compound	Samplitig sites																			
	F	D	M	E	P	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10	ST11	ST12	ST13	ST14	ST15
Naphthalene	114.0	125.00	60.90	27.20	82.10	54.20	21.00	103.00	58.10	60.70	63.30	43.90	76.95	110.00	183.00	129.98	119.99	110.00	115.50	121.00
Aecnaphthylene	39.80	43.60	16.80	9.30	25.10	ND	ND	22.00	9.20	14.55	19.90	21.40	25.50	29.60	39.90	32.70	31.15	32.90	35.95	39.00
Acenaphthene	ND	173.00	30.70	24.00	114.00	ND	ND	64.30	26.10	47.70	69.30	66.70	33.35	ND	ND	16.68	8.34	ND	72.50	145.00
Anthracene	378.0	232.00	261.00	ND	230.00	590.00	266.00	398.00	282.00	246.50	211.00	0.30	232.65	465.00	742.00	487.33	476.16	384.00	281.50	179.00
Fluoranthene	47.40	28.00	ND	ND	ND	33.20	ND	ND	10.50	9.20	7.90	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	45.30	36.00	24.90	ND	23.50	78.40	38.80	35.80	25.90	22.05	18.20	ND	18.90	37.80	55.60	37.25	37.53	31.70	15.85	ND
Benzo(b)fluoranthene	16.00	34.80	12.90	ND	14.00	34.80	22.80	11.80	13.70	14.15	14.60	ND	8.45	16.90	ND	4.23	10.56	16.90	16.95	17.00
Benzo(k)fluoranthene	17.5O	46.70	9.70	ND	ND	15.50	15.50	10.70	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	34.70	686.00	52.00	33.80	30.10	104.00	667.00	40.90	34.40	24.35	14.30	13.70	6.85	ND	ND	3.43	1.71	16.10	15.15	14.20
Dibenzo(a,h)anthracene	0.60	11.90	0.90	0.60	0.50	1.80	11.60	0.10	0.10	0.20	0.30	0.20	0.10	ND	ND	0.05	0.03	0.30	0.30	0.30
Benzo(ghi)perylene	4.90	30.70	132.00	ND	ND	97.30	5.10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PAHs	698.2	1,447.7	601.8	94.9	519.3	1,009.2	1,047.8	686.6	460.0	439.4	418.8	146.2	402.8	659.3	1,020.5	711.6	685.5	591.9	553.7	515.5
Total COMB	166	874	232	34	68	365	761	99	85	70	55	14	34	55	56	45	50	65	48	32
TCOMB/TPAHs	0.17	0.58	0.38	0.36	0.13	0.33	0.72	0.14	0.16	0.14	0.11	0.09	0.08	0.08	0.05	0.06	0.07	0.11	0.09	0.06
TF-PAHs	531.8	573.6	369.4	60.5	451.2	644.2	287.0	587.3	375.4	369.5	363.5	132.3	368.5	604.6	964.9	666.7	635.6	526.9	505.5	484.0
TF-PAHs/TCOMB	3.20	0.66	1.59	1.76	6.63	1.76	0.38	5.91	4.44	5.28	6.57	9.52	10.74	11.05	17.35	14.83	12.76	8.11	10.48	15.37
Fluo/Pyr	1.05	0.78	NR	NR	NR	0.42	NR	NR	0.41	0.42	0.43	NR	NR	NR	NR	NR	NR	NR	NR	NR
Fluo/(Fluo + Pyr)	0.51	0.44	NR	NR	NR	0.30	NR	NR	0.29	0.29	0.30	NR	NR	NR	NR	NR	NR	NR	NR	NR
BbF/BaP	0.46	0.05	0.25	NR	0.47	0.33	0.03	0.29	0.40	0.58	1.02	NR	1.23	NR	NR	1.23	6.17	1.05	1.12	1.20
BkF/BaP	0.50	0.07	0.19	NR	NR	0.15	0.02	0.26	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TALIPH	137.4	565.20	222.70	152.40	9.30	345.31	372.30	60.60	35	47	89	101	40	64	6	87	75	74	156	197
Pristane	0.8	7.50	6.50	0.80	ND	13.80	3.70	ND	ND	ND	0	1	ND	ND	ND	ND	ND	ND	2	1
Phytane	2.8	5.20	ND	1.10	ND	5.10	2.30	ND	ND	ND	1	ND	ND	0	ND	1	1	ND	ND	1
Pr/Ph	0.29	1.44	NR	0.73	NR	2.71	1.61	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	1
TOC	4.40	13.00	0.90	1.30	20.00	17.90	0.70	11.40	6.70	5.00	3.30	2.00	1.80	1.60	1.60	1.70	1.65	1.20	1.45	1.33

ND below detection limit, *NR* not recorded because one of values is not found or below detection limit, *Total COMB* sum of (fluoranthene + pyrene, BbF, BkF, BaP, BghiP), *TF-PAHs* compounds with molecular weight <178, sum of (anthracene + acenaphthene + acenaphthylene-l-naphthalene), *TOC* total organic carbon, *LMW* low molecular weight, *HMW* high molecular weight, *Fluo* fluoranthene, *Pyr* pyrene, *BbF* benzo(b)fiuoranthene, *BkF* benzo(k)fluoranthene, *BaP* benzo(a)pyrene, *TALIPH* SumC10-C34, *Pr* pristine, *Ph* phytane

Table 2 Correlation matrix of PAHs in sediments of Abu Oir Bay

PAHs	na	ace	aca	An	Fluo	Py	BbF	BkF	BaP	DBA	BghiP
na	1										
ace	0.85[b]	1									
aca	0.21	0.4	1								
An	0.71[b]	0.44	–0.12	1							
Fluo	0.09	0.15	–0.06	–0.16	1						
Py	0.35	–0.03	–0.13	0.62[b]	0.31	1					
BbF	0.04	–0.01	–0.38	0.12	0.43	0.56[a]	1				
BkF	0.09	0.19	0.34	–0.06	0.61[b]	0.26	0.64[b]	1			
BaP	–0.14	–0.07	0.23	–0.13	0.24	0.1	0.49[a]	0.77[b]	1		
DBA	0.04	–0.08	0.23	0.3	–0.2	0.43	0.19	–0.17	–0.21	1	
BghiP	–0.2	–0.28	–0.12	–0.24	0.28	0.21	0.3	0.32	–0.11	0	1

na naphthalene, *ace* acenaphthylne, *aca* acenaphthene, *An* anthracene, *Fluo* fluoranthene, *Py* pyrene, *BbF* benzo(b)fluoranthene, *BkF* benzo(k)fluoranthene, *BaP* benzo(a)pyrene, *DBA* dibenzo(a,h)anthracene, *BghiP* benzo(ghi)perylene

[a] Correlation is significant at 0.05 level (2-tailed)

[b] Correlation is significant at 0.01 level, (2-tailed)

pyrolytic origin. Combustion of coal and wood gave Fluo/Pyr ratios of 1.4 and 1, respectively, while crude oil and fuel oil had values of 0.6–0.9 (Gschwend and Hites 1981). In the present study, most sites had Fluo/Pyr ratio <1 (Table 1) reflecting petrogenic origin. The ratio of major combustion specific compounds (∑COMB; Flu, Pyr, BbF, BkF, BaP and BghiP) to the sum of total PAHs (∑COMB/∑PAHs) were ranged from 0.05 to 0.72 and the ∑COMB concentrations displayed values from 14 to 874 ng/g (Table 1), representing an average value of 19.6% of total PAHs. Three significant PAH ratios were calculated for the studied samples: Fluo/(Fluo + Py), BbF/BaP, BkF/BaP. In addition to the less significant ratio of ∑F-PAHs/∑COMB (∑naphthalene + acenaphthylene + acenaphthane + anthracene)/(∑Fluoranthene + pyrene + Benzo(b)fluoranthene + benzo(k)fluoranthene + benzo(a)pyrene + Dibenzo(a,h)anthracen+benzo(ghi) perylene). Table 2 declares that the ratio of ∑F-PAHs/∑COMB was varied between 0.66 and 17.35 with an average value 7.42, suggesting petrogenic PAH origin. When lower molecular weight PAHs (∑F-PAHs) dominate over the HMW PAHs (∑COMB) during low temperature maturation of organic matter, petrogenic origin of PAHs could be accepted (Garrigues et al. 1993). Few sediment samples from sites D and 2 (situated in the southwestern basin of the Bay), revealed LMW/HMW ratio values <1, indicating pyrolytic origin.

In addition, most of the sediment sites in the Bay were characterized by Fluo/Py values <1 which is an indication of pyrolytic and petrogenic contaminations with strong pyrolytic input. This finding is in good agreement with Tsapakis et al. (2003) who recorded ratios of Fluo/(Fluo + Py) in the Eastern Mediterranean sediment samples <0.50. Based on correlation values between individual PAHs (Table 2), one can give an idea whether they all originate from the same source or not. Significant correlations were noticed between naphthalene and acenapthylene ($r = 0.85$) and naphthalene and anthracene ($r = 0.71$). This indicates that naphthalene, acenaphthylene and anthracene might be originated from the same source. This gives an indication that naphthalene has only close relation with the low molecular weight PAHs: acenaphthylene and anthracene. Consequently isomeric ratios between these compounds were not used in the present work due to their little significance. The two widely spread PAHs in most sampling sites; anthracene and pyrene are significantly correlated (0.62 at 0.05 level). A plot of the isomeric ratios BbF/BaP against BkF/BaP in sediments of Abu Qir Bay is shown in Fig. 2. This diagram was drawn on spatial distribution basis. BbF and BkF are significantly correlated with BaP ($r = 0.53$ at 0.05 level for BbF/ BaP, while $r = 0.77$ at 0.01 level for BkF/BaP). It was noticed from this plot that the southwestern basin of the Bay including stations: F, D, M, E, P, 1, 2, 3 and 4 had the lowest ratios <0.5, suggesting pyrolytic origin of PAHs. However, high ratios calculated in sediments of the northeastern basin indicate petrogenic sources for PAHs. The concentrations of total aliphatic in fish (*Solea solea* and *Diplodus vulgaris*) were 319.27 and 21.93 ng/g (wet weight), respectively. However, concentrations of 307.28 and 326.15 ng/g (wet weight) were recorded for *Peneaus japonicus* and *Donax trunculu*, respectively (Table 3). On the other hand, the accumulation of total PAHs were more pronounced in the muscle tissues of the bottom dwelling fish (*Solea solea*), 1,770 ng/g (wet weight), followed by the fish (*Diplodus vulgaris*), (mean: 1,203 ng/g wet weight), then the bivalve

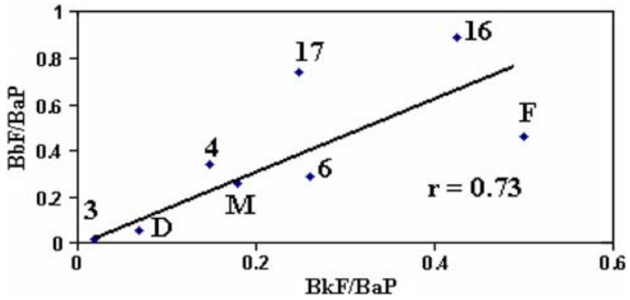

Fig. 2 Plot of isomeric ratios BbF/BaP against BkF/BaP in sediments of Abu Qir Bay during 2004

Table 3 Concentrations of aliphatic and PAH fractions in muscle tissues of the selected biota samples of Abu Qir bay during winter 2004

Compound	Concentration (ng/g; wet weight)			
	Solea Solea	*Donax truaulus*	*Peneaus japonicus*	*Diplodus vulgaris*
Naphthalene	ND	3.67	119.11	17.75
1-Methyl naphthalene	6.32	4.67	0.67	92.25
Aecnaphthylene	53.04	40.00	6.67	65.50
Acenaphthene	258.11	143.33	ND	165.0
Phenanthrene	ND	ND	22.33	17.25
Anthracene	517.22	396.00	138.33	ND
2-Methyl phenanthrene	3.05	2.00	0.67	ND
1-Methyl phenanthrene	1.27	0.33	ND	ND
Pyrene	ND	ND	141.02	4.25
Benzo(a)anthracene	ND	ND	111.67	3.75
Chrysene	21.25	12.33	6.33	7.52
Benzo(b)fluoranthene	ND	ND	99.05	71.75
Benzo(k)fluoranthene	16.23	6.33	ND	272.75
Benzo(a)pyrene	358.06	30.33	77.67	32.50
Dibenzo(a,h)anthracene	533.33	480.67	191	ND
Benzo(ghi)perylene	ND	ND	6.33	601.75
Indeno(1,2,3-cd)pyrene	ND	ND	2.2	157.01
Total PAHs	1,767.88	1,137.07	923.05	1,509.03
Total ALIPH: C10–C34	319.27	21.93	307.28	326.15
THC	2,087.15	1,159.01	1,230.32	1,835.18

ND below the detection limit, *THC* TPAHs + TALIPH

(*Donax trunculus*); mean 1,120 ng/g; wet weight, while the crustacean shrimp (*Peneaus japonicus*) contained the lowest values of total PAHs. Table 3 illustrates the individual and total PAHs detected in biota samples. It was noticed that dibenz(a,h)anthrathene is the most dominant PAH in all specimens varied between 62 and 944 ng/g (fresh weight). The present work shows that biota samples should be considered as an indicator for PAH contamination in marine environment regarding to its high content of lipids that leads to accumulation of organic contaminants. The average background value for uncooked fish ranges from 0.01 to 1 ng/g for individual PAHs (European Union 2002). The Joint FAO/WHO Expert Committee on Food Additives (Simko et al. 2004) has developed a notification that the concentration of BaP should not exceed the limit of 10 ng/g. This value is lower than that obtained in the present work varied between 19 and 43 ng/g for the bivalves and between 21 and 212 ng/g for shrimp, and between 41 and 246 ng/g for fish *Diplodus vulgaris*, while the bottom dwelling fish *Solea solea* contained the highest value of BaP; 358 ng/g among all species.

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