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Hydrocarbon Pollution in the Arabian Gulf Catfish (*Arius bilineatus* Val.)

J. M. Al-Hassan, M. Afzal, V. N. R. Chava, S. Fayad

Department of Biological Sciences, Faculty of Sciences, Kuwait University, Post Office Box 5969, Safat 13060, Kuwait

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The Arabian Gulf having cloudless sky for most days of the year, with little inflow of fresh water and high rates of evaporation as well as being surrounded by arid deserts makes its environment very harsh to marine organisms. The intense petroleum activities in the Gulf makes its marine organisms more prone to pollution by petroleum hydrocarbons. In addition, the 1991 Gulf war and the intentional discharge of an estimated nine million barrels of crude oil into the Gulf further escalated the environmental problems. Gushing oil wells together with incompletely combusted crude oil from oil well fires in the nearby oil fields threatened the Gulf ecosystem. Polycyclic aromatic hydrocarbons (PAHs) and aliphatic hydrocarbons (HCs) being important components of crude oil and petroleum products can produce significant contamination of marine environment, adversely affecting marine life (Clark Jr and MacLeod 1977). Many studies have shown that the sediments are the reservoirs for pollutants such as aromatic hydrocarbons. These compounds being hydrophobic, are known to accumulate in sediments and living organisms (Govers 1990) and are also known for their carcinogenic and toxic activities on marine organisms (Malins et al. 1984). Fish and other organisms are known to accumulate many of these chemicals from the polluted aquatic environment, causing many pathological conditions such as fin erosion (Falkmer et al. 1979) and liver neoplasm (Smith et al. 1979). The photoinduced toxicity of PAHs to aquatic organisms has been well established (Ankley et al. 1994; Monson et al. 1995). The uptake and bioaccumulation of PAHs in bivalves have been compared using undisturbed sediments and suspended oil borne sediments that resulted from water disturbance. The results indicated that PAHs in disturbed sediment become more bio-available (Menon and Menon 1999).

Varanasi et al. (1985) have reported that the fish uptake and bio-concentration of PAHs correlate grossly with the hydrophobicity of the compound. They also have found that three and four ring PAHs to be more available than five and higher ring PAHs compounds for accumulation from contaminated sediments in aquatic organisms such as clams. Larger size PAHs are less available due to their size, even though partitioning would favour their bioaccumulation. Reports of high prevalence of liver neoplasm in bottom dwelling fish from urban waterways have heightened our awareness of the potential problems concerning the quality

Correspondence to: J. M. Al-Hassan

of fish habitats, as well as food chain transfer of contaminants from fish and shell fish to humans (Varanasi and Stein 1991).

The Arabian Gulf catfish, (*Arius bilineatus* Val.) is a bottom dwelling fish. Some of the Gulf inhabitants consume this fish. In addition, the pharmaceutical characteristic of its spine venom and epidermal gel secretion makes it much more important medically and biochemically (Al-Hassan et al. 1983, Al-Hassan et al. 1991). When this fish is threatened or injured, it elaborates a proteinaceous epidermal gel secretion. Preparations from this gel secretion have been implicated in wound and diabetic ulcer healing (Al-Hassan 1990), and in treatment of back pain, muscle spasm and some dermatological problems (Al-Hassan 1999). It is because of these unusual combination of pharmaceutical and biochemical characteristics that we decided to explore the levels of hydrocarbon pollution in this fish.

MATERIALS AND METHODS

Catfish (*Arius bilineatus* Val.) were caught on baited hook on line at different intervals of time (1997 and 1999) from different locations in the north western waters of the Arabian Gulf as shown in Table 1. Samples were stored on ice immediately after collection and brought to the laboratory. Liver, gills and muscle were taken and placed in aluminium foil and kept in clean dark glass jars and stored frozen at - 80^0 C until analysed. Samples of epidermal gel secretion were collected and mixed for different locations in the north western waters of the Gulf during 1988, 1995 and 2000 and were analysed for hydrocarbons. Anhydrous sodium sulphate and potassium hydroxide were of analytical grade, and were purchased from Fluka, Switzerland. All solvents were HPLC grade and purchased from either Fluka or BDH, England.

Table 1. Sample collection locations

S.	Local Name	Scientfic Name	Date of col.	Lati. N	Long. E	Location
1	Catfish	*Arius bilineatus* Val.	27 06 1997	$29^0$20.14'	$48^0$10.73'	Sunken Trawler
2	Catfish	*Arius bilineatus* Val.	01 06 1997	$29^0$22.48'	$48^0$28.30'	Auha
3	Catfish	*Arius bilineatus* Val.	30 07 1999	$29^0$28.50'	$48^0$10.00'	Kuwait Bay
4	Catfish	*Arius bilineatus* Val.	07 08 1999	$29^0$19.97'	$48^0$12.58'	Sunken Trawler
5	Catfish	*Arius bilineatus* Val.	20 08 1999	$28^0$57.51'	$49^0$08.45'	Al-Durrar oil field area
6	Catfish	*Arius bilineatus* Val.	27 08 1999	$28^0$59.07'	$48^0$44.84'	Madaira
7	Catfish	*Arius bilineatus* Val.	01 10 1999	29^0 05.70'	$48^0$29.37'	Kubbar

A modified procedure of Kristiina et al. (1986) was followed for extraction of

PAHs and HCs from catfish as described by Al-Hassan et al. (2000).

RESULTS AND DISCUSSION

Samples of catfish were caught at different locations during 1988 to 2000. Gel samples were collected from catfish caught during 1988, 1995 and 2000 and were mixed for each year. The analytical data for PAHs and HCs are shown in Tables 2 and 3. Samples collected from Durrar in 1999 showed the highest level of PAHs at 335.11 ng g^{-1}(wet wt.), followed by Auha and Kuwait Bay at 144.59 ng g^{-1} and 138.88 ng g^{-1} respectively. The samples of Sunken trawler collected during 1997 and 1999 showed 105.49 ng $g^{-1}$and 62.525 ng g^{-1} concentration of total PAHs respectively. Kubbar and Madeira samples showed 49.96 ng $g^{-1}$and 42.675 ng g^{-1} of total PAHs wet weight respectively. These results showed that Durrar samples carried the highest level of PAHs followed by Auha and then Kuwait Bay samples. Epidermal gel samples showed approximately the same values of PAHs (1.17 to 1.67 ng g^{-1}) for all the different years (1988, 1995 and 2000). The most common PAHs observed in these samples are phenanthrene, fluoranthene and pyrene. Amongst these three PAHs, pyrene is the most carcinogenic. Another most potent toxicant Indeno [123-cd] pyrene (65.43 ng g^{-1}) was observed in the livers of Auha samples.

Samples caught at Durrar, Kubbar and Kuwait Bay showed closely related concentrations of 836 ng g^{-1}, 892 ng g^{-1} and 845 ng g^{-1} wet wt of alkanes respectively. Sunken trawler samples showed the lowest concentration of alkanes (16.9 ng g^{-1}) followed by Madeira samples at 58.0 ng g^{-1}. The most predominant alkanes in these samples were C_{14} to C_{24} indicating that they originated from crude oil.

Temperature of the northern waters of the Gulf could drop to less than 12^0 C during the winter months(December to February), while the highest temperature ($\approx 35^0$ C) is reached during the summer months of July to September. Catfish (*Arius bilineatus* Val.) is anaesthetised by cold temperature ($\approx 12^0$.C). In order to avoid injuries by the catfish venomous spines during our experiments out at sea, a temperature of 11^0 C in aquarium was repeatedly used for safe handling of the fish. This fish migrates to the mud flats of the northern waters of the Gulf towards the end of March of every year for breeding purposes. Its outwards journey to the south starts in August. Although it is common scientific knowledge that catfish do not feed while incubating their eggs during the breeding season, and that males incubate the eggs in their mouths, we have caught hundreds of catfish during our catch effort for sample collection using baited hook on line and found both males and females of *Arius bilineatus* Val. with eggs in their mouths, indicating that these fish were still feeding, although their feeding rate might have decreased. The level of PAHs found in catfish caught at collection sites with mud bottom of Kuwait Bay, Auha, Sunken trawler, Kubbar and Durrar in the north western waters of the Gulf were higher than those caught foraging on the hard bottom, coral coated areas near Madeira reef. This correlates well with other reports (Neff 1979) that bottom sediments act as a

Table 2. Levels of PAHs in Arabian Gulf catfish (Arius bilineatus Val. in ng/g (wet wt.)

S.No.	Location	Col. Date	Organ	Naph	Acen	Flu	Phe	Anth	Fluo	Pyr	BaA	Chr	BbF	BkF	BaP	Ind	Tot.
1	Sunken	27 06 1997	Liver (2)	12.5	ND	2.7	8.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	23.2
2	trawler		Gills (2)	ND	ND	< 0.1	6.4	ND	10.0	11.3	8.3	13.8	ND	ND	ND	ND	49.8
3			Muscle (2)	7.2	ND	1.4	5.7	ND	4.2	ND	ND	ND	ND	ND	ND	ND	18.5
4			Total	19.7	ND	3.9	20.2	ND	14.2	11.3	8.3	13.8	ND	ND	ND	ND	91.4
5	Sunken	07 08 1999	Liver (2)	ND	ND	ND	2.3	4.6	< 0.1	ND	ND	0.9	< 0.1	< 0.1	ND	ND	7.8
6	trawler		Gills (2)	ND	Tr	< 0.1	3.7	ND	9.5	30.5	ND	ND	ND	ND	ND	ND	43.7
7			Muscle (2)	ND	ND	ND	1.0	ND	1.7	5.6	ND	ND	ND	ND	ND	ND	8.3
8			Total	ND	ND	ND	7.0	4.6	11.2	36.1	ND	0.9	ND	ND	ND	ND	59.8
9	Auha	01 06 1997	Liver	11.3	ND	ND	7.7	ND	ND	ND	ND	ND	31.9	ND	ND	65.4	116.3
10			Gills	ND	ND	3.2	6.8	6.3	11.7	ND	ND	ND	ND	ND	ND	ND	28.0
11			Total	11.3	ND	3.2	14.5	6.3	11.7	ND	ND	ND	31.9	ND	ND	65.4	144.3
12	Durrar	20 08 1999	Liver (2)	1.2	ND	ND	4.5	ND	106.44	ND	Tr	14.4	ND	ND	< 0.1	ND	126.5
13			Gills (2)	< 0.1	ND	Tr	3.5	4.8	14.2	8.9	13.2	4.9	ND	ND	ND	ND	49.5
14			Muscle (2)	0.8	ND	Tr	19.1	23.4	80.3	23.6	ND	9.7	ND	ND	ND	ND	156.9
15			Total	2.0	ND	ND	27.1	28.2	200.94	32.5	13.2	29.0	ND	ND	ND	ND	332.9
16	K.Bay	30 07 1999	Liver (4)	0.8	ND	ND	10.0	< 0.1	45.3	1.1	ND	ND	ND	ND	ND	ND	57.2
17			Gills (4)	Tr	ND	ND	3.9	ND	43.8	13.5	ND	3.9	ND	ND	ND	ND	65.1
18			Muscle (4)	0.1	ND	ND	2.6	< 0.1	9.5	2.8	ND	ND	ND	ND	< 0.1	ND	15.0
19			Total	0.9	ND	ND	16.5	ND	98.6	17.4	ND	3.9	ND	ND	ND	ND	137.3
20	N.Kubbar	01 10 19999	Liver (2)	ND	ND	ND	5.7	< 0.1	3.8	3.2	ND	ND	ND	ND	ND	ND	12.7
21			Gills (2)	ND	ND	< 0.1	< 0.1	< 0.1	< 0.1	18.6	ND	ND	< 0.1	4.7	ND	ND	23.3
22			Muscle (2)	ND	ND	ND	1.0	< 0.1	4.7	5.4	ND	ND	ND	ND	ND	ND	11.1
23			Total	ND	ND	ND	6.7	ND	8.5	27.2	ND	ND	ND	4.7	ND	ND	47.1
24	Madeira	27 08 1999	Liver (2)	1.3	ND	ND	15.2	1.0	ND	3.0	ND	ND	ND	ND	ND	ND	20.5
25			Gills (2)	ND	Tr	< 0.1	2.9	1.9	3.9	Tr	ND	ND	ND	ND	ND	ND	8.7
26			Muscle (2)	ND	7.6	Tr	1.4	< 0.1	1.4	< 0.1	1.0	< 0.1	ND	ND	ND	ND	11.4
27			Total	1.3	7.6	ND	19.5	2.9	5.3	3.0	1.0	ND	ND	ND	ND	ND	40.6
28		26 09 1988	Gel	ND	ND	ND	1.6	ND	ND	< 0.1	ND	ND	ND	ND	ND	ND	1.6
29		1995	Gel	ND	ND	ND	< 0.1	ND	ND	1.0	ND	ND	ND	ND	ND	ND	1.0
30		02 06 2000	Gel	ND	ND	ND	< 0.1	ND	< 0.1	ND	< 0.1	ND	ND	ND	ND	ND	1.1

Tr = Trace; ND = Not Detected; Naph = Naphthalene; Acen = Acenaphthylene; Flue = Fluorene; Phe = Phenanthrene; Anth = Anthracene; Fluo = Fluoranthene; Pyr = Pyrene; BaA = Benzo [a] anthracene; Chr = Chrysene; BbF = Benzo [b] fluoranthene; BkF = Benzo [k] fluoranthene; BaP = Benzo [a] pyrene; Ind= Indeno [123-cd] pyrene; Ben = Benzo [ghi] perlene;
Number in parenthesis is the number of fish samples analysed for each station

Table 3. Levels of Alkanes in Arabian Gulf catfish (Arius bilineatus Val.) in ng/g (wet wt.)

S.No.	Location & Col. Date	Organ	C_{14}	C_{15}	C_{16}	C_{17}	Pr	C_{18}	Py	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	C_{30}	C_{31}	Tot.
1	Sunken	Liver (2)	1.9	3.3	2.2	1.9	ND	ND	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	9.3
2	trawler	Gills (2)	Tr	<0.1	<0.1	<0.1	<0.1	<0.1	Tr	<0.1	Tr	<0.1	ND	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	<0.1
3	07.08.99	Mus.(2)	<0.1	<0.1	<0.1	<0.1	ND	ND	Tr	Tr	Tr	<0.1	Tr	Tr	<0.1	<0.1	<0.1	2.5	3.3	1.9	<0.1	<0.1	7.7
4		Total	1.9	3.3	2.2	1.9	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.5	3.3	1.9	<0.1	<0.1	17.0
5	Durrar	Liver (2)	11	23	14	8.3	9.8	5.8	2.4	8.4	ND	ND	144	257	107	126	ND	ND	ND	ND	ND	ND	717.0
6	20.08.99	Gills (2)	4.6	4.7	4.2	4.1	2.1	1.8	<0.1	ND	ND	ND	41	ND	ND	ND	ND	ND	ND	ND	ND	ND	62.5
7		Mus.(2)	4	3.4	2.9	1.5	<0.1	<0.1	<0.1	<0.1	Tr	7.8	11	20	6.2	<0.1	ND	ND	ND	ND	ND	ND	56.8
8		Total	20	31	21	14	12	7.6	2.4	8.4	ND	7.8	196	277	113	126	ND	ND	ND	ND	ND	ND	836.0
9	K.Bay	Liver (4)	9.5	11	17	8	5	11	1.2	15	Tr	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	77.7
10	30.07.99	Gills (4)	12	66	62	172	226	41	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	579.0
11		Mus.(4)	63	35	23	15	11	4.6	1.3	14	14	<0.1	ND	ND	7.5	ND	ND	ND	ND	ND	ND	ND	188.0
12		Total	85	112	102	195	242	57	2.5	29	14	<0.1	<0.1	<0.1	7.5	ND	ND	ND	ND	ND	ND	ND	846.0
13	N.Kubbar	Liver (2)	175	275	151	216	17	42	<0.1	<0.1	<0.1	ND	ND	ND	ND	ND	ND	ND	<0.1	ND	ND	ND	876.0
14	01.10.99	Gills (2)	1.1	1.5	<0.1	2.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.1	ND	ND	ND	ND	ND	7.9
15		Mus.(2)	Tr	<0.1	<0.1	<0.1	ND	<0.1	<0.1	<0.1	<0.1	ND	<0.1	1.3	1.7	ND	2.1	ND	<0.1	<0.1	1.6	1.6	8.3
16		Total	176	277	151	218	17	42	ND	ND	ND	ND	ND	1.3	1.7	ND	5.2	ND	ND	ND	1.6	1.6	892.0
17	Madeira	Liver (2)	2.2	9.6	4.8	5.2	ND	<0.1	<0.1	<0.1	1	3.6	1	1.5	1.3	ND	2.9	2.9	1.9	2.2	3.1	3.2	46.4
18	27.08.99	Gills (2)	3.1	2.8	3.7	2	<0.1	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11.6
19		Mus.(2)	<0.1	<0.1	<0.1	<0.1	ND	Tr	Tr	Tr	Tr	ND	Tr	Tr	Tr	ND	Tr	Tr	ND	ND	ND	ND	< 1.0
20		Total	5.3	12	8.5	7.2	<0.1	<0.1	<0.1	<0.1	1	3.6	1	1.5	1.3	ND	2.9	2.9	1.9	2.2	3.1	3.2	58.0
21	26.09.88	Gel	<0.1	<0.1	<0.1	<0.1	ND	<0.1	<0.1	<0.1	ND	ND	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	< 1.0
22	1994-1995	Gel	ND	<0.1	<0.1	<0.1	ND	<0.1	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	< 1.0
23	02.06.2000	Gel	<0.1	<0.1	<0.1	<0.1	ND	<0.1	<0.1	<0.1	<0.1	<0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	< 1.0

ND = Not Detected; Pr = Pristane; Py = Phytane; Number in parenthesis indicates the number of fish analysed.

reservoir for hydrocarbon pollutants. It is difficult to assign the area that provided the highest concentration of PAHs to the analysed catfish, as these fishes are bottom dwellers and find their way to the northern mud flats for breeding. Obviously these fish feed throughout their journey from the southern to the northern waters during their breeding season. The catfish are not only important as a source of fish meat to some inhabitants of the Gulf, they are also very important as a source of proteins and lipids that are highly active both biochemically and pharmacologically (Al-Hassan 1987). It is interesting to see that analysis of the gel showed only small traces of PAHs (1.17-1.67 ng g^{-1}) and HCs (< 1.0 ng g^{-1}). It has not been possible so far to assign the source of these hydrocarbons whether from the animal biological system, or from the surrounding sea water.

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