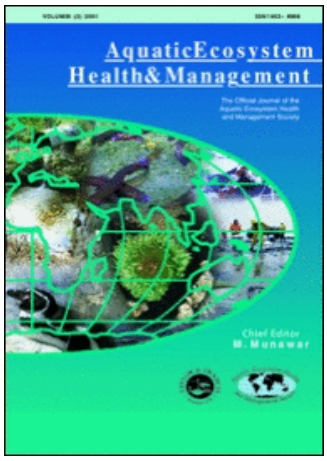

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Petroleum hydrocarbons in water and sediments of northwest Arabian Gulf 1980–2005

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A survey has been conducted to evaluate pollution by petroleum hydrocarbons (PHC's) in water, sediments and living organisms of southern Iraqi sectors represented by Shatt Al-Arab River, Khor Al-Zubair, Umm Qasser, Khor Abdullah and the northwest Arabian Gulf. Petroleum hydrocarbons in water as dissolved and particulate, in sediments as exchangeable and residual and in the organs of living organisms were reported for the period 1980–2002. During 1980, levels of PHC's reported in Shatt Al-Arab river ranged from a lower value of 2.6 $\mu g\ l^{-1}$ in Qurnah and a higher value of 44 $\mu g\ l^{-1}$ in Basrah, while the range was little bit higher in the estuary of Shatt Al-Arab reaching 16–56 $\mu g\ l^{-1}$ during the same period. Then this range was lowered afterwards to reach 4–14 $\mu g\ l^{-1}$ in Shatt Al-Arab and 6–7 $\mu g\ l^{-1}$ in it's estuary during the year 1993, then it jumped afterwards to reach 2.5–47 $\mu g\ l^{-1}$ and 31–80 $\mu g\ l^{-1}$ in Shatt Al-Arab river and it's estuary respectively during the year 2000. The same trend was found for the northwest Arabian Gulf. For sediments it seems that total petroleum hydrocarbons declined from Shatt Al-Arab River towards its estuary, Khor Al-Zubair, Khor Abdullah and the northwest Arabian Gulf.

Keywords: Shatt Al-Arab river, oil pollution, Iraq, Basrah

Introduction

Shatt Al-Arab River, Khor Al-Zubair and the Iraqi coastal waters are liable to contain small amounts of oil spills. Among expected sources are loading and transportation facilities, effluent discharges from oil refineries, atmospheric fall-out, etc. (Al-Saad, 1995). Petroleum hydrocarbons as contaminants in water environment are toxic components, relatively soluble in water and stable to chemical and biological interactions.

The north-west part of the Arabian Gulf, the heaviest oil production area in the world, had suffered during the last 40 years from oil spills due to natural seepages, production, loading and transportation (Oostdam, 1984), as well as from military activities (Literathy and Foda, 1985; UNEP, 1991). In 1978 the spills from transported oil in the Arabian Gulf were estimated to range from 0.951–1.27 million barrels (Oostdam, 1984). Oil spilled from the Iranian Nowruz oil field in early 1983 was estimated to be 400,000 barrels. By the end of February 1991, oil spilled during the 2nd Gulf war, from Al-Khafji, Mina Al-Ahmadi and Mina Al-Baker was estimated to be 3–7 million barrels.

Procedures and methods

Present observations were made from different studies conducted by specialized researchers from Marine Science Centre/University of Basrah as well as those from Kuwait Institute for Scientific

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Research (KISR)/State of Kuwait starting in 1978, in addition to recent personal research. At least three samples each of sub-surface water, surface bottom sediments and different biota were collected from different stations along Shatt Al-Arab river from Qurnah (2) to it's estuary (3), the discharging point to Arabian Gulf, Shatt Al-Basrah (4), Khor Al-Zubair (5), Khor Abdullah (6) and the north western part of the Arabian Gulf which is represented by Iraqi regional waters (7), as well as the Iraqi marshland represented by Hor Al-Hammar (1), as shown in Figure 1. Amber glass bottles were used for the collection of water samples, while polyethylene bags were used for sediment and biota samples. For analysis, only bottom sediments were used. Petroleum hydrocarbons as a dissolved phase in water samples were extracted by carbon tetrachloride, while petroleum hydrocarbons as a particulate phase in water and exchangeable and residual phases of sediments were extracted by a 1:1 solution of benzene and methanol. Extracts were then evaporated until dryness, and the petroleum hydrocarbons in the residues were dissolved in hexane for measurements either by UV-Fluorescence or Gas Chromatography. For spectroflourometry, measurements were made at an emission wavelength of 360 nm after excitation of 310 nm, and Basrah crude oil was used as a standard.

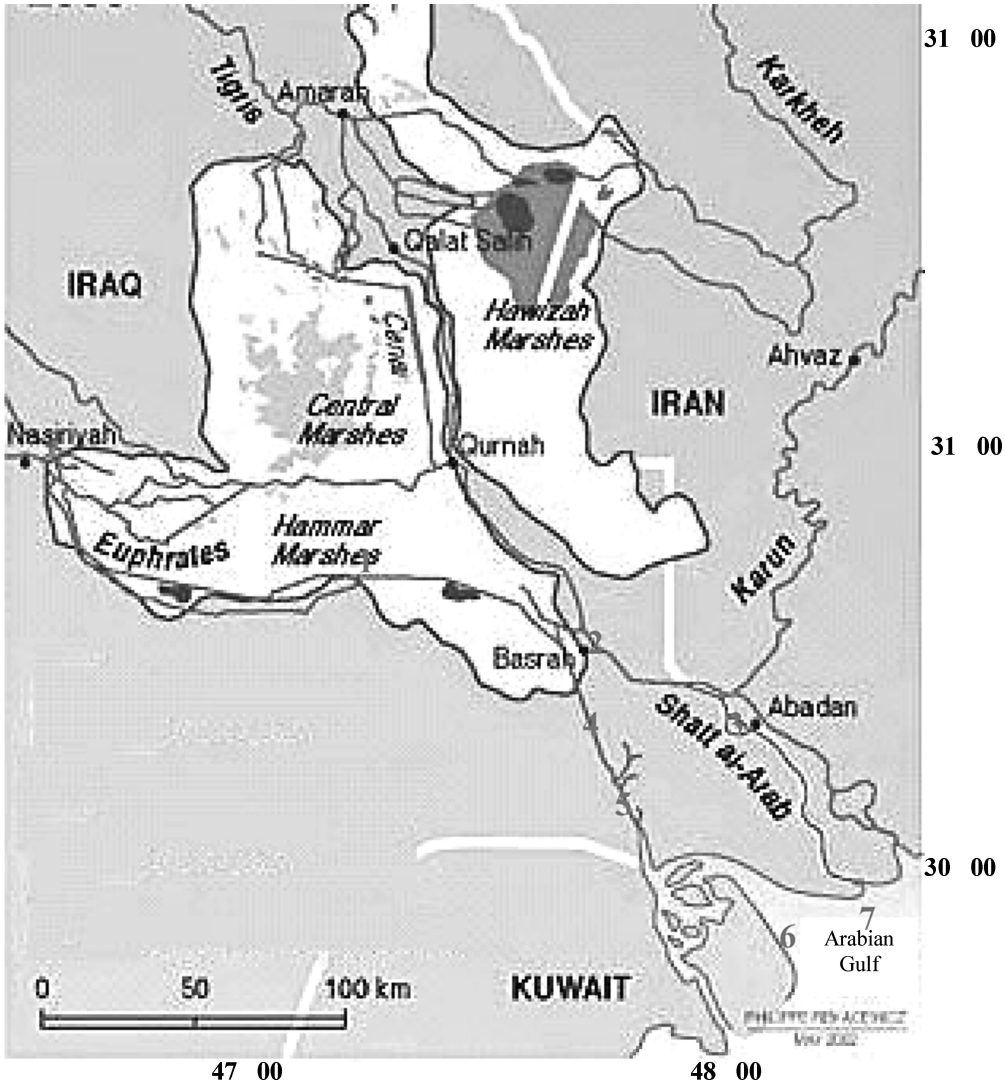

Figure 1. Location map of the study area showing the sampling stations (1–7). (Source: www.unep.org).

Results and discussion

Among the first published studies on oil pollution in the southern parts of Iraq and north western part of Arabian Gulf, DouAbul et al. (1984) reported values of petroleum hydrocarbons around 13 μg g^{-1} for sediments collected from Shatt Al-Arab River at the very north of the Arabian Gulf. Grimlet et al. (1985) identified n-alkanes by GC-Mass technique for sediments collected in the same area and found values ranging between 3.3 and 18.8 μg g^{-1} dry sediments. DouAbul and Al-Saad (1985) reported concentrations of petroleum hydrocarbons in the water from five different sites at Shatt Al-Arab River and reported ranges between 5 μg l^{-1} at Qurnah and 14 μg l^{-1} at Basrah. In the same area DouAbul (1984) and Al-Saad and Bedair (1989) reported concentrations of dissolved petroleum hydrocarbons in the range 12–18 and 7–24 μg l^{-1} respectively. Later on Al-Saad et al. (1995) recorded values in the range 4–14 μg l^{-1}. In the late 1990's the concentrations were increased to a range of 1.3–35 μg l^{-1} (Al-Saad et al., 1998) and then later in 2000 increased to a range of 2.5–47 μg l^{-1} (Al-Timari et al., 2000).

Zarba et al. (1985) had estimated spectrofluorometrically the total petroleum hydrocarbon concentrations to be 5.4 μg g^{-1} in surface sediments of Khor Abdullah. Al-Hamdi (1989) had studied spectrofluorometrically the sediment cores in Khor Al-Zubair and recorded range values of 3.64–26.07 μg g^{-1} dry weight for a depth down to 70 cm. Concentrations reported in the sediments of Shatt Al-Arab River and Khor Abdullah were estimated to range between 3.83–58.78 and 0.2–18.75 ng g^{-1} dry weight respectively as determined by Gas Chromatography (Al-Saad, 1987). In sediments sampled from the Arabian Gulf, values recorded after the 2nd Gulf war ranged between 3–450 ng g^{-1} dry weight, which were lower than those reported during 1983–1986 from the same sites (Readman et al., 1992). In the water sample from Khor Abdullah and the north west Arabian Gulf, the concentrations of total petroleum hydrocarbons determined spectrofluorometrically were in the ranges 1.02–4.34 and 6.45–9.62 μg l^{-1} respectively. In the surface sediments from the same sites petroleum hydrocarbons recorded were 0.244 and 1.41 μg g^{-1} dry weight. Differences were explained due to the effect of oil spills during the 2nd Gulf war (Al-Imarah et al., 1995). During the year 2000, the concentrations of petroleum hydrocarbons in waters of Shatt Al-Arab River, Kohr Al-Zubair and Iraqi regional waters were reported to range 2.5–47 μg l^{-1} and 1.62–31.1 μg g^{-1} in dissolved and particulate phases of water at Shatt Al-Arab River. In other sites, their ranges were 0.91–25.0 μg l^{-1} and 0.8–21.8 μg g^{-1} in Shatt Al-Basrah, 0.99–23.0 μg l^{-1}

Table 1. Concentration levels of petroleum hydrocarbons in water from Southern Iraqi waterways NW Arabian Gulf, 1980–2005.

	Concentrations of Petroleum Hydrocarbons in Water(μg l^{-1})					
Date	Shatt Al-Arab river (2)	Shatt Al-Arab Estuary (3)	Khor Al-Zubair (5)	Khor Abdullah (6)	Regional Iraqi water (7)	References
1980	12–87				2.7– 68	DouAbul (1984)
1985	7–24					Al-Saad & Bedair (1989)
1993	4–14				2.6–3.7	Al-Saad et al. (1998)
1997	1.3–35					Al-Saad et al. (1998)
2000	31–80		0.99–23	44–75		Al-Timari et al. (2000)
2002			4.6–22.6		4.92–46.4	Nasir (in press)
2003	2.5–47					Al-Timari et al. (2003)
2004	3.97–11.72					Ibraheem (2004)
2005	5.67– 9.48					Ali (2006)

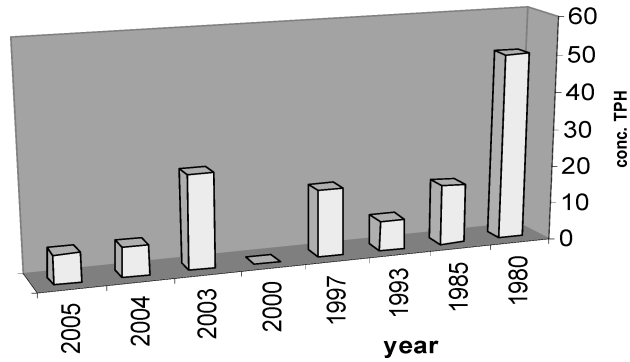

Figure 2. Variation of TPH in water from Shatt Al-Arab during the period 1980–2005.

and 0.8–20.2 μg g^{-1} in Khor Al-Zubair, 1.07–20.0 μg l^{-1} and 0.99–18.8 μg g^{-1} in Umm Qasser port. The levels were 31.0 μg l^{-1} and 25.8 μg g^{-1} in Shatt Al-Arab Estuary, and 75.0 μg l^{-1} and 33.4 μg g^{-1} in deep port close to Al-Baker terminals (Al-Timari et al., 2003).

This survey revealed that concentrations of petroleum hydrocarbons in water of Shatt Al-Arab River and it's estuary were high in the early 1980's, decreased during 1985 and further decreased during 1993. It then increased in the late 1990's, decreasing afterwards during 2003 as shown in Table 1 and Figure 2. This is explained mainly on the basis of oil production and transportation which diminished during the periods of 1st (1983) and 2nd (1991) Gulf wars. Following the 2nd Gulf war Readman et al. (1992) found that concentrations of petroleum hydrocarbons in the Arabian Gulf water were lower than those recorded before the war. The same trend has been found for petroleum hydrocarbons in the water of Khor Al-Zubair and Iraqi regional area as shown in Table 1 and Figure 2.

For sediments, these results are quite important because they give a clear idea about levels of pollution by petroleum hydrocarbons in the studied areas (Edgren, 1977); they change according to their contents of biogenic organic matter as a natural source or anthropogenic source coming from different domestic activities. For Shatt Arab river water, the concentrations of petroleum hydrocarbons in the sediments are effected heavily by the sources of water pollution. It is found that these pollutants were increased from it's beginning at Qurnah towards is estuary at the Northern Arabian Gulf as shown in Table 2. In Khor Al-Zubair oil loading terminals, the pollution of sediments by petroleum hydrocarbons were increased with time from 1980 to 1988 and then to 2002 as shown in Table 2. The situation

Table 2. Concentrations of petroleum hydrocarbons (μg·g^{-1})in the sediments from NW Arabian Gulf, 1980–2005.

	Concentrations of Petroleum Hydrocarbons in Sediments (μg·g^{-1})					
Date Stations	Shatt Al–Arab River	Shatt Al-Arab Estuary	Khor Al-Zubair	Khor Abdullah	Regional Iraqi Waters	Reference
1980	2.6–44	26–40	3.5–5	3.6–22	0.4–24	DouAbul et al. (1984)
1988			3.7–26			Al-Hamdi (1989)
1991				1.4–1.7		Al-Imarah et al. (1995)
1993	9.7 – 38	10.7–23.0			5.7	A-Saad et al. (1995)
1997					2.4–5.8	Al-Saad et al. (2000)
2002			21–178		16.34–190.94	Nasir (in press)

Table 3. Levels of PHC's in water ($\mu g\,l^{-1}$) and sediments ($\mu g\,l^{-1}$ dry weight) from station 3 during 2005.

Month	Water temp. °C	Total Petroleum Hydrocarbons	
		Water ($\mu g \cdot l^{-1}$)	Sediments ($\mu g \cdot g^{-1}$)
April	22.2	16.76	148.42
June	26.2	9.42	75.69
July	30.1	5.64	59.52
August	36.2	5.08	61.57
September	38.1	9.78	101.06

in the northwest part of the Arabian Gulf in which levels of petroleum hydrocarbons were high in the early 1980's, decreased in the early 1990's due to the effects of the 2nd Gulf war. They then increased in the early part of the 21st century as a reflection of high concentrations of petroleum hydrocarbons in the sediments of highly turbid Khor Al-Zubair and Khor Abdullah.

Total petroleum hydrocarbons (THP) in surface sediments from Hor Al-Hammar (station 1) was 4.79 $\mu g\ g^{-1}$ measured by GC, adopted from Al-Timari et al. (1997), and 32.93 $\mu g\ g^{-1}$ recorded by spectroflourometry.

The most effective parameter controlling the fate of petroleum hydrocarbons in the study area was the temperature which causes a high evaporation rate and decreases the levels. Table 3 shows the levels in water and surface sediments taken from Shatt Al-Arab estuary (station 3) during the period April–Sept. 2005.

As temperature increased from April–August, TPH decreased in both water and sediments due to increased vaporization with temperature. On the other hand the increase of TPH's during September in both water and sediments could be explained on the basis of increased inputs of petroleum hydrocarbons from different sources (Al-Saad, 1995).

Another factor which contributes to self purification of PHC's pollution in the northwest Arabian Gulf is the existence of micro organisms (Shamshoom et al., 1990).

The determined concentrations of petroleum hydrocarbons in water from southern Iraqi waterway's were either lower or similar to those found in surface water of nearby locations as shown in Table 4.

Table 4. Concentration of petroleum hydrocarbons in water throughout the southern Iraqi waterways during summer 2005, together with levels in water from nearby locations.

Locations	Water HC $\mu g\,l^{-1}$	Remarks/ References
Hor Al-Hammar	48.715	Boating activities for fishing
Qurnah	1.077	Dilution by Tigris and Euphrates
Paper mill	1.377	
Ashar	11.816	Transportation activities
Seebah	5.482	Dilution by Karun river
Shatt Al-Basrah	12.642	Effect of Basrah Petroleum refinery
Khor Al-Zubair	4.656	Dilution effects
Umm Qasser	2.178	Dilution effects by high tide from Arabian Gulf.
Fao	9.42	Fishing Activities.
Qatar	1.2–428	El- Samra et al. (1986)
Saudi Arabia	4.3–546	El- Samra et al. (1986)
Kuwait	2.1–3.6	El- Samra et al. (1986)
Rivers (U.K.)	11–48	MAFF (1993)
Arabian Sea	1.6–11.1	Sen Gupta et al. (1993)

Conclusions

Compared to studies in nearby sites, especially the Arabian Gulf, it appears that the level of pollution by petroleum hydrocarbons in the northwest Arabian Gulf is lower than that in the Arabian Gulf itself. For inner Iraqi waterways the levels of petroleum hydrocarbons increased from the north (Qurnah) towards the south (Shatt Al-Arab estuary). Those levels increased during peace and decreased during times of war. The main factors behind the increase of pollutants in water and sediments are the illegal and transportation of crude oil and its derivatives throughout

southern Iraqi waterways, as well as the discharging of oily ballast water from small vessels, and effluent from the petroleum refineries located on the banks of waterways (Abadan on Shatt Al-Arab river and Al-Shuaiba on Shatt Al-Basra).

It is recommended to minimize the increased levels of PHC's in order to prevent and control the pollution created by them in the fresh waters of the southern Iraqi waterways.

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