Total Petroleum Hydrocarbon (TPH) Burden in Fish Tissues from the Arabian Gulf

Waqar Ashraf

Department of Natural Sciences, Prince Mohammad Bin Fahad University, Al Khobar 31952,

Kingdom of Saudi Arabia (mashraf@pmu.edu.sa)

&

Atiq Mian

Center for Environment & Water,

King Fahad University of Petroleum & Minerals, Dhahran 31261,

Kingdom of Saudi Arabia

Abstract:

The levels of total petroleum hydrocarbons (TPH) and lipid contents have been reported for eight commercially important fish species from the Arabian Gulf. GC-FID has been used as quantification technique. Out of the species analyzed, Scarus Ghabon showed the highest level of TPH (7.4±3.2 µg-g^{-1}) in the muscle tissue followed by Epinephelus Tauvina (6.8±3.6 µg-g^{-1}). Except for Epinephelus Microdon (4.8±2.1 µg-g^{-1}), all other fish species showed a similar level of TPH concentration. Significant correlations were obtained between lipid contents and TPH levels in the muscles of the fish. Body weight of the fish was also found to be strongly correlated with TPH concentration in the muscle tissue. There is a tendency of accumulating higher TPH in the winter season as compared to in the summer season.

Key Words: TPH; Lipids; Fish; Muscle Tissue; Seasonal Variation; Gulf

Introduction

The Arabian Gulf has been subject to inputs of oil pollution from a variety of sources and it has been estimated that oil pollution in the Gulf represents 4.7% of total oil pollution in the world. This figure has increased even more after the Gulf war. The Gulf region has approximately two-thirds of the world's proven oil reserves (Khan 2002). Problems associated with oil pollution appear to be of greater importance in the Gulf compared with other regions. This region has undergone considerable development, increased urbanization, industrialization and refineries have become major sources of pollution to the marine environment. Accidental spills and increasing tanker traffic are also contributing factors.

One of the characteristics of the Gulf is that it is relatively shallow, semi-enclosed sea with poor flushing characteristics. Consequently, pollutants undergo slower dispersion than would occur in open oceans (Sheppard 1993). Maintaining good marine environmental quality is important for several economic reasons. The sea food is of value for both local consumption and export revenue. Also, the region relies heavily upon sea water as a source of fresh water through desalination (de Mora et al 2004). Oil may enter fish through the skin or gills. In addition, pollutants such as tar balls may ingress through the intestine by water gulped in the physiological process of desalination (Al-Zarouni 1997). Although risks to human health, due to presence of petroleum hydrocarbons

are not well documented, the possible consequences of bioaccumulation should not be ignored especially in communities consuming large quantities of fish. Saudi Arabia has coast lines on the Red sea and Arabian Gulf. While the coast lines are long neither areas are marked by great productivity. Total fishery production of the Kingdom of Saudi Arabia in 1997 was 53170 metric tones where the production in the Arabian Gulf was 22875 metric tones (Fisheries Statistics of Saudi Arabia 1997). In the present study we report the levels of total petroleum hydrocarbons (TPH) in several fish species commonly consumed by population in the Gulf. The paper also reports the data pertaining to relationship of TPH concentrations in fish tissues with seasonal variation and lipid changes in fish.

Materials and Methods

Fish samples of 8 commercially important fish species were collected from the Arabian Gulf (Qateef, Eastren Province, Saudi Arabia). All the samples were procured from local fishermen at the spot as soon as their boats landed. Samples were packed on ice and brought to lab as soon as possible. In the laboratory, the standard length and total body weight of each fish were measured before dissection. About 100g of the dorsal muscle from a single individual was dissected for sample and kept frozen until extraction process. Samples were soxhlet extracted, in duplicate, for 8 hours with 250mL of methanol. Saponification of the extracts was carried out by adding 20mL of 0.7M KOH and 30mL of water and refluxing for about 2 hours. The resulting mixture was transferred to separating funnel and extracted thrice with hexane. Then, the extracts were combined, filtered through glass wool and dried with anhydrous sodium sulfate. Concentration of the extracts was carried out by rotary evaporation down to 15mL, which was further reduced to 5mL under a gentle flow of pure nitrogen (Tolosa et al, 2005). Finally, the extract was cleaned up and fractionated by passing it through a silica/alumina column (Law et al. 1988). For the determination of lipid contents, 50g of fish tissues were extracted with 100mL of dichloromethane for 24 hours. After evaporation, the extractable organic materials were weighed with an analytical digital balance.

The quantification of petroleum hydrocarbon compounds was carried out using a Agilent 6890N gas chromatograph with a flame ionization detector (FID). The carrier gas was nitrogen at flow rate of 1.5mL/min. The column used was DB-1, length 30 meters, I.D 0.25 mm, film 0.5μm. Column temperature was programmed with initial temperature 60^0C followed by an increase at the rate of 8^0C per minute up to the final temperature of 275^oC. The detector temperature was set at 275^oC. The sum of all aliphatic and aromatic hydrocarbons measured by GC-FID provides a measure of total hydrocarbon concentration. Appropriate blanks were run with each set of fish samples. Standard reference material, IAEA-142, was also processed and run to ascertain quality control and quality assurance in our methodology. Precision of measurements, determined from triplicate measurements of the reference material was better than 8%.

Results and Discussion

The results for the body weight, length, lipid contents and concentration of total petroleum hydrocarbons in the selected fish species are presented in Table 1. Scarus Ghabon showed the highest level of TPH (7.4±3.2 $\mu g\text{-}g^{-1}$) in the muscle tissue followed by Epinephelus Tauvina (6.8±3.6 $\mu g\text{-}g^{-1}$). Except for Epinephelus Microdon (4.8±2.1 $\mu g\text{-}g^{-1}$), all other fish species showed a similar level of TPH concentration. Higher concentration of hydrocarbons in these species is probably due to the higher lipid content of their muscle tissue (Shriadah 2001). Pruell et al (1988) have showed that hydrocarbons are accumulated by simple equilibrium between sea water and body lipids. Moreover, higher TPH concentration in the muscle of the fish may also reflect differences in the marine habitat, feeding habits and the different depths in which they live in the marine environment. Significant correlation coefficients ($p > 0.70$) between lipid contents-TPH and between body weight-TPH were observed for Scarus Ghabon (0.91 and 0.89) and Epinephelus Tauvina (0.85 and 0.88). This showed a strong positive evidence that ability of fish to accumulate hydrocarbons in their tissues is directly related to lipid content and body weight.

In order to see the seasonal impact on TPH and lipid content of fish tissue, sampling was conducted in winter (December – February) and in summer (June – August) of 2007. The relevant data is presented in Table 3 and Figure 1. It was observed that most fish species acquire higher concentration of TPH in winter season as compared to in summer season. This indicated an important fact that TPH concentration not only varies between the tissues of different fish species but it also varied in the same specie depending on the season. The increased hydrocarbon concentration in winter is probably due to the active intake during the cooler season and as a result, large amounts are stored. El-Deeb (1998) has reported that slackness in movement of fish in winter, particularly demersal species, near the bottom provides a favorable condition for the accumulation of hydrocarbons in their muscle tissue. Another factor contributing towards the seasonal variations in the hydrocarbons in fish tissue is the changes which took place in the environmental conditions of the habitat (Shriadah 1999 & 2001).

The results obtained for Lethrinus Nebulosus (3.6±2.8 $\mu g\text{-}g^{-1}$) were much less than reported for the same specie (10-31 $\mu g\text{-}g^{-1}$) from the oil-impacted coastline of Saudi Arabia after Gulf War oil spill (Fowler et al 1993), but are comparable with those from sites in Bahrain (0.8-3.8 $\mu g\text{-}g^{-1}$) and Oman (2.4-7.3 $\mu g\text{-}g^{-1}$) that were not impacted by the 1991 spill (Fowler et al 1993). Tolosa et al (2005) have reported TPH concentaration in tissues of Epinephelus Coioides (2.07$\mu g\text{-}g^{-1}$) and Lethrinus Nebulosus (3.40 $\mu g\text{-}g^{-1}$) caught from Al Marfa, UAE. Relatively higher values have been reported in the same species with higher weight from Bidaiya, Bahrain (Tolosa et al 2005).

The present values compared well with uncontaminated fish tissue, 0.33 – 3.7$\mu g\text{-}g^{-1}$, from the north and central Arabian Sea collected in 1991 (Sen Gupta et al 1993), and are also similar to those reported for fish collected in 1990 from coastal waters of Oman (Badawy et al 1993). From the present study it can be concluded

that TPH levels are not as high as could be expected in the Gulf, therefore, consumption of these fish species does not pose a significant health risk to the local population.

Acknowledgements: Authors gratefully acknowledge the support of Dr.Rahim Karimpour, Department Chair. Thanks are also due to Dr.Sufyan Akram for the provision of Standard Reference Material IAEA-142. Generous help of Zahid Nazir is also acknowledged for collection and identification of fish samples.

References

Al-Zarouni, M.A.R.H.:1997, 'Effect of oil pollution on juvenile and adult Rabbitfish (Siganus Canaliculatus). M.S. Thesis submitted to University of UAE, UAE, 141pp.

Badawy, M.I., Al-Mujainy, I.S., Hernandez, M.D.:1993, 'Petroleum derived hydrocarbons in water, sediment and biota from the Mina Al Fahal coastal waters', Mar. Pollut. Bull., 26, 457-460.

de Mora, S., Fowler, S.W., Wyse, E., Azemard, S.:2004, 'Distribution of heavy metals in marine bivalves, fish and coastal sediments in the Gulf and Gulf of Oman', Mar. Pollut. Bull., 49, 410-424.

El-Deeb, K.Z. and El-Ebiary, E.H.:1988, 'Total aromatic hydrocarbon content in the muscle and liver lipid extracts of two sea bream fishes from the Arabian Gulf', Arab. Gulf J. Sci. Res., B6, 139-151.

Fisheries statistics of Saudi Arabia.:1997, Ministry of Agriculture and Water Marine Fisheries department, Riyadh, Saudi Arabia.

Fowler, S.W., Readman, J.W., Oregioni, B., Villeneuve, J.P., McKay, K.:1993, 'Petroleum hydrocarbons and trace metals in near shore Gulf sediments and biota before and after 1991 war: An assessment of temporal and spatial trends', Mar. Pllout. Bull., 27, 171-182.

Khan, N.Y.:2002, Physical and human geography. In: Khan, N.Y., Munawar, M., Price, A.R.G. (Eds), The Gulf Ecosystem: Health and Sustainability. Bukhuys Publishers, Leiden, pp. 3-21.

Law, R.J., Filwman, T.W., Portnman, J.E.:1988, 'Methods of analysis of hydrocarbons in marine and other samples' Lowsoft UK., Ministry of Agriculture, Fisheries and Food.

Pruell, R.J., Lake, J.I., Davis, W.R., Quinn, J.G.:1986, 'Uptake and depuration of organic contaminants by blue muscles (Mytilus edulis) exposed to environmentally contaminated sediments' Mar. Biol. 91, 497-507.

Sen Gupta, R., Fondaker, S.P.,Alagarasamy, R.:1993, 'State of oil pollution in the northern Arabian sea after 1991Gulf oil spill', Mar. Pollut. Bull., 27, 85-91.

Sheppard, C.R.C.: 1993, 'Physical environment of the Gulf relevant to marine pollution: an overview', Mar. Poll. Bull., 27, 3-8.

Shriadah, M.A.:2001, 'Petroleum hydrocarbon concentrations in Arabian Gulf fish tissues' Bull. Environ. Contam. Toxicol. 67, 560-567.

Shriadah, M.A.:1999, 'Oil contamination along oil tanker routes off the United Arab Emirates', Bull. Environ. Contam. Toxicol. 63, 203-210.

Tolosa, I., de Mora, S.J., Fowler, S.W., Villeneuve J.P., Bartocci, J., Cattini C.: 2005, 'Aliphatic and aromatic hydrocarbons in marine biota and coastal sediments from the Gulf and the Gulf of Oman' , Mar. Pollut. Bull. 50, 1619-1633.

Table 1: Levels (ranges & X±SD) of TPH (µg-g^{-1}) and lipids content (%) along with length and body weight of selected fish species from the Arabian Gulf

Fish Species	**Common Name**	**n**	**Length** (cm)	**Weight** (gm)	**Lipid** (%)	**TPH** (µg-g-1)
Scarus Ghabon	Bluebarred Parrot Fish	36	39.8-66.9	357.8-565.6	1.9-3.2	3.6-11.2
			55.2±12.2	560.4±32.2	2.4±0.2	7.4±3.2
Epinephelus Microdon	Grouper	32	33.4-47.4	357.9-778.9	0.8-2.0	2.8-6.9
			38.8±11.6	418.5±78.9	1.3±0.7	4.8±2.1
Epinephelus Coioides	Orange Spotted Grouper	38	41.7-52.0	420.7-679.6	0.3-3.2	2.4-5.6
			47.2±9.5	544.8±65.6	1.7±0.3	3.9±2.8
Epinephelus Tauvina	Greasy Grouper	41	40.9-55.2	515.7-657.3	1.7-2.9	3.5-9.7
			47.9±12.0	585.7±88.9	2.1±0.6	6.8±3.6
Acanthoparagus Bifasciatus	Doublebar Bream	28	29.8-43.6	267.8-378.5	1.7-2.9	2.7-6.2
			36.9±12.3	320.5±56.6	1.8±0.3	3.7±1.8
Siganus Canaliculatus	Rabbit Fish	27	13.1-19.5	93.2-318.7	0.8-2.7	2.3-5.2
			15.2±1.8	123.5±36.3	1.8±0.2	3.4±2.3
Lethrinus Miniatus	Emperors	29	23.5-30.7	228.7-265.9	0.9-2.7	2.1-4.7
			25.7±3.2	245.6±34.6	1.6±0.6	3.2±1.9
Lethrinus Nebulosus	Spangled Emperor	30	20.6-33.4	198.6-245.8	0.7-1.2	2.9-5.5
			27.3±7.1	220.2±19.6	0.9±0.7	3.6±2.8

Table 2: Correlations between total fish body weight & TPH as well as between lipid contents & TPH in selected fish species

Fish Species	**n**	**Correlation Coefficients**	
		Weight-TPH	Lipid-TPH
Scarus Ghabon	36	0.91	0.89
Epinephelus Microdon	32	0.64	0.55
Epinephelus Coioides	38	0.44	0.32
Epinephelus Tauvina	41	0.85	0.88
Acanthoparagus Bifasciatus	28	0.57	0.45
Siganus Canaliculatus	27	0.65	0.71
Lethrinus Miniatus	29	0.43	0.51
Lethrinus Nebulosus	30	0.68	0.47

Table 3: Seasonal variations of TPH (µg-g^{-1}) levels and lipid (%) contents in selected fish species

Fish Species	**n**	**Winter** Lipid	**Season** TPH	**n**	**Summer** Lipid	**Season** TPH
Scarus Ghabon	17	2.7±0.6	8.6±1.2	19	2.2±0.7	6.9±1.3

Epinephelus Microdon	16	1.3±0.5	6.8±1.9	16	0.9±0.2	5.3±2.1
Epinephelus Coioides	20	1.7±0.4	6.3±2.1	18	1.5±0.6	4.1±2.8
Epinephelus Tauvina	20	2.8±0.9	9.7±2.5	20	2.1±1.4	7.5±3.1
Acanthoparagus Bifasciatus	15	1.2±0.5	4.1±1.9	13	0.9±0.7	3.5±2.2
Siganus Canaliculatus	16	1.9±0.7	4.7±1.5	11	1.7±0.5	4.1±1.8
Lethrinus Miniatus	16	2.1±0.3	5.7±2.3	14	1.8±0.9	3.5±2.1
Lethrinus Nebulosus	14	1.6±0.5	5.3±1.9	16	1.1±0.3	4.7±2.3

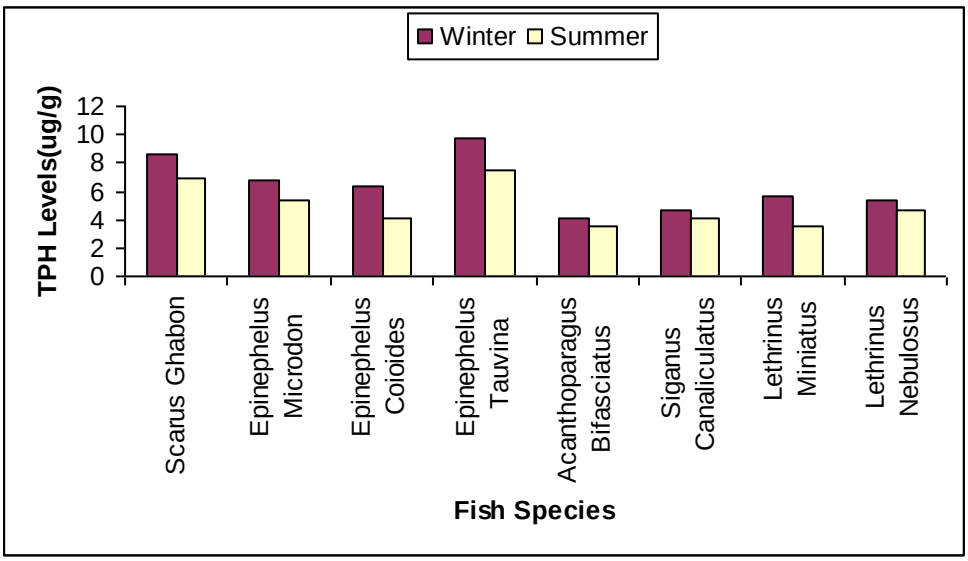

Figure 1: Seasonal variation of TPH in selected fish species