

Distribution of petroleum hydrocarbons in sea water of the Aden city - Yemen

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Abstract

This study is to determine the concentration and distribution of petroleum hydrocarbons residual in sea water in the coast of the city of Aden, Yemen, during three seasons: the first was in the period from 11 to 14 July 2014, the second was in December 2014, and the last was during March 2015, where the use of a gas chromatography and spectrofluorometer to determine the characteristics of the hydrocarbons extracted. The results confirmed the concentration of hydrocarbons levels with regard to the coast of the city of Aden. The results showed that the concentrations of petroleum hydrocarbons in water ranging from 0.688715 in Gold Mohour to 15.891754 μ /L in the refineries area, with an average concentration of 6.3269 μ g /L. The study revealed that the level of hydrocarbons in sea water of the coast of the city of Aden is close to the levels of petroleum hydrocarbons in the region and other parts of the world, after comparing their results with other regions of the world, which showed that it is low/ within the range in the permissible limits.

Keywords: Concentration; Petroleum Hydrocarbons; Gas chromatographic; spectrofluorometer, Gulf of Aden; Yemen.

Introduction

The republic of Yemen is one of many countries, which have a long shoreline on the Gulf of Aden and the Red Sea, situated on a close proximity to one of the world's busiest shipping lanes. There are a lot of kinds of ships passing in this line, especially oil tank, and transporting them. Most of the oil produced in the region is exported via sea and pipeline, while the local refineries and consumption are located in the coastal area. The widespread of oil pollution in the Red Sea and the Gulf of Aden are not surprising (27, 10, 11, 13, 4). The growing appearance of Yemen as an oil producing nation, and its close proximity to one of the world's busiest shipping lanes means a high risk of oil pollution in various forms.

The Arabian region has several distinctive features, including species diversity, geographical location and climatic conditions (26). This region has been recognized for crude oil production and exportation. It is well established that such activities are bound to result in contamination of the marine environment by petroleum hydrocarbons through day-to-day operations (25, 13). This phenomenon is greatly intensified by accidental discharges as oil spills of various magnitudes that have been reported in the region (22, 24). The first necessary step in assessing the seriousness of oil pollution in the marine environment involves the determining of magnitude of petroleum hydrocarbon concentration.

The Red Sea and the Gulf of Aden form a part of the major east-west shipping route passing through the Sues Canal, which carries around 7% of global sea born trade. Some 14000 vessels totaling 440 million NRT transit through the Canal each year (19). The great majority of these vessels also pass through Bab el-Mandeb, the southern entrance to the Red Sea. Coastal ships trading between the Gulf of Aden and ports in the southern part of the Red Sea, deep sea ships trading between the Red Sea, Indian Ocean and far east, as well as fishing vessels and dhows, add to the volume of traffic transiting Bab el-Mandeb, where a Traffic Separation Scheme was introduced about 30 years ago. Total traffic passing through the southern Red Sea is now estimated

to be around 20000 ships per year, including tankers carrying an estimated 85 million tonnes of oil from the Gulf annually(19). The traffic ships, fishing vessels and tankers have an impact on the regions by deballasting, heavy metals, litter, ect. Accordingly, both the Red Sea and the Gulf of Aden are designated "special area" under the international MARPOL convention. This means that operational discharges from shipping have great effect on the marine environment(6).

Petroleum hydrocarbons in the marine environment may be organic coming from various sources; fossil fuels, municipal and industrial wastes, runoff, oil accidents, illegal discharges, pipe line leakage and shipping. Oil and oily discharges from ships represent a significant threat to marine ecosystems. These discharges may be international or accidental. International illegal discharges of oil from ships tend to be limited in size and geographically scattered, but, surprisingly, their sum is greater than the amount in oil spill and they may create a chronic impact in certain areas. Historically, accidental oil spills have been of crude oil rather than of refined products such as diesel or fuel oil; but, in recent, years, the trend has reversed and spills of heavy fuel oil that are more common(12, 4).

Shipping discharges in the Gulf of Aden of dirty ballast water and tank washing overboard at sea. Shore facilities in Aden Port, Aden Refinery effluent, oil spill which occurred in the region and offshore hydrocarbons exploration(17).

Objective of the study

- 1- To assess and determine residue level of Petroleum Hydrocarbons in various matrixes in the coast of Aden city and attempting to identify the most important sources of pollution to the region.
- 2- To focus on the sub-lethal effects of Petroleum Hydrocarbons on marine environment in the coast of Aden city.
- 3- To collect and review relevant existing data and arrange the results obtained during the study in a manner thus to serve as a baseline data for further follow-up studies in the region.
- 4- To compare the levels of petroleum hydrocarbons concentrations in the sediment and water samples with relevant data in the literature from similar studies in some or other areas of the region or the world.

Materials and Methods

Study Area

Aden is located on the coast of the Gulf of Aden in the south of the country. It extends between latitude $12^{\circ} 48' 0''$ N and longitude $45^{\circ} 2' 0''$ E (Fig.1) and away from the capital Sana'a, a distance of up to about 363 kilometers. It is the economic capital of Yemen, and the second most important after the Yemeni city of Sana'a. Aden is the largest coastal city and farms for transit trade, boat building, ship repair and bunkering. Before the closure of the Suez Canal in 1967, Aden was the third largest bunkering port in the world. Besides port related activities, the major economic resources in the coastal zone are fisheries, maritime traffic, oil and gas exploitation. Crude oil is supplied by pipelines from the shore, and then transferred from the vessel to tankers. A barge is available for transport of ship based garbage and oily waste, which is carried by lorries to a municipal landfill where it is burned. The port and entrance channel are dredged regularly and dredge spoil is dumped offshore (1, 5).

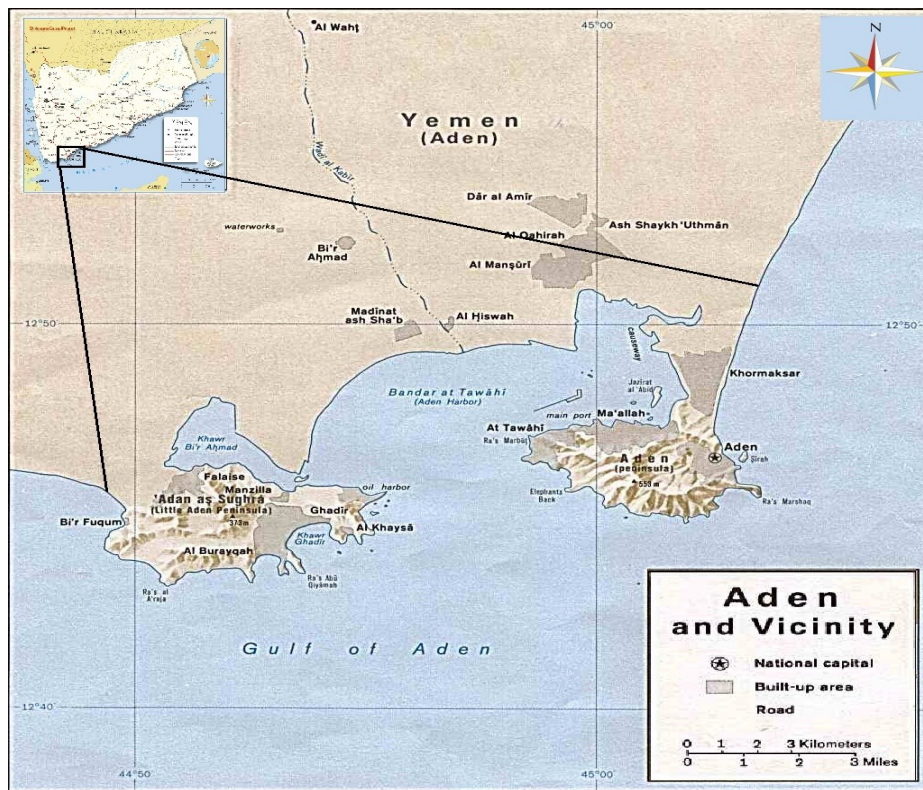


Fig. (1) Location of the study area.(28).

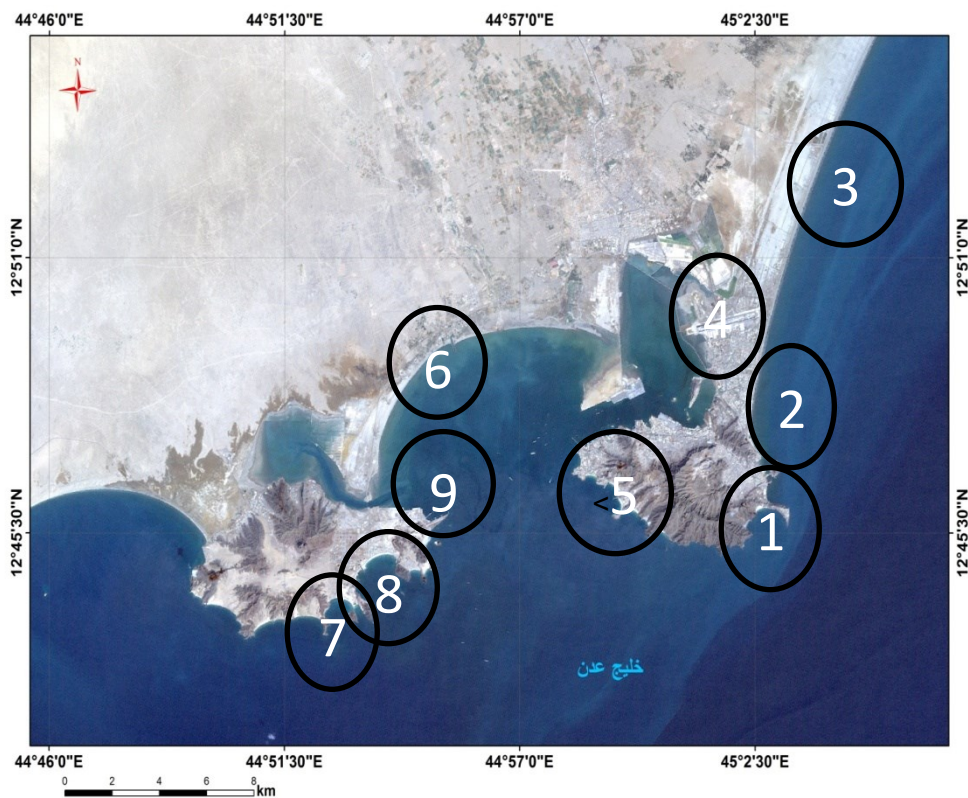


Fig.(2) Collection and processing sample(29).

Surface seawater samples were collected at (~1 m depth) from nine stations from Aden area along the Gulf of Aden coast of Yemen, during three months (July 2014, December 2014 and March 2015) by a small fishing boats (Table 1) (Fig.2). Water samples were drawn in situ via PTFE tube connected to a peristaltic pump into 2.5 L amber glass bottle containing 50 ml re-distilled carbon tetra-chloride (14). The procedure used for extraction and analysis of aliphatic hydrocarbons in the surficial water samples was based upon that of (20, 21). For the present work gas chromatography (GC) a Shimadzu GC- 2010 C.N. 1134102760 Sa, with split/split less injector furnished with a 60 m. 250 mm. 25µ fused silica capillary with a chemically bonded gum phase DB-wax, was used. Blank determinations were carried out by repeating the procedure with pre-extracted sample. A calibration was used with Marib export blend crude oil and the detector response was 45.8 mV at 360 nm emission wavelength.

The procedure used for extraction on analysis of PAHs in the water samples was performed according to conventional procedures (15) .The samples were analyzed by spectrofluorometerwork that is required here in order to know the carbon number of each resolved peak.

Results and Discussions

The results of measuring the concentration of residual petroleum hydrocarbons in water samples prepared in table (1)and (Fig .3). The lower of the concentrations of the total petroleum hydrocarbons were observed at stations 1,2,3,4,5and 6, while the higher values were observed at stations 7,8 and 9, which were 13.094897, 13.793685 and 15.891754 µg/L respectively (Table1).Results showed that the concentrations of petroleum hydrocarbons ranging from 0.688715at Gold Mohur to 15.891754 µg/L at the Refinery area. This high concentration is affected by oil spills through loading and unloading the oil, illegal discharging the ballast water, pipe leakage (23) because they are old and weak. The low concentration of petroleum hydrocarbons residual in water sample was in station (5) at Gold Mouhor, it was found 1.568145 µg/L this low concentration happens because the station is protected natural and far away from the industrial and human activities(7, 16).

There is an increase in the concentrations in all sites by residual petroleum hydrocarbons. These values have increased in recent years, when compared a with the last study in Aden City Coast in Al-Shwafi (2007), Al-Shwafi, N and Al-Jabbari, M.M.(2008).(4, 6)

Table (1) Spectrofluorometer Determinations of Total Petroleum Hydrocarbons(µg/L) in seawater Collected from Aden area along the Gulf of Aden Coast (July, December 2014 and March 2015).Subsurface seawater (~1m).

Sta. No.	Name of Station	Position		Hydrocarbons Concentration µg/L
		Latitude(N)	Longitude(E)	
1	Syra'a	12°46 ' 540 N	45°02 ' 710 E	0.918633
2	Abian Coast 1	12°47 ' 998 N	45°02 ' 430 E	2.889681
3	Abian Coast 2	12°50 ' 247 N	45°02 ' 696 E	3.780865
4	Al-Omal Island	12°48 ' 641 N	45°01 ' 233 E	2.594580
5	Gold Mohur (RF)	12°46 ' 362 N	44°59 ' 112 E	0.688715
6	Steam Station	12°49 ' 018 N	44°54 ' 785 E	3.289809
7	Algader Coast	12°44 ' 018 N	44°52 ' 936 E	13.094897
8	KoodAlnamer	12°44 ' 898 N	44°54 ' 156 E	13.793685
9	Refinery Area	12°45 ' 904 N	44°53 ' 341 E	15.891754
Range				6.3269

RF = Reference Station

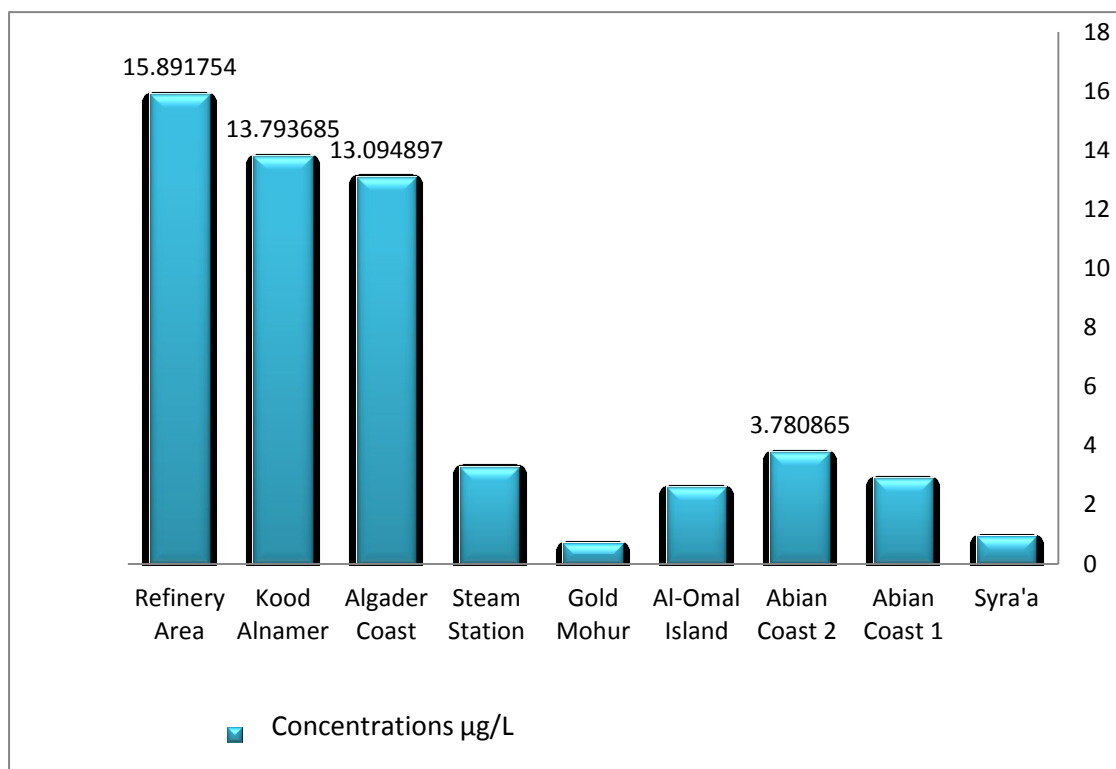


Fig.(3) Mean Concentrations of total petroleum hydrocarbonsµg/Lin seawater sample from Aden area along the Gulf of Aden Coast.

Comparing the concentrations of petroleum hydrocarbons concentrations in water was found in the present study with the values reported for the World in Table.(2). As shown in the table, the values of the present study are low and reasonable values, compared to the others, if we consider the difference between the years in the present study and other studies. Finally, the percentage of concentration of petroleum hydrocarbons residual in water is still low/within the rang and in the permissible limits.

Table (2): Comparison of Petroleum Hydrocarbons residues in Sea Water Collected from Different Region of the World.

Area	Mean Conc. (µg/L)	References
Shatt al-Arab River & Estuary & NW Arabian Gulf	2.7-86.7	(12)
Oman	1.3-28.9	(7)
Arabian Gulf	2.46-38.33	(3)
Red Sea Coast of Yemen	1.21-6.94	(13)
Al-Dabah-Gulf of Aden	0.03-0.91	(8)
Red Sea	1.12-6.94	(18)
Aden Coast	0.30-25.72	(9)
Coast water of Aden city	0.15211	(4)
Port of Yemen	7.728-14.868	(6)
Sudan (Red Sea Coast)	6.8-219.2	(23)
Al-Hodaidah Area Red Sea Coast	4.17-18.88	(/3)
Aden area along the Gulf of Aden Coast. Yemen	0.688715-15.891754	Present Study, (2016)

Conclusions

This study provides an assessment of distribution of the residual petroleum hydrocarbons in water from the coastal of the city of Aden, maritime areas, the results of this study, It is clear that, there is an increase in the concentrations in all sites by residual petroleum hydrocarbons. These values have increased in recent years when compared with the last study in Aden area along the Gulf of Aden Coast.

The concentration of petroleum hydrocarbons residual in water is still low/within the range and in the permissible limits.

- The results showed that there is a significant insufficiency in regard to the problems of ballast water in terms of the lack of legislation and laws working to reduce the discharge of contaminated water into the marine environment, especially in the coast of Aden city and in the marine environment of Yemen in general.
- The results showed that the weakness and fragility of the installations and pipelines and tanks in refineries and other facilities to increase oil spills and pollution of the marine environment and thus to increase the concentration of petroleum hydrocarbons residual.

Recommendations

- Activation of environmental monitoring of facilities that cause oil spill pollution to the marine environment by loading and unloading oil operations through environmental inspector of Maritime Affairs Authority.
- There should be ratified MARPOL in order to join them to limit oil pollution at sea.
- There should be enact legislation and laws to prevent the discharge of ballast water operation in the Yemeni marine environment, particularly in the port basins.
- Repairing the sewage treatment plant and treatment of sewage must be done before drain it into the sea.

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توزيع الهيدروكربونات البترولية في مياه البحر من مدينة عدن – اليمن

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المخلص

هذه الدراسة جاءت لتحديد تراكيز وتوزيع الهيدروكربونات البترولية المتبقية في مياه البحر في ساحل مدينة عدن، اليمن والتي كانت خلال ثلاثة مواسم، الموسم الأول خلال الفترة 11-14 يوليو 2014 في حين كان الموسم الثاني خلال ديسمبر 2014 وكان الموسم الأخير خلال مارس 2015. تم استعمال جهاز الغاز الكروماتوغرافي والتحليل الطيفي. وأكدت النتائج مستويات وتراكيز الهيدروكربونات فيما يخص ساحل مدينة عدن كما ورد سابقا. وأظهرت النتائج أن تراكيز الهيدروكربونات البترولية في المياه تتراوح بين 0.688715 في جولد مور إلى 15.891754 ميكروغرام / لتر في منطقة المصافي، مع متوسط تركيز 6.3269 ميكروغرام/ لتر. وكشفت الدراسة عن أن مستوى الهيدروكربونات في مياه سواحل مدينة عدن متقاربة لمستويات الهيدروكربونات البترولية لدراسات سابقة اجريت في المنطقة ومع مناطق أخرى من العالم وذلك بعد القيام بمقارنة نتائجها مع مناطق أخرى من العالم، والتي أظهرت انها منخفضة وفي الحدود المسموح بها.

الكلمات المفتاحية: تركيز، الهيدروكربونات البترولية، غاز كروماتوجرافي، التحليل الطيفي خليج عدن، اليمن.