2013

The impact of maritime oil pollution in the marine environment: case study of maritime oil pollution in the navigational channel of Shatt Al-Arab

Farhan M. Al Fartoosi
World Maritime University

WORLD MARITIME UNIVERSITY
Malmö, Sweden

The Impact of Maritime Oil Pollution in the Marine Environment

Case Study of Maritime Oil Pollution in the Navigational Channel of Shatt Al-Arab

BY
FARHAN MOUHASIEN AL FARTOOSI
Iraq

A dissertation submitted to the World Maritime University in partial Fulfilment of the requirements for the award of the degree of

MASTER OF SCIENCE
In
MARITIME AFFAIRS
(MARITIME SAFETY AND ENVIRONMENTAL ADMINISTRATION)

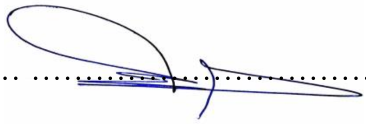
2013

DECLARATION

I certified that all the materials in this dissertation that is not my own work has been identified, and material is included for which a degree has previously been conferred on me.

The content of this dissertation reflect my own personal views, and not necessarily endorsed by the university

(Signature)… ……………………………………..



(Date)……………………………………..

Supervised by:

Professor Olof Linden

World maritime university

Assessor:

Professor

World maritime university

Co-assessor:

Professor Ali A. Z. Douabul

Head Department of Marine Environmental Chemistry &

Head Delta Research Group

Marine Science Centre

University of Basra, Iraq

ACKNOWLEDGEMENTS

At the outset, I would like to thank almighty God who is the source of the wisdom and knowledge. Also I would like to extend my gratitude to the Iraqi Transport Minister and General Company of Ports of Iraq for providing me the opportunity to join the World Maritime University, with special thanks to the General Director and I extend the thanks to my organization, Iraqi State Company for Maritime Transport and to the General Director for supporting me during the study period.

I am also grateful from the depth of my heart to Professor Olof Linden for supervising me providing valuable advice and ensuring that this research was focusing on the right track.

I would also like extend my sincere thanks to Professor Ali A. Z. Douabul for his valuable information that he provided me and his continuous guidance in the right way .

I also take this opportunity to extend my special thanks to Mr. Chris Hoebeke and all the library staff for their assistance, finding research materials from various libraries, and special thanks also due to Ms. Inger Battista for her careful linguistic supervision. I would also like to thank Ms Lundahl Lyndell for her kind assistance.

Many thanks also to my colleagues in my company Ch.Eng. Abdulkarim, J. Jassim, Ch.Eng Mubder Al Tamimi, Ch.Eng Abbas Kadhim and Ch.Eng Hiader Ali and my thanks are also due to all colleagues of the class, specially, Mazin Dawood and Gunawardhane, Wanniarachchi K. Samantha for their assistance and encouragement.

Lastly, I express my profound gratitude to my mother for her unbounded love, blessings and scarifies. Also, I would like to express my very special thanks to my wife, for her encouragement and patience during my studies.

ABSTRACT

Title of Dissertation: The Impact of Maritime Oil Pollution in the Marine Environment: A Case Study of Maritime Oil Pollution in the Navigational Channel of Shatt Al-Arab

Master of Science Degree

Potential increment of global marine transportation of petroleum products eventually results in accidental oil spills. Introduction of preventive measures with the safety concerns internationally and nationally were able to reduce the potential effects of spills and amount of accidental releases into the sea in the past decades. However, recent incidents in this concerns show that marine oil spills are unpredictable events that may cause significant damage not only to the marine ecosystems and wildlife, but the coastal communities in large.

This dissertation is study of the impact of oil spills in the marine environment of the Arab Gulf region and in the navigational channel of Shatt Al-Arab specifically. A comprehensive analysis of related factors, which contribute to oil spill risks of the North West of Arab Gulf region, is investigated. Measures taken in this event to reduce and control oil pollution risks are examined especially with the existing oil spill preparedness measures. The legislative arrangements in Iraqi context to reduce and control potential oil pollution were taken into account to analyse the oil spill control mechanisms nationally and regionally.

The main reasons of oil pollution in the regional countries are examined, using literature research and field study to the Iraqi waters; in addition, analysing samples of sediment and water from different locations and then making a comparison with previous studies. Furthermore, suggestions will be made for the possibility of reducing oil pollution in the Arab Gulf region and in the Iraqi waterways. The dissertation critically points out the lack of awareness of the international instruments in the Arab Gulf region.

Key words: Oil Spill, Contingency Planning, Preparedness, International legislations and Local legislations

LIST OF ABBREVIATIONS

AEHMS	Aquatic Ecosystem Health and Management Society
bbls	barrels
BP	British Petroleum
CACEFAS	Centre for Environment, Fisheries and Aquaculture Science
CAMRE	Council of Arab Ministers Responsible for Environment
CC_{l4}	Carbon tetrachloride
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CL Convention	International Convention on Civil Liability for Oil Pollution Damage
Cu	copper
DR	Data Recording
IDE	Thermal Seawater Desalinization Technique
FAO	Food and Agriculture Organization
g	gram
GCC	Gulf Cooperation Council
GESAMP	Group of Expert on the Scientific Aspects of Marine Environment Protection
GC-MS	Gas Chromatography Mass Spectrometry
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission

IPEICA	International Petroleum Industry Environmental Conservation Association
ISM	International Safety Management
ITOPF	International Tanker Owners Pollution Federation Limited
JCEDAR	Joint Committee on Environment and Development in the Arab Region
JICA	Japan International Cooperation Agency
kg/m^3	kilo gram per cubic meters
km^2	Square kilometres
KSA	Kingdom of Saudi Arabia
LOT	Load On Top
MARPOL	International Convention for the Prevention of Pollution from Ship
MED	Multi-Effect Seawater Desalinization Technique
ml	Millilitre
mg/m^2	Mali gram per square meter
mm	millimetre
CAMRE	Council of Arab Ministers Responsible for Environment
MSF	Multi-Stage Flash Seawater Desalinization Plant
MSL	Micro Surface Layer
N_2	Nitrogen gas
nm	Emission Wave length

OILPOL	International Convention for Prevention of Oil Pollution of the Sea by Oil
OPRC Convention	the International Convention on Oil Pollution Preparedness, Response and Co-operation
PAHs	Polycyclic Aromatic Hydrocarbons
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
RECSO	Regional Clean Sea Organization
UAE	United Arab Emirates
UK	United Kingdom
TPH	Total Petroleum Hydrocarbons
µg	microgram
Zn	Zinc
RECSO	Regional Clean Sea Organization
RF	Shimadzu RF-450 spectrofluorometer
RO	Reverse Osmosis technique
ROPME	Regional Organization for the Protection of the Marine Environmental
ROWA	Regional Office for West Asia (of UNEP)
S.A	Saudi Arabia
SBT	Segregated Ballast Tank
SE-30	Methyl Silicone

SD	Standard Deviation
SSW	Sub-Surface Water
U.K	United Kingdom
UN	United Nation
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
US	United States
UVF	Ultraviolet Fluorescence
VC	Vapor-Compression Seawater Desalinization Technique
XAD-2	Amerblite resin type XAD-2
4 N KOH	4 normal potassium hydroxide

Table of Contents

List of Figures

Last of table

Chapter I

1. Introduction

1.1 Global pollution

Environmental pollution is the pollution of air, land and water in many ways. There are several reasons for environmental pollution, such as from agriculture, industry, and urban sources. Environmental pollution has drastically changed the air, water and terrestrial ecosystems as a result of the industrial revolution in Europe, North America and China in the 19th century. Moreover, different types of toxic gases and different forms of carbon components were produced from factories, transport, and energy sectors has resulted in different changes in the global climate and weather patterns, and become a source of contamination of land, as well as the ocean environment where the average temperature and acidity are increasing. In addition, many other chemicals like fertilizers used in the agricultural industry also contribute to the pollution of the seas over vast areas (Committee on Energy Futures and Air Pollution, 2007).

1.2 The Degradation of the Marine Environment

The marine environment is affected by a number of human induced stressors and the degradation can be seen not only in coastal areas but has spread to very remote areas in the deep seas and well as in polar areas. Coastal areas are being urbanized throughout the world. There has been a global migration of humans from inland areas to the coastal areas, a phenomenon very obvious in East Asia but also very pronounced in South Asia, the Mille East, Europe and the Americas. Pollution is spreading via water and air as well through direct dumping. Human induced changes in drainage areas affect the input of sediment into coastal waters leading to erosion, and construction, landfilling and dredging also results in affected erosion and sedimentation patterns. Fisheries is a major factor affecting the environment of the seas, both because the balance of the ecosystem is affected by the removal of fish, and through the damage caused by the use of destructive fishing gear. ,

1.3 Maritime pollution activities

Maritime industry activities, basically ship operations are the prime factor causing maritime pollution, for example from accidents during oil transportation and ballast water tank transfers of harmful aquatic species between different places in the ocean. In addition there are the wastes disposed into the sea, especially plastics that remaining for several years without decomposition. Ships and marine platforms also release exhaust gases containing SOx and NOx as well as green-house gases. Ships also release wastewater into the sea. Furthermore it has been estimated that container ships lose over 10,000 containers at sea each year. In addition to that the discharge of cargo residues from bulk carriers has a potential risk of polluting environmentally high sensitive areas as well as economically and commercially important strategic locations, like ports, channels and beaches. Oil spills can have devastating effects on waterways and oceans. In the oil it is the polycyclic aromatic hydrocarbons (PAHs) that cause most of the toxicity but the physical nature of oil, i.e. the stickiness is a major problem for a number of organisms such as birds. Spills of oil has a numerous negative impacts both short and long term, resulting in economic and financial losses. Also the recovering and clean-up processes are very costly; see for example cases such as the clean-up from the Exxon Valdes or the Deepwater Horizon.

1.4 Main sources of oil pollution of the marine environment

Oil tanker vessel accidents are one of the most dangerous sources of oil pollution of the marine environment. A major disaster occurred on March 18, 1967; the Torrey Canyon was one of the first large supertankers, and it was also the source of one of the first larger oil spills. Although the ship was originally designed to carry 60,000 tons, it was enlarged to a 120,000-ton capacity, and that is the amount the ship was carrying when it hit a reef off the coast of Cornwall (UK). The spill formed an oil slick measuring 270 square miles, polluting 180 miles of coastland with many other catastrophic consequences (AL-Azab, 2005).

Ship operations are one of the main sources of oil pollution of the marine environment, especially operating giant oil tanker vessels to transport oil from production regions to consumers. It is not only the risks for catastrophic oil spills when ships ground or collide. All ships also carry fuel oil which may be as bad to the environment. There are many reasons for potential risks of environmental pollution, not only from accidents but also from the operation in the field of maritime navigation. For example, the dirty water contaminated with even small amounts of oil in the engine room space, causes pollution of the marine environment when pumping out this water into the sea further, the oil leaking from fuel oil bunkering into the sea in high sensitive areas has the high impacts on the marine environment (National Research Council, (2002).

1.5 The Arab Gulf marine environment pollution sources

The clear, shallow waters with warm temperatures of the Arabian Gulf are one of the most productive water bodies in the world. Much of the nutrient input comes from the Iraqi Shatt Al-Arab, which is the nexus of Tigris and Euphrates Rivers. Moreover, it is one of the richest oil regions in the world and the Gulf States are contributing close to one third of oil production in the world. Most of this oil is transported by ships through the Gulf. There is a potential risk for oil pollution that is about 28 times higher than the other areas in relation to the oil transportation and production (Poonian, 2003).

The most serious types of oil pollution for the Gulf environment are created as a result of the wars in the Arabian Gulf region, for instance, during the Iran-Iraq war from 1980 to 1988, at least 80 ships were sunk, many of which were carrying oil and munitions resulted in a chronic source of pollution in the Arabian Gulf for many years. Furthermore, in 1991, during the second Gulf war, a greater amount of oil spilled into the open waters of the Arabian Gulf which was estimated about 6 million oil barrels. This is the largest spill in history (Poonian, 2003).

There are many other sources that could be found in relation to the maritime pollution in the Gulf region. The desalination process to the water resource industry is one of the hot topics in this region for marine pollution in this era (Dawoud, & Al

Mulla, 2012). The ecological imbalance threatens the native species in the maritime environment because the marine pollution from different sources of toxic components dissolves in to the Gulf water (Khan et al., 2002).

1.6 Shat Al-Arab channel oil pollution

Considering the oil pollution in Shatt Al-Arab channel, it is not different from the other marine areas of pollution. However, it has different, unique properties considering other environments with mainly ecological and geographical concerns. Since 1980 when the military war was declared between the two States of Iraq and Iran, the marine oil pollution started from many ships which sank in the ports and anchorage areas because of these military attacks. With the second Gulf war in 1991, the pollution further increased because less attention was given to the environmental concerns by the political system at that time. Then the third war in 2003 appended more difficult to control marine pollution in this connection as no specific legal framework was established because of the nonexistence of a governing body in the country until 2007. In this period, it caused a disarray to enforce the international or local rules and regulations to prevent, control or minimise maritime oil pollution in this area. In addition, border disputes of the Shatt Al-Arab channel with the Iranian side and lack of understanding on the joint part of the marine pollution reduction strategies, it was more difficult to mitigate or control maritime oil pollution (Al-Saad & Al-Timari, 1989)

Presently, the pollution of the marine environment of the Shatt Al-Arab navigation channel is caused by spills from ships that use various types of fuel, and pollution from too many fishing boats, especially in the southern part of the Shatt Al-Arab channel. The pollution has caused economic and environmental damage in the Shatt Al-Arab. As a result of toxicity from the pollutants and the physical presence of oil and garbage, many aquatic fauna and flora have been destroyed in the river and one the river banks. Fish in this river water is mostly fresh water species. However also marine fish migrate into the river for breeding in the channel water and then return to the sea. This shows the importance of the Shat Al Arab and the need to strengthen its environment protection (Iraqi Ocean Science Centre, 2005).

Some of the toxic substances in the Shat are concentrated by marine organisms and may bio-accumulate in food chain so that eating fish becomes a threat to human health. Thus the contamination of the river environment will put human life in danger and also cause economic loses as a whole. Although the proportion of marine pollution posed by oil spill pollution is a small percentage when compared to other pollutants of the environment, the world community is closely monitoring these activities and trying to limit or reduce it by imposing rules, regulations and standards through the establishment of international conventions, codes with domestic legislation (Jeffrey, 1997).

1.7 The purpose of this research

As mentioned above the Shatt Al-Arab which is of strategic importance to the world is at the same time an ecologically sensitive environment with high productivity of fish and shellfish. There is an obvious risk that the environment in this part of the Gulf will be damaged even more due to the current and historic activities in the Gulf region. Hence, the purpose of this research is to**:**

1. Determine the types, sources and quantities of oil pollution in Shatt Al-Arab, in order to provide the necessary critical information to the decision makers in the Iraqi maritime authority. With relevant data it will be possible to find proper solutions for the problems of oil pollution in the channel of Shatt Al-Arab.
2. Due to the increasing number of ships that use Shatt Al-Arab as a navigational passage to Iraqi ports it will be necessary to propose instruments that will improve the situation. There is a need to establish strict rules and regulations to prevent all kinds of oil pollution resulting from ships passing through the channel.
3. Emphasize on applying a solution for this problem by the implementation of IMO Conventions related to pollution issues, such as, the MARPOL Convention, the Civil Liability for Oil Pollution Convention, the International Convention on Civil Liability for Oil Pollution Damage (CL Convention), the International

Convention on Oil Pollution Preparedness, Response and Co-operation (the OPRC Convention) of 1990 and the International Convention on Civil Liability for Bunker Oil Pollution (the Bunker Convention).

Chapter II

2. Challenges of Oil Spills and International Response to Oil Pollution

2.1 Environment pollution

The Oxford dictionary defines pollution as “the presence in or introduction into the environment of a substance which has harmful or poisonous effect. There are many types of pollution including air pollution, water pollution, land pollution, radioactive pollution and thermal pollution” (oxforddictionaries.com).

Pollution can originate from land or from the sea. If it comes from land pollution can be classed as point source or nonpoint source pollution. Point source pollution refers to pollution from a single, identifiable, and localized source such as directly discharging sewage and industrial waste into the ocean. Nonpoint source pollution, on the other hand, refers to pollution from ill-defined and diffuse sources for example agricultural runoff and windblown debris. Much of the land based pollution ends up in the ocean through rivers polluting the marine environment (Tan Jin, 2005).

2.2 Marine environment pollution

According to FAO Corporate Document Repository the marine pollution is defined by (GESAMP, 1991b)

> “the introduction by means directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities.”

Generally there are three main types of inputs of pollution into the ocean: direct discharge of waste water into the oceans, runoff into the waters due to rain, and contaminants that are released from the atmosphere. Runoff from agriculture, urban dwellings, construction etc., carry soil and particles laden with carbon, nitrogen, phosphorus, and other minerals to rivers and subsequently to the ocean. This nutrient-rich water cause algal blooms in coastal areas which have the potential to create hypoxic conditions by using all available oxygen (Hulsey & Ludivina, 2012).

Windblown dust and debris, including plastic bags, are blown seaward from landfills and other areas polluting the oceans.

Inland mining is a source of marine pollution. Some minerals, such as copper, discharge during land water wash up into the ocean gets harmful effects which can be detected in the history of life and development of coral polyps too (Heubeck et al., 2003).

Deep sea mining is a relatively new mineral retrieval process that takes place on the ocean floor, for the purpose of extracting minerals such as silver, gold, copper, manganese, cobalt, and zinc by drilling seabed depth about 1400 to 3700 m below the ocean's surface. The removal of parts from the seabed will cause turbulences to the benthic layer; as a consequence that will increased toxicity of the water column and sediment plumes from tailings. Removing parts of the sea floor disturbs the habitat of benthic organisms, possibly, depending on the type of mining and location, causing permanent disturbances. Moreover, there are toxic metals on the seabed that can be introduced into marine food webs, which can cause a change to tissue matter, biochemistry, behaviour, reproduction, and suppress growth in marine life (Hulsey & Ludivina, 2012).

The **Climate change** caused an increase in ocean temperature and level of carbon dioxide in the atmosphere. The oceans are normally a natural carbon sink, which is absorbing carbon dioxide from the atmosphere; as a result of rising levels of carbon dioxide in the water, it will acidify the ocean water. This, in turn, is changing aquatic ecosystems and adjusting fish distributions, with impacts on the sustainability of fisheries and the livelihoods of the communities that depend on them. Healthy ocean ecosystems are also important for the mitigation of climate change (IMO, 2005).

2.2.1 Marine pollution sources from ships

There are many ways of polluting waterways and oceans by ships such as garbage, sewage, invasive species, noise and oil spills. In many instances, vessels intentionally discharge illegal wastes, for instance garbage and sewage, which have a negative impact on the marine environment, particularly plastic materials that remain many years in the ocean without the disintegration and will effect to the food chains for marine organisms (Gesamp, 2007).

The water from ballast tanks can spread danger algae and other invasive species which can take over once occupied the areas, facilitate the spread of new diseases, introduce new genetic material, alter underwater seascapes and jeopardize the ability of native species to obtain food. Ships also create noise pollution that disturbs natural wildlife, their habitats and behavioural patterns. Furthermore, the oil spills from ships can have devastating effects. While being toxic to marine life, polycyclic aromatic hydrocarbons (PAHs), the components in crude oil, are very difficult to clean up in different geographic conditions, and the effects last for years in the sediment and marine environment (Hulsey & Ludivina, 2012).

2.2.2 Oil spills

An oil spill is a release of a liquid petroleum hydrocarbon into the environment due to human activity; the term often refers to marine oil spills (ITOPF, 2011). Oil spills include releases of crude oil from tanker ships, directly from accidents and indirect from ship operations, offshore platforms, drilling rigs and wells, as well as spills of refined petroleum products, such as gasoline, diesel and their by-products and heavier fuels such as bunker fuel used by large ships, or the spill of any oily white substance refuse or waste oil (Hulsey & Ludivina, 2012).

2.3 Figures for number of oil spills

2.3.1 Major Oil Spills

According to ITOPF (2013, pp.1-2) for historical reasons, “spills are generally categorised by size, <7 tonnes, 7–700 tonnes and >700 tonnes (<50 bbls, 50–5,000 bbls, >5,000 bbls)”, although the actual amount spilt is also recorded. Information is now held on "nearly 10,000 incidents, the vast majority of which (81%) fall into the smallest category i.e. <7 tonnes. Large spills often result from collisions, groundings, structural damage, fires or explosions"; they contain all oil lost to the environment, counting that which burnt or remained in a sunken vessel.

A brief summary of "the top 20 major spills that have happened since the TORREY CANYON disaster in 1967 is given in Table 1 and the locations are shown in Figure 1; of the 19 largest spills recorded between 1970 and 2007, 95% happened in the 1970s, 1980s and 1990s, and only 5% happened in the 2000s" (ITOPF 2013, pp.1-2). A number of these incidents despite their large size caused little or no environmental damage as the oil was spilt some distance offshore and did not impact coastlines.

Table 1: Major oil spills since 1977 (quantities have been rounded to nearest thousand)

Position	Ship name	Year	Location	Spill size (tonnes)
1	Atlantic Empress	1979	Off Tobago, West Indies	287,000
2	Abt Summer	1991	700 nautical miles off Angola	260,000
3	Castillo de Bellver	1983	Off Saldanha Bay, South Africa	252,000
4	Amoco Cadiz	1978	Off Brittany, France	223,000
5	Haven	1991	Genoa, Italy	144,000
6	Odyssey	1988	700 nautical miles off Nova Scotia, Canada	132,000
7	Torrey Canyon	1967	Scilly Isles, UK	119,000
8	Sea Star	1972	Gulf of Oman	115,000
9	Irenes Serenade	1980	Navarino Bay, Greece	100,000
10	Urquiola	1976	La Coruna, Spain	100,000
11	Hawaiian Patriot	1977	300 nautical miles off Honolulu	95,000
12	Independenta	1979	Bosphorus, Turkey	95,000
13	Jakob Maersk	1975	Oporto, Portugal Oporto, Portugal	88,000
14	Braer	1993	Shetland Islands, UK	85,000
15	Khark 5	1989	120 nautical miles off Atlantic coast of Morocco	80,000
16	Aegean Sea	1992	La Coruna, Spain	74,000
17	Sea Empress	1996	Milford Haven, UK	72,000
18	Nova	1985	Off Kharg Island, Gulf of Iran	70,000
19	Katina P	1992	Off Maputo, Mozambique	66,700
20	Prestige	2002	Off Galicia, Spain	63,000

Source: ITOPF Handbook, 2013, p. 2

2.3.2 Number of Oil Spills

According to ITOPF (2013**,** p. 4), there is a drastic decrease in incidence of large spills. Thus, it seems from Table 2 that "the number of large spills (>700 tonnes) has a decreased significantly through the last 43 years, during which registers have been kept. The average number of major spills for the previous decade (2000-2009) is just over three, approximately one eighth of the average for the years in the 1970s". Looking at this downward trend from another perspective, 55% of the large spills noted happened in the 1970s, and this percentage has reduced each decade to 7% in the 2000s. A decline can also be observed with medium sized spills (7-700 tonnes) in Figure 2 and Table 2. Here, "the average number of spills in the 2000s was close to 15, whereas in the 1990s the average number of spills was almost double this number". No large spills were logged for 2012, but 7 medium spills were logged. Despite being higher than those seen in 2010 and 2011, this figure is still far below the averages for previous decades (See Figure 1 and Table 2).

Table 2: Annual number of oil spills (>7 tonnes)

Year	7–700 Tonnes	>700 Tonnes		Year	7–700 Tonnes	>700 Tonnes
1970	7	30		1980	52	13
1971	18	14		1981	54	7
1972	48	27		1982	46	4
1973	28	31		1983	52	13
1974	90	27		1984	26	8
1975	96	20		1985	33	8
1976	67	26		1986	27	7
1977	69	16		1987	27	10
1978	59	23		1988	11	10
1979	60	32		1989	33	13
Total	542	246		**Total**	361	93
Average	54.2	24.6		**Average**	36.1	9.3

Year	7–700 Tonnes	>700 Tonnes	Year	7–700 Tonnes	>700 Tonnes
1990	51	30	2000	21	4
1991	30	14	2001	17	3
1993	31	27	2002	12	3
1994	31	31	2003	19	4
1995	26	27	2004	17	5
1996	20	20	2005	22	3
1997	20	26	2006	13	5
1997	28	16	2007	13	4
1998	25	23	2008	8	1
1999	20	32	2009	7	1
Total	282	246	**Total**	149	33
Average	28.2	24.6	**Average**	14.9	3.3

Year	7–700 Tonnes	>700Tonnes
2010	4	4
2011	5	1
2012	7	0
Total	16	5
Average	5.3	1.7

Source: ITOPF Handbook, 2013, p. 4

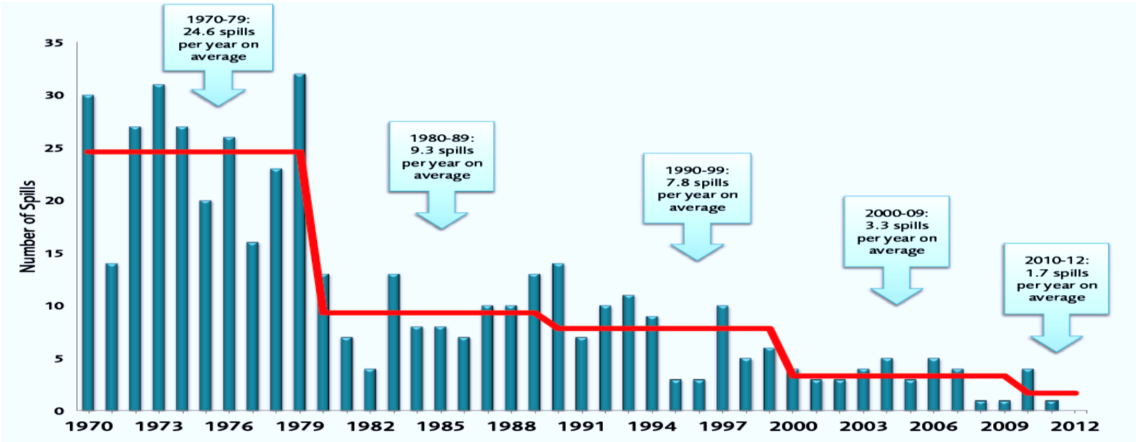


Figure 1: Number of large spill (>700 tonnes) from 1970 to 2012

Source: ITOPF Handbook, 2013, p. 5

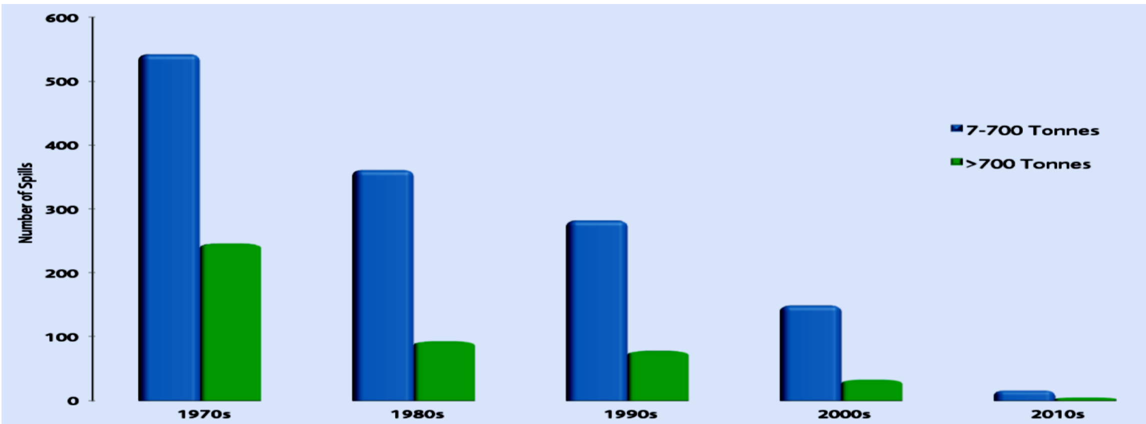


Figure 2: Number of Medium (7–700 tonnes) and large (> 700 tonnes) spills per decade from 1970 to 2012

Source: ITOPF Handbook, 2013, p. 5

2.3.3 Quantities of Oil Spilt

ITOPF, (2013) presented in Figures 3 and 4 pointed to the volume of oil spilt from tankers which shows substantial improvement in oil spill incidents from 1970 to 2012,which is estimated to read as 5.75 million tonnes of oil were lost as a result of tanker incidents in that period. The volume of oil spilt shows a remarkable reduction as a result of decreasing the number of oil spills from tanker ship operations. It is further reflected in Table 3 that an amount more than the total quantity of oil spilt in the time period, “from 2000 to 2009 (212,000 tons) was spilt in several particular years in earlier decades. The total amount of oil lost to the open environment in 2012 is the lowest on record; with 7 medium spills this equates to an average of approximately 100 tons per incident” (ITOPF, 2013, p. 6).

Table 3: Annual quantity of oil spilt

Year	Quantity (Tonnes)	Year	Quantity (Tonnes)	Year	Quantity (Tonnes)	Year	Quantity (Tonnes)
1970	409000	1980	206000	1990	61000	2000	14000
1971	143000	1981	48000	1991	431000	2001	8000
1972	313000	1082	12000	1992	167000	2002	67000
1973	159000	1983	382000	1993	140000	2003	43000
1974	173000	1984	29000	1994	130000	2004	16000
1975	351000	1985	85000	1995	12000	2005	18000
1976	364000	1986	19000	1996	80000	2006	23000
1977	275000	1987	30000	1997	72000	2007	19000
1978	393000	1988	190000	1998	13000	2008	3000
1979	636000	1989	174000	1999	29000	2009	2000
Total	3218000	**Total**	1176000	**Total**	1135000	**Total**	212000

Year	Quantity (Tonnes)
2010	12000
2011	2000
2012	1000
Total	15000

Source: ITOPF Handbook, 2013, p. 6

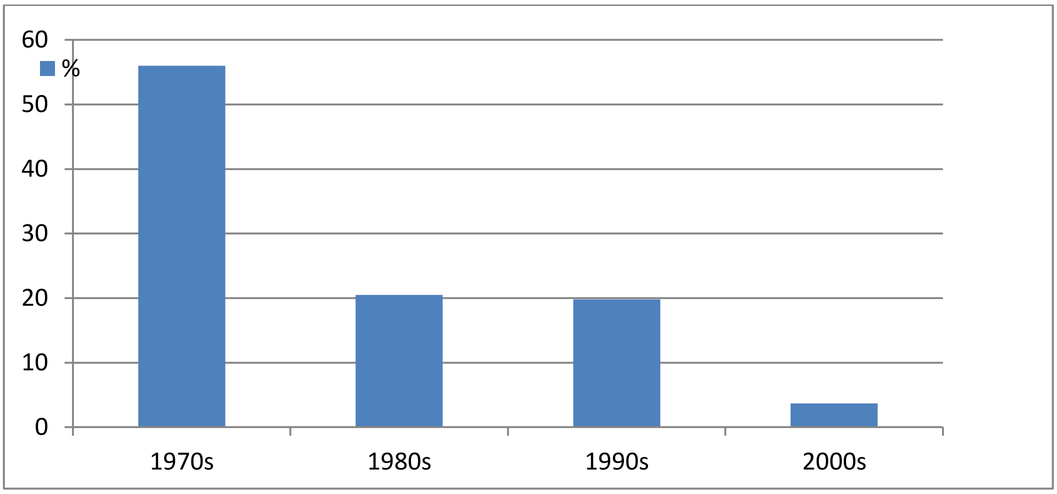


Figure 3: Oil spilt per decade as a percentage of the total spilt between 1970 and 2009

Source: ITOPF Handbook, 2013, p. 6

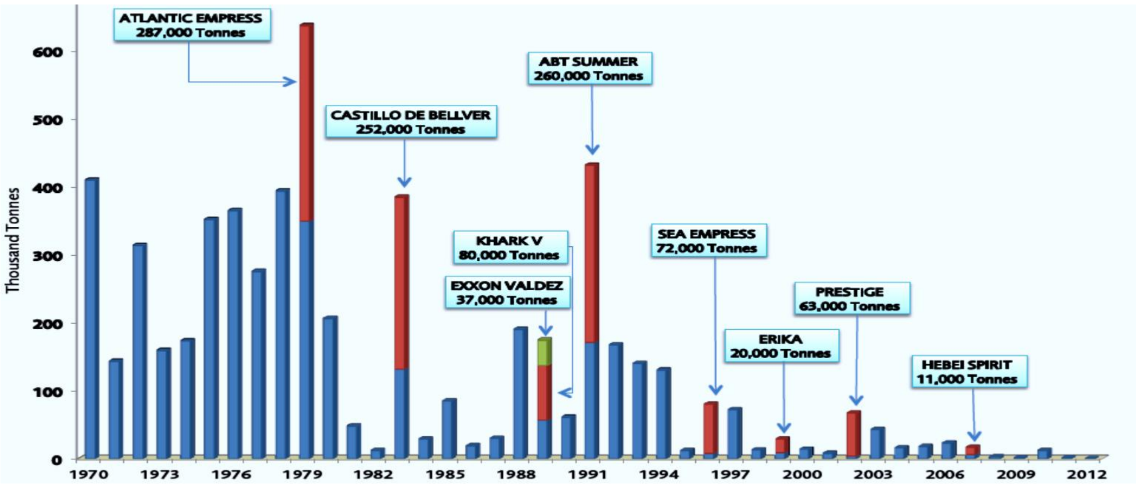


Figure 4: Quantities of oil spilt > 7 tonnes (rounded to nearest thousand), 1970 to 2012

Source: ITOPF Handbook, 2013, p. 7

2.4 Fate of oil spills in the marine environment

There are different types of oils such as crude oil, petroleum products, and persistent oils. So when oil is spilled into sea water, it undergoes a number of physical and chemical changes, some of which lead to its disappearance from the sea water surface. However, other types of oil remain although they cannot be scene. The time involved in this process depends on the initial physical and chemical characteristics of the oil and the natural weathering processes. According to IMO (2005), the fate of oil spills into the marine environment is a process as follows:

2.4.1 Properties of oil

The behaviour of oil the sea surface and its rate of dissipation by natural processes are depending on individual properties of oil, such as a follow;

2.4.2 Density (specific gravity)

Specific gravity is the measure of the density of the oil in relation to freshwater, whose density is 1 kg/m^3, as a general rule, oils are low density. Density, dictates the buoyancy of oil on water and it influences spreading and natural dispersion. The density of oil is expressed either in units of mass per unit volume (kg/m^3).

2.4.3 Boiling point and boiling range

The rate at which oil evaporates is indicated by its initial boiling point and boiling range. The lower these are the faster evaporation will occur.

2.4.4 Viscosity

There is an inverse relationship between oil viscosity and oil movement on the water surface. When the oil is high in viscosity, it will move slowly, but when the oil viscosity is low, the oil movement is fast, depending on water temperature. Further, absorption of heat from the sun will affect the apparent viscosity of spilled oil.

2.4.5 Pour point

The pour point is the formation of an internal micro crystalline structure of oil, when the ambient temperature below the oil will not flow and it will behave as a solid.

2.4.6 Flashpoint

This is an important factor in relation to the safety of clean-up operations, because the flashpoint is the lowest temperature at which sufficient vapour exists above the spilled oil to yield a flammable mixture.

2.4.7 Solubility

Some kinds of oil components are soluble in water, but the more volatile components are the more soluble, which represents a significant toxicity to marine life.

2.4.8 Asphaltenes content

Asphaltenes is the main role in the formation and stability of water-in-oil emulsions; therefore, the low Asphaltenes oil is not stable emulsions.

2.5 Natural weathering processes acting on spilled oil

When the oil spilled into the seawater, it will start a series of processes together known as weathering, which will change characteristics and behaviour. According to IMO (2005, p. 11), there are main factors which affect the oil behaviour of the oil, as follows:

- Physical characteristics of the oil, in particular, specific gravity, viscosity and boiling range;
- Composition and chemical characteristics of the oil;
- Meteorological conditions (sea state, sunlight and air temperatures); and
- Characteristics of the seawater (specific gravity, currents, temperature, presence of bacteria, nutrients and dissolved oxygen and suspended solids).

The knowledge of these processes and how they related to changing the nature of oil is valuable when responding to spills. Figure 5 depicts the processes and Figure 6 shows how the relative importance of the processes varies with time (ITOPF, 2002)

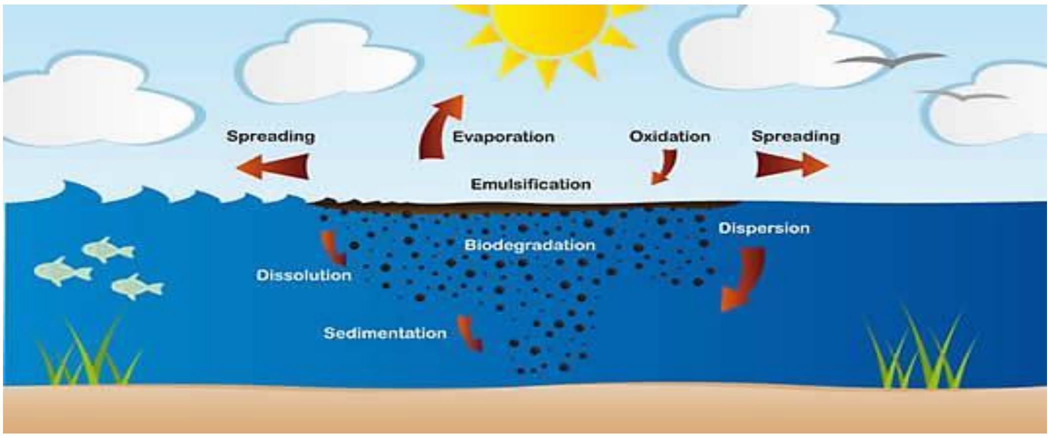


Figure 5: Processes taking place after oil spill

Source: ITOPF Handbook, 2002, p. 4

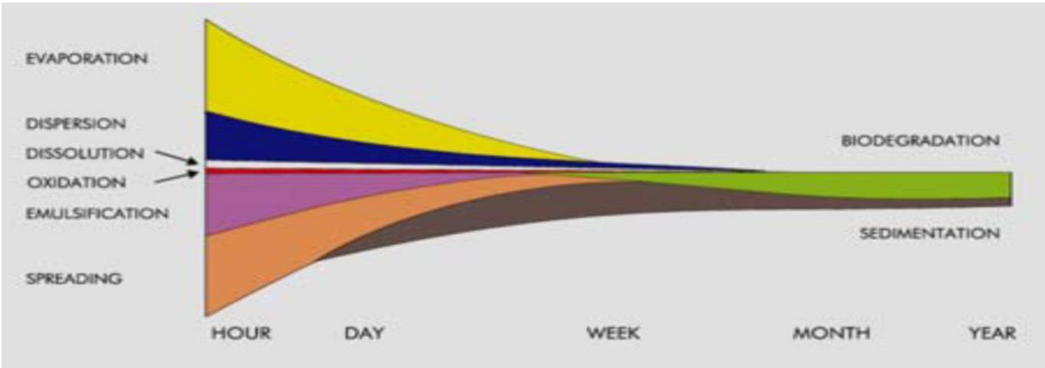


Figure 6: Time span and relative importance of processes acting in oil spill

Source: ITOPF Handbook, 2002, p.5

2.5.1 Spreading

After an oil spill at the sea, it will be floated and start to spread. There are exceptions for few oils to sink while spreading out because the density of that oil is higher than seawater density. The oil slick rapidly spreads on the seawater surface and controls the process at the time of a release. However, the oil weight is the most important factor causing the oil to spread as a coherent slick, while, when the oil viscosity is high, it will spread more slowly than oils with low viscosities. On the contrary, when the sea water has a high temperature, the oil will easily spread on the sea water surface (Cormack, 1999).

The oil slick after few hours from spreading will begin to break up and form narrow bands in the same wind direction. In this case the oil viscosity becomes less important because of the turbulence at the sea surface. In addition to that, the oil spreading rates depend on currents (both residual and tidal) and wind speed. The oils spilled will cover several square kilometres after 12 hours from the oil spill, thus limiting the possibility of effective clean-up (ITOPF, 2002).

2.5.2 Evaporation

Oil evaporation is the most important process in which the oil from the water surface is removed. The proportion of low-boiling fractions in the oil is the limitation of the speed and extent of the oil evaporation. When the oil spreading is also in larger area, the light components will evaporate faster, and there are also some factors that encourage faster evaporation, such as rough seas, higher temperatures and wind speeds. Light oils such as gasoline, kerosene and light fuel oil may evaporate completely within a few hours and light crudes can lose up to 40% during the first day. In some cases, the heavy crudes and fuel oils virtually have no evaporation, so a major consequence of evaporation will be an increase in density and viscosity of any remaining oil (ITOPF, 2002).

2.5.3 Natural dispersion

Under rough sea conditions, the oil spill will separate as droplets. Some of these droplets will be suspended in the water and others, it disperse through the upper layers of the seawater, depending on droplet size, as well as density difference between the water and oil. Natural dispersion does not lead to changes in the physical and chemical properties of the spilled oils, but largely determines the lifetime of oil on the sea surface. Most small slicks of lighter oils will fade within a few hours through this natural dispersion (IMO, 2005).

2.5.4 Water-in-oil Emulsion

Water-in-oil emulsion is created when some of oils exhibit a tendency to absorb water droplets, which it leads to changing oil colour to red-brown or orange. The asphalting content of the oil is determining the stability of emulsion; moreover, there is 0.5% from those foul oils that tends to form stable emulsions, whilst those containing less are unlikely to be stable. Emulsion formation is depending on sea weather conditions, such as rough sea or calm waters. The formation of water-in-oil emulsion can increase the volume of the oil spill by a factor of up to 5, because the viscosity and density will be increased (IMO, 2005).

According to IMO (2005, p. 11), Figure 7 "illustrates the volume of oil and water-in-oil emulsion remaining on the sea surface shown as a percentage of the original spill volume (100%). The curves represent an estimated 'average' behaviour for each group. The behaviour of a particular crude oil may differ from the general pattern depending on its properties and environmental conditions at the time of the spill".

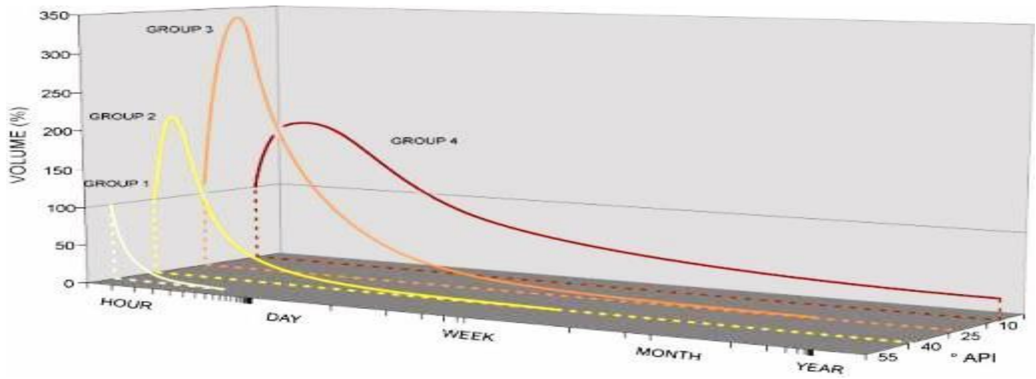


Figure 7: The rate of removal of oil from the sea surface according to their physical properties

Source: IMO 2005, p. 11

2.6 Movements of oil slicks

The winds, waves, tides and currents are the combined influence of the oil slick movements. The oil slick movements depend on which of these will have a greater influence than the other in affecting the movement of the oil slick. This is very important to determine the follow-up of the movement, direction of an oil slick and the oil clean up time (IMO, 2005).

2.7 Effects of oil spills on the marine environment

The effects of oil spills on the marine environment depend on a number of factors such as the physical features of the affected region, weather conditions and season; the nature and the efficiency of the clean-up operations, the biological and economical characteristics of the area and the area's vulnerability to oil pollution; the category of oil and its behaviour once spilled among others (ITOPF, 2002).

Oil spills into the sea from sources, such as ships, oil terminals and pipelines create serious marine environmental problems. When oil spills occur in a particular area, it causes different kinds of damage to the environment, for instance oil coated shorelines, dead or moribund wildlife, and oiled seabirds and marine mammals (ITOPF, 2008).

Oil pollution has the long-term effect on every population within this region and the community-level impacts in different ways. Even small amounts of oil released over a long period create chronic impacts on the whole entire environment; short duration gets limited impacts. The oil effect can also be classified depending on the time and duration of the spill with the numbers and types of organisms affected (National Research Council, Committee on Oil in the Sea: Inputs, Fates, and Effects Staff, 2002).

There are two complex ways of detecting change in the effects of oil pollution in the oceans, first, through gathering of observational data. This, however, possesses strategic challenges to determining the impact of oil as inevitably, assumptions are made about the variability in an ecosystem and that variability can obscure large and continuing impacts. Secondly, the actual impact of the oil may be more complex than can be realized if it interacts with spatially or temporally constrained phenomena (National Research Council, Committee on Oil in the Sea: Inputs, Fates, and Effects Staff, 2002).

Sea and shore birds such as shags, fulmars, kittiwakes, razorbills and guillemots are easily more affected by oil spills because some of these dive under water for their food. In the event of an oil spill, they are definitely impacted by the oil. In addition, when the birds' feathers are coated with oil, there is loss of body heat which may cause death. The birds may also be unable to fly and could hence drown. The birds' may also starve to death because the food sources at sea or on shorelines are covered with oil (Heubeck, et al., 2003).

Oil pollution can affect **Fish and shellfish** in three ways: direct lethal or sub-lethal effect on the fish itself; direct effect on fisheries, and indirect effect via ecosystem disturbance (IMO, 2005). Shellfish are more affected by oil spills than fish because of their habitat. Similarly, water column organisms such as planktons may be impacted by oil pollution. Laboratory studies have revealed toxic and sub-lethal effects on planktons (ITOPF, 2002).

With respect to **sea mammals** in the open sea, there are no significant impacts from oil spills to whales, dolphins and seals, but when the sea mammals are breeding on the shorelines, they are more prone to be affected by oil pollution. The most affected mammal species are those which rely on fur to regulate their body temperature because if the fur becomes contaminated with oil, the mammal may die from hypothermia or overheating (ITOPF, 2002).

Interestingly, some kinds of **plants and marine animals** such as the adult fish, squid, and shrimps seldom suffer long-term damage from oil spill exposure. The greatest oil impacts occur on shorelines where animals and plants may be physically coated and smothered by oil or exposed directly to toxic components in the oil. Soils and vegetation e.g. the mangroves will be affected by oil spills**.** However, the toxicity resulting from oil pollution will possibly affect the **coral reefs** (ITOPF, 2002).

Macro-fauna such as the benthic fauna in offshore sediments are very sensitive to polluted material attached to particles. Since they feed on organic particles either suspended in the water or living on the seabed, they are good indicators of biological conditions of sediments (IMO, 2005).

There are serious impacts on the **human health,** when an oil spill has effects such as significant atmospheric pollution and subsequent pollution of inland waters, and the fresh water systems**.** Furthermore**,** with regard to human health, when individuals are exposed to constituents of oil such as polycyclic aromatic hydrocarbons (PAH), these may be harmful because they have been identified as carcinogenic to humans. Human beings are at the end of sea food chains and their health may be impacted by ingesting oil polluted sea food. In addition, oil pollution can cause many other health problems such as coughing, difficulties in breathing and nasal obstruction (ITOPF, 2011).

2.8 International legal regime to prevent oil pollution, development of international legal regime and compensate pollution damages for oil pollution from ships

2.8.1 Development of an international legal regime for oil pollution from ships

In the first half of the 20th century after the big revolution in maritime transportation, oil pollution of the seas was considered as a serious problem. Accordingly, many countries introduced various national regulations to control discharges of many waste materials not only from ships but also from other sources of pollution, especially oil in their territorial waters to protect their marine environment. In 1954, the United Kingdom organized a conference on marine oil pollution which resulted in the adoption of the International Convention for Prevention of Oil Pollution of the Sea by Oil, OILPOL. This enteral into force in 1958, the depository and Secretariat functions in relation to the convention were transferred from the United Kingdom government to IMO (Tan, 2006).

2.8.2 International Convention for Prevention of Oil Pollution of the Sea by Oil (OILPOL)

The 1954 Convention, which was amended subsequently in 1962, 1969, 1971, with some important issues to point out suitable solutions that primarily address the pollution resulting from daily tanker operations and from discharging oily wastes into the sea from machinery spaces, regarded as the major causes of oil pollution from ships. The 1954 OILPOL Convention which enteral into force on 26th July 1958, attempted to address the key issues of pollution of the seas by oil, defined as a crude oil, heavy diesel oil and lubrication oil in two main ways:

- It established prohibited zones extending at least 50 miles from the nearest land in which the discharge of oil or mixtures containing more than 100 parts of oil per million was forbidden; and
- It required contracting parties to take all appropriate steps to promote the provision of facilities for the reception of oily water and residues (IMO, 2002, p. 60).

In 1962, IMO made an amendment by considering two key factors of an operational ship to the convention by extending its application to the ships having lower tonnage and also by extending the prohibited zones. The amendment adopted in 1969 contained regulations to further restrict operational discharge of oil tankers and from machinery spaces of all ships (Tan, 2006).

As a result of the major oil disaster of the Torrey Canyon in 1967, the IMO Assembly decided after two years from this incident, in 1969, to convene an international conference in 1973 to prepare a suitable international agreement for placing restraints on the pollution of the sea, land and air by ships under the title of MARPOL. (Tan, 2006)

2.8.3 MARPOL Convention 73/78

The MARPOL Convention was adopted on the 2th November, 1973 as another important IMO Convention and covered pollution by the main and key sources of oil, chemicals, and also harmful substances in packaged form, sewage and garbage. The protocol of 1978 related to the 1973 International Convention for the Prevention of Marine Pollution from Ships was adopted in a convention on tanker safety and pollution prevention on February, 1978. The main purpose of this Convention is preventing and minimizing marine pollution from ships, both accidental pollution and daily operations; it includes six Annexes to address the key areas given above and Annex I is prepared for "the regulations for the prevention of pollution by oil" which is the important part in this research, enteral into force on 2 October in 1983 (IMO, 2002).

2.8.4 Annex I of MARPOL Convention 73/78

The 1973 Convention prescribed the oil discharge criteria prescribed in 1969 the amendments to the 1954 - Oil Pollution Convention, with important changes, which the discharge operation of any kind of oil from operational ships are allowed in specific conditions. It includes "the total quantity of oil discharged does not exceed 1/1500 (for existing tanker) or 1/ 30,000 (for new tankers) of the total quantity of cargo which was carried on the previous voyage" (IMO, 2002, p. 58). The specific concentration rate at which oil may be discharge "must not exceed 60 litres per mile travelled by the ship; and it gives some constrains with no discharge of any oil whatsoever must be from the cargo spaces of a tanker within 50 miles of the nearest land" (IMO, 2002, p. 58).

As with the 1969 OILPOL amendments, the 1973 Convention recognized the Load On Top (LOT) system which had been developed by the oil industry people in the 1960s. In most cases tankers, when they discharge cargo volume sea water is used as ballast operations means in cargo tanks (departure ballast). Also after the few days, the water settles at the bottom of the tanks and the oil flows to the top because of the density change. Then the water is transferred to the ballast water tanks and the oil to the slop tanks. After further setting and decanting, the next cargo is loaded on the remaining oil in the slop tank (Tan, 2006).

Another new and important feature of the 1973 Convention is the concept of "special areas". The 1973 Convention identified those areas which were amended many times. Those areas include: the Mediterranean Sea, the Black Sea, the Baltic Sea, the Red Sea, and the Gulf area as special areas, Gulf of Aden, Antarctic area, North West European waters, Oman area of the Arabian Sea, and Southern South African waters. The last amendments to these areas were made in 2006. All oily wastes, carried by ships are not allowed to discharge in the areas as specified as special areas and it should be discharged to shore reception facilities through the (load on top) system (IMO, 2012).

The protocol of 1978 too made a number of changes to Annex I of the parent convention. However, Segregated Ballast Tank (SBT) is required on all new oil tankers of its capacity of 20,000 tons deadweight or more than this tonnage (in the parent convention SBT was only required on new tankers of 70,000 tons deadweight and above). The protocol also required SBTs to be protectively located, so they must be positioned in a way to help in protecting the cargo tanks in case of an incident, a collision or grounding (IMO, 2002, pp. 68-69).

The other important method is called Crude Oil Washing (COW), which had been developed by the oil industry in the 1970s and it opened major benefits considering other methods. Under this new method of COW, tanks are washed not with water but with crude oil, the cargo itself. COW was accepted as an alternative to SBTs on existing tankers and is an additional requirement that should be applied on new tankers (Tan, 2006).

Additionally, for more protection of the marine environment against ship collision accident the Annex I of MARPOL was amended in 1992. The annex make it mandatory for new oil tankers to have double hull tanks as a precautionary engineering measure and it brought in a phase in schedule for existing tankers to fit double hulls, which was subsequently revised in 2001 and 2003 (Terhune, 2011).

2.8.5 The International Convention on Civil Liability for Oil Pollution Damage (CL Convention)

The purposes of the CL Convention, guarantees that compensation is available to parties that have been damaged, in particular, marine oil pollution, caused by a maritime accident. The Convention recommended complete liability on the ship owner, but there are a number of specific exceptions given in this regards. The CL Convention was adopted in 1969 and entered into force in 1975; it was amended in 1992 by a Protocol of 1992, which entered into force in 1996. In this case the owner should be providing the evidence for each case to get the exceptions. Ships under this convention should maintain an insurance and financial security that is supposed to be corresponding to the owner's total liability for one incident. The 1992 Protocol of this convention increased the compensation limits and extended the scope to this (IMO, 2011).

2.8.6 The International Convention on Civil Liability for Bunker Oil Pollution (the Bunker Convention)

The other high potential risk had been identified was oil pollution from ship operations when fuelling or bunkering. Hence, another important convention the Bunker Convention was adopted in 2001 and entered into force in the year of 2008. The main purpose of the convention is to ensure that typical, swift, and effective compensation is available to the parties that suffer damage caused by spills of oil, when carried as fuel in ships' bunkers. This creates a liability and compensation regime in case of marine pollution as damage has happened by spills of bunker oil from ships in the territorial water and exclusive economic zone of a State (IMO, 2004).

2.8.7 The International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (1969) (the Intervention Convention)

The Intervention Convention, which was adopted in 1969, they gave the right to coastal states to take such procedures on the high seas in which, they gave contribute to preventing, mitigating or eliminating danger to its coastline or related interests from marine pollution by oil or the threat after a maritime casualty (IMO, 1977).

2.8.8 The International Convention on Oil Pollution Preparedness, Response and Co-operation (the OPRC Convention) of 1990

The OPRC Convention, which was adopted in 1990, came into force in 1995. The importance of the convention is that it regulates marine pollution caused from accidental oil spills. The main objectives of the convention are to support and facilitate international cooperation with mutual assistance to the knowledge based activities. It was developed as preparing for and responding to major oil spills and urges States to the convention to develop adequate capability concerning the whole scope to deal with oil pollution incidents to protect their marine related environment (IMO, 1991).

2.8.9 International Legal Instruments related to the Compensation for Damages caused due to Oil Spills

After the Torrey Canyon incident, two voluntary agreements and two conventions were developed. Compensation is available under these instruments for the damages occurred and cost incurred for clean-up as a result of a spill of persistent oil from a tanker (IPIECA, 2007).

Chapter III

3. Arabian Gulf and Shatt Al- Arab channel

3.1 The Arabian Gulf from a historical point of view

The Arab Gulf was a strategic location considering the international trade network which was called the spice route and was a trading centre in the Gulf for trade between the Middle East, Europe, Africa, India and China. Even earlier, in ancient days of Mesopotamian glory, this was a significant route and it was named as a hub of golden international trade. "Also important was discovery of substitute trade linking India with the Mediterranean Sea through the Arabian Sea, the Gulf of Aden and Red Sea and then Suez channel" (Khan, et al., 2002 p.7).

"The Arabian Gulf is an arm of the Arabian Sea located in the North-Temperate tropical margin and bordered by eight countries; Iran, Iraq, Kuwait, Saudi Arabia (S.A), Bahrain, Qatar, United Arab Emirates (UAE), and Oman (See Figure 8). It has a surface of 239,000 km^2, average depth of 36m, and average volume of 8,630 km^3" (Khan, et al., 2002 p.7).

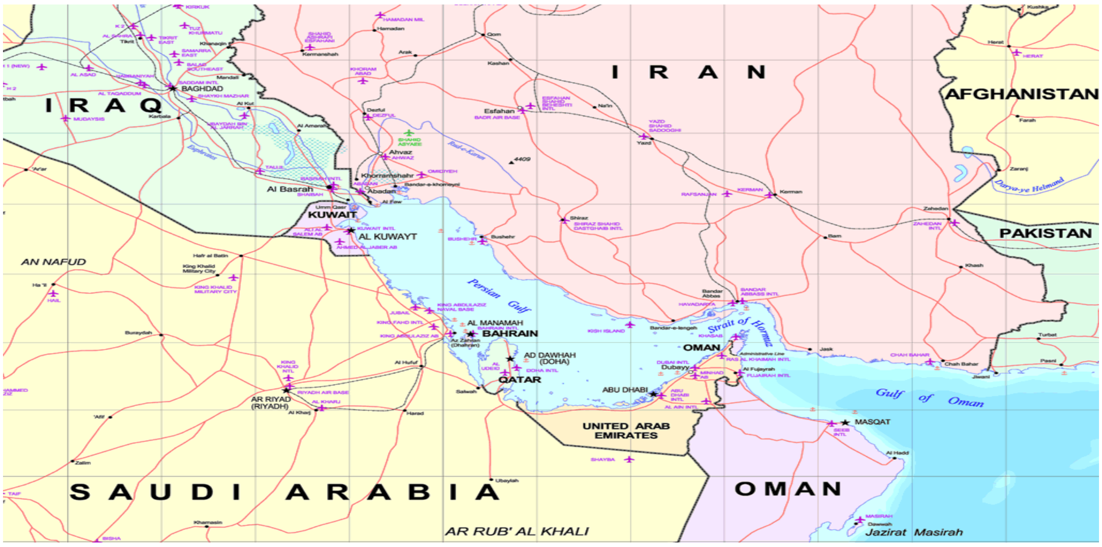


Figure 8: Showing the Arabian Gulf Countries

Considering many aspects of the region, it has a strategic position since about four thousand years and it has its own special history together with unique characteristics in different ways (Khan, et al., 2002).

Soon after the industrial revolution and particularly after the discovery of oil and gas, and its rapid development, the Arab Gulf has become one of the most important, more strategic areas of the world and it plays an essential role in the field of the international oil industry (Fattouh & El-Katiri, 2012). According to British Petroleum (2013) petroleum statistics, the annual output of petroleum volume has been increased by about 27.9% in 2013 compared to world’s crude oil exports in 2012. This region’s petroleum reserves capacity founded around 45.8% of the world’s crude oil reserves is estimated as 780.3 thousand million barrels.

As a result of this importance and development of petroleum related activities, the Arabian Gulf region is filled with tanker traffic along oil export ports and other related marine based events (British Petroleum BP, 2013). This results in the potential negative impacts to the sensitive marine and ecological ocean system. These effects will be discussed in a broader way in this chapter.

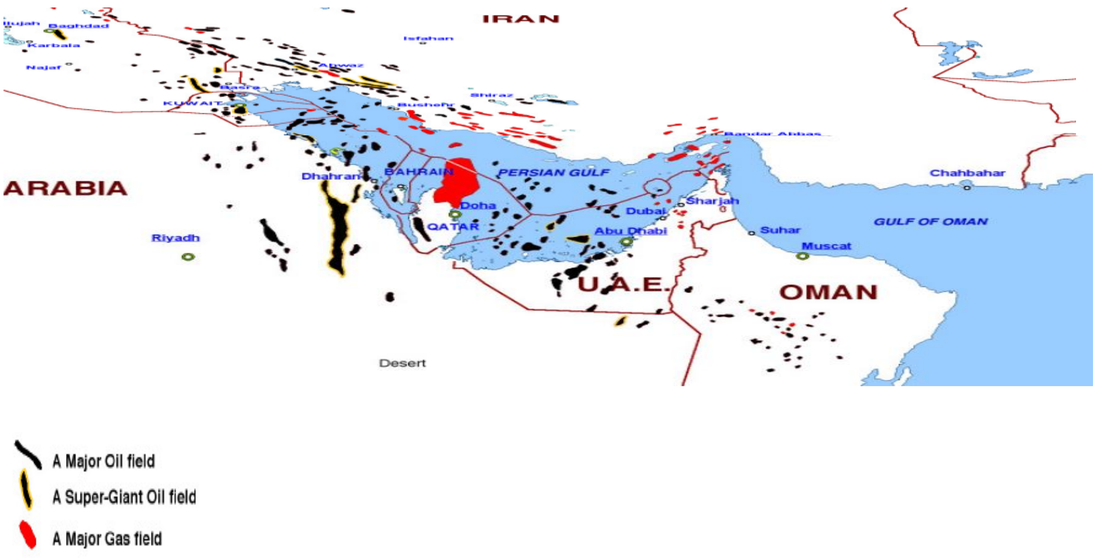


Figure 9: Showing the huge number of oil installations in the Arab Gulf

Source: ROPME 2013

3.2 Arabian Gulf Environment features

According to the First International Aquatic Ecosystem Health and Management Society (AEHMS) Conference of the State of the Gulf Ecosystem: Future and Threats (UAE University, 2006), the clear shallow waters, warm temperatures and an inflow of nutrients make marine productivity in larger scales. The Tigris and Euphrates Rivers provide such nutrients and other exact factors make the Arabian Gulf one of the most productive water habitats in the world.

Fisheries productivity is typical for waters of this latitude of the Gulf area and the river mouth of Shatt Arab Cannel. Many kinds of marine organisms of the Gulf are contributing to its high productivity values. Especially, the coral reefs on the offshore islands are most vital as the substrate to these sub tidal ecosystems provide shelter and feeding grounds for various kinds of marine invertebrates and fishes. Although this area is a relatively small regional sea, it is highly productive with at least four species of sea grasses commonly distributed in shallow areas forming the base of many food chains and webs. Naturally grown mangroves are found in the tidal zone and are characterised by a single species. However, the mangrove forests are less extensive in the Gulf compared to the Red Sea, nearly 125-130 km^2 compared to 400-500 km^2 (UAE University, 2006).

In addition, Shatt-al-Arab River is the main source of fresh water for the Arab Gulf, which flows primarily from Iraq into the northern end of the Gulf. The Gulf loses an estimated 326 km^3 of water evaporation per year due to the high temperatures of the region (Baumann, 2008).

3.3 The main sources of pollution in the Arab Gulf

According to Baumann (2008), there are different sources that could cause sea water and sediment contamination especially in the Arab Gulf such as wars, oil industry and oil transportation and desalination plants.

As an example in the second Arab Gulf war period (1990-1991), the mean monthly rates of atmospheric dry deposition of sulphate and nitrate at Dhahran in the month of May 1991 were as follows. The nitrate, non-sea sulphate and sea sulphate deposition were approximately, 19 mg/m^2, 65 mg/m^2 and 24 mg/m^2. The petroleum hydrocarbon concentrations were raised near the locations where tanker vessels had sunk or any other oil leaking source (Poonian, 2003).

3.4 The Tragedy of burning oil wells through second Gulf war in 1991

The Saddam Hussein regime of Iraq burnt approximately 850 oil wells in Kuwait during the second Gulf war in 1991, before withdrawing the military troops from the country. It has been estimated that nearly 500 million barrels of petroleum products were burnt and "approximately 22 Gg (Gigagram) of sulphur dioxide, 18 Gg (Gigagram) of soot, and thousands of tonnes of carbon monoxide and oxides of nitrogen emanated from the wells on daily basis in the early stages" (Poonian, 2003 p.5). This massive emission of toxic materials gave the negative impacts to the high sensitive ecosystem within the Gulf region and even outside the area (Poonian, 2003).

3.5 Effects of the wars to the marine environment by oil spills

As far as the environment issues are concerned, two destructive wars experienced in last decades, Iraqi- Iranian and Gulf Wars because of Dictator Saddam Regime which were affected the region of Gulf environment largely. Especially the Arabian Gulf area has been suffering from oil related pollution activities more than any other marine waters in the world due to non-standard operational activities and non-availability of legal instruments to the international standards. This has resulted in many major maritime related accidents mainly oil spills. In 1991 during the second Gulf war, where 22 events were reported, an approximate amount of 371 million US gallons of oil was spilled (Sadiq & McCain, 1993).

According to Lavieren, et al. (2010), approximately 80 ships were sunk during the Gulf war in addition to the major disaster which was given earlier, in this region. These will have a chronic effect on contamination of the Arabian Gulf ecosystem for many years along with those which still are remaining on the seabed due to the Iran-Iraq war.

Other activities in relation with petroleum industries, approximately 800 offshore oil and gas platforms and 25 major oil terminals are situated here with some 25,000 tankers passing the Strait of Hormuz annually (Lavieren & David, 2010).

3.5.1 Total Petroleum Hydrocarbon (TPH) concentrations in seawater

As it explained in section 2.3, the fate of oil spills into the marine environment in chapter 2, it is important to have the hydrocarbon concentration levels to measure the effects of seawater surface and seabed sediment. For example, the Total Petroleum Hydrocarbon (TPH) concentrations in seawater was reported at Akkah beach in both MSL (Micro Surface Layer) and SSW (Sub-Surface Water) a high level of TPH (15 µg/l as a ROPME oil equivalent" (Elshorbaghy, 2005, p.5). TPH concentrations at other positions in the MSL and SSW were: "1.1-19µg/l, in UAE 0.62-3.5µg/l, in Qatar and 0.51-6.7µg/l in Oman" (Elshorbaghy, 2005, p.5).

El-Samra et al. (1986) reported the highest range of total hydrocarbons (100-500 µg/l) in the surface water at the area close to the offshore drilling and oil production area at the border between Kuwait and Saudi Arabia. Moreover, higher levels of oil concentration in Saudi Arabia and Kuwait were reported in 1992 following the 1991 Gulf War oil spill (149 µg/l) in the SSW; MSL in sediments, near shore areas usually show higher TPH contamination than the offshore deep water (Sadiq & McCain, 1993).

3.5.2 Total Petroleum Hydrocarbon (TPH) concentrations in sediments

Due to the many facts and events explained in this paper, oil and hydrocarbon materials heavily affect the coastal waters and sediments in Kuwait and along the north Saudi coastline.

According to published information on petroleum hydrocarbon concentrations in the sediments in spill contaminated areas. Sediments were collected from the coastal areas of Qatar and were analysed for oil hydrocarbons were ranged between 2.8 and 248 microgram/gram. The concentration found in sediments of Qatar coastal areas were higher, but the PAH concentrations in surface sediments from Kuwait were in the range of 12.21-1318.5 microgram/gram wet weight (Sadiq & McCain, 1993).

Moreover, Extreme levels were reported from BAPCO samples near Bahrain (1600 µg/g) (Elshorbaghy, 2005).

Literathy & Zarba, (1985) gave a mean of concentration of (5.8 µg/g) for the clay-silt fraction of seabed sediments near the shore of Kuwait. Moreover, Zerba, et al., (1985) found that hydrocarbon concentrations exceeding 100 µg/g for seabed sediments at the offshore area of Kuwait (close to the offshore drilling and oil production area at the border between Kuwait and Saudi Arabia). DouAbul (1984) and Zerba & Literathy (1985) gives the values of total hydrocarbons around 13 µg/g from sediment collected at Shatt Al-Arab mouth at the north of the Arabian Gulf.

3.6 General effects of oil pollution on ecosystems

Scientists have ensured the great negative impact of oil spills for the life cycle of the species living in these polluted areas, in the event of increasing of TPH concentrations, had contributed in destroying the food chain and breeding of that species. This has been proven by many studies of organizations and institutes that deal with environmental issues considering the impact of the incident in 1991 war on the Arabian Gulf species. These studies are referring to different kinds of species that were affected. For example some of the fish species in the Arabian Gulf live close to the edge of their thermal tolerance range and have difficulties in surviving at particularly higher temperatures (Sadiq & McCain, 1993). Most marine organisms in the Gulf, including shrimp, typically breed during a transition period in the spring when a significant rise in sea water temperatures occurs. Therefore, the slight change of temperature brought about by the presence of the dark plume, especially combined with the pollutants given by the oil spills, could have seriously deleterious effects on these commercial fisheries at large. Also the sea turtle species are affected by oil pollution, which represent a great motive for the Gulf nations to cooperate in order to protect the sea turtle (Poonian, 2003).

Birds were the most severely affected by group of organisms. It was reported that at least three thousand wintering seabirds, mainly cormorants and grebes died after the oil spill between January and April 1991. "Numerous effects have been seen of marine mammals such as dolphins in this region**.** Furthermore shellfish are affected by metals that could be found as a component of any crude oil. significant portion of heavy metals is added into the marine environment by burning fossil fuels which results increasing Cu and Zn concentration. This had been noticed in various organs of the shellfish from the Kuwait coast." (Sadiq & McCain, 1993).

3.7 Another factor that affects the marine environment of the Arabian Gulf

Many countries that belong to the Gulf Cooperation Council (GCC) do not have fresh water sources and use desalination plants in order to get fresh water. Desalination may give negative impacts on the marine environment in the Gulf waters. As a result of desalination operations, discharge of effluents and water effluents causes localized water temperatures to increase at sea which can directly affect all organisms in these discharging areas. This will indirectly result in the decreasing the quality of water as it decreases the oxygen content of the water (Dawoud & Al Mulla, 2012).

According to Dawoud & Al Mulla (2012), Figure 10 shows the geographical position of the sea water desalination plants in the whole area, and more than 199 locations that can be found. Furthermore, there are plans to establish another 38 in the future as shown in Table 4 and Table 5. The total seawater desalination capacity is about 5000 million m3/year is little less than half (45%) of the world's production in this area which gives the potential impacts on the marine environment.

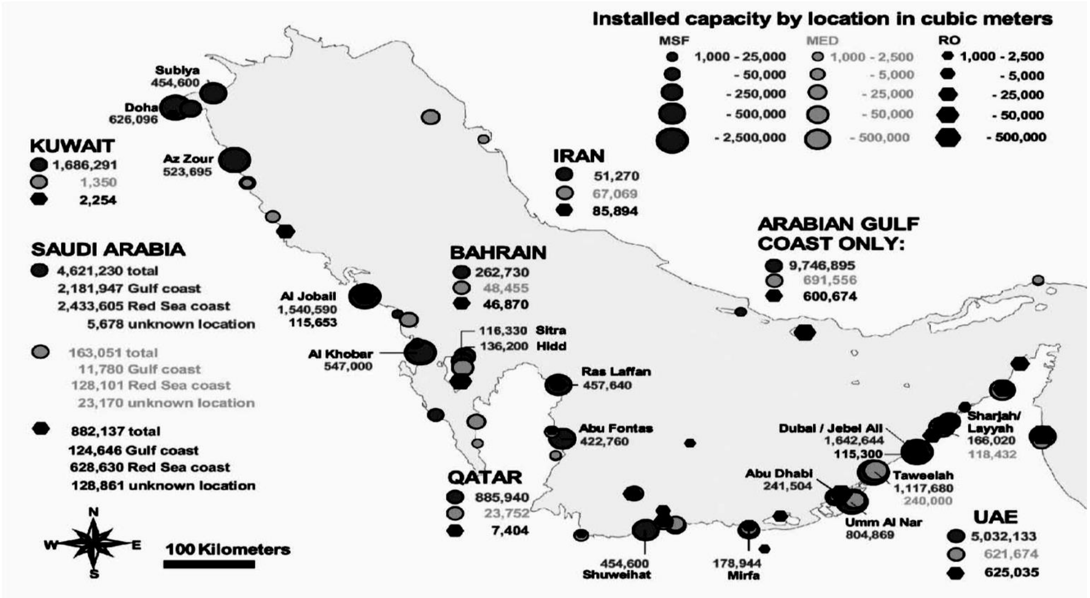


Figure 10: Sea water of desalination capacity in the Arabian Gulf

Source: Dawoud & Al Mulla, 2012, p.23

Table 4: Existing desalination plants in GCC countries in 2010

Note: The table is not including very small scale desalination plants in some countries

Technology	Country Capacity (Million m^3/year)						
	UAE	Bahrain	KSA	Oman	Qatar	Kuwait	Total
MSF	20	1	18	3	5	6	53
RO	18	2	76	31	2	0	129
MED	8	1	3	0	1	0	13
VC	0	1	0	0	0	0	1
ED	0	0	0	0	0	0	0
Combined (MSF+RO)	1	1	0	1	0	0	3
Total	47	6	97	35	8	6	199

Source: Dawoud & Al Mulla, 2012, p.24

Table 5: Future Planed Desalination Plants in GCC countries

Technology	Country Capacity (Million m3/year)						
	UAE	Bahrain	KSA	Oman	Qatar	Kuwait	Total
MSF	0	0	2	0	1	1	4
MED	1	0	6	0	1	0	8
VC	0	0	0	0	0	0	0
ED	0	0	0	0	0	0	0
Combined MSF+RO	1	0	0	0	0	0	1
RO	7	1	3	14	0	1	26
Total	9	1	11	14	2	2	38

Source: Dawoud & Al Mulla, 2012, p.24

3.8 Major regional and national organizations for marine protection in the Arab Gulf

There are several regional and national organizations that are concerned about the protection of the marine environment of the Gulf sea region, as follows:

3.8.1 Regional Organization for the Protection of the Marine Environment (ROPME)

ROPME situated in Kuwait, is an intergovernmental body assigned for the protection and monitoring of activities of the coastal and marine environment in the Gulf sea region. The main intention of the organization is to protect and develop the marine environment of the coastal belts of Bahrain, I. R. Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. The ROPME organization sponsored the regional Conference of Plenipotentiaries. The Conference adopted on 23 April 1978, covers the Action Plan for the Protection and Development of the Marine Environment and the Coastal Areas; the plan included pollution by oil and other harmful substances in cases of emergencies (ROPME, 2013).

3.8.2 Regional Organization for the protection of the Environment of the Red Sea and Gulf of Aden (PERSGA)

PERSGA, located in Jeddah (KSA), is an intergovernmental body dedicated to the conservation of the coastal and marine environments in the Red Sea Region and Gulf of Aden (PERSGA, 2013).

3.8.3 The Gulf Cooperation Council Secretariat (GCC)

GCC, located in Riyadh (KSA), has a revised section called “Directorate of Man and Environment” and its main role is to conduct regional assessments, training programs and facilitate information exchange with other regional and national institutions (Al-Thukair, 2012).

3.8.4 Regional Clean Sea Organization (RECSO)

RECSOs operations, centred in Dubai (UAE), is an oil industry co-operative organization established with its objective to protect the Gulf's marine resources from oil pollution (UNEP, 2013).

3.8.5 Council of Arab Ministers Responsible for Environment (CAMRE)

CAMRE, The League of Arab States, has a mandate section, which is responsible for issuing general decisions related to protection of the environment in the Arab region (Al-Thukair, 2012).

3.8.6 The Joint Committee on Environment and Development in the Arab Region (JCEDAR)

JCEDAR was established to endorse cooperation and coordination between regional and national organizations (UNEP, 2013).

3.8.7 United Nations Environment Programme Regional Office for West Asia (UNEP/ROWA)

UNEP/ROWA is based in Bahrain and coordinates in the Gulf with respect to environmental protection and conservation (UNDP, 2013).

3.8.8 Marine Environment & Wildlife Section Environment Department Prevention and Control against Oil Pollution

This organization is responsible for design of contingency plans in case of oil spill and it helps to minimize the potential danger to human health and the whole environment. Further, it concentrates on optimising the solutions in action plans, such as ensuring a timely and coordinated response, as well as designed local, regional and national contingency plans. It extends the duties and activities to post application of oil spills with efforts to contain and clean up oil spills by providing information according to the requirements of the response team (Dubai Municipality, 2011).

3.9 Case study area (Iraqi Shatt Al-Arab Channel)

3.9.1 Geographical location of Shatt Al-Arab River

Shatt Al-Arab River is a fresh water river of around 190 km in length, formed by connecting each of the rivers, Euphrates and Tigris in the city of Al-Qurnah in the Basra Governorate of southern Iraq (FAO, 2008). The southern part of the river is bordered between Iraq and Iran down to the mouth into the Arabian Gulf. It varies in width from about 400 meters at Basra to 1500 meters at its end at the Arabian Gulf. It is thought that the waterway formed relatively recently in geologic time, with the Tigris and Euphrates originally emptying into the Arabian Gulf via a channel further to the west (Iraq Foundation, 2003).

According to the Iraqi Ocean Science Centre, the area is known as the largest date palm forest in the world. In the mid-1970s, the region included 17 to 18 million date palms trees, and it was estimated as one-fifth of the world's 90 million palm trees. It was changed in the 1980s when the war, salt concentrate and pesticides wiped out more than 14 million of the palms, including around 9 million and 5 million in both Iraq and Iran. Many of the remaining 3 to 4 million trees are in poor condition.

Shatt Al-Arab River flows south-eastward and passes the Iraqi port of Basrah and the Iranian port of Abadan before flowing into the Arabian Gulf. The depth of the river ranges between 8-15 meters. The difference in water level between low and high tide is 1.5 meters during the summer and 0.25 meters during the flood season of April and May.

The average annual runoff of the Shatt Al-Arab River is around 1,750 cubic meters per second. Flow increases during the spring and summer season, reaching its maximum in April and May. The flow decreases to its minimal during October. The yearly flow peaks in spring and summer due to ice melting in the northern reaches of Iraq. The Shatt Al-Arab River is under the continuous effect of floods from the Tigris, Euphrates, and Kargah rivers. Two great floods occurred in 1969 and 1988 (Iraq Foundation, 2003).

Over the year, there is a large variation in the water temperature of the Shatt Al-Arab River. Water warms rapidly in March, reaches its highest temperature to about 32 degrees Celsius in July, then a minimum to about 16 degrees Celsius in December (FAO, 2008).

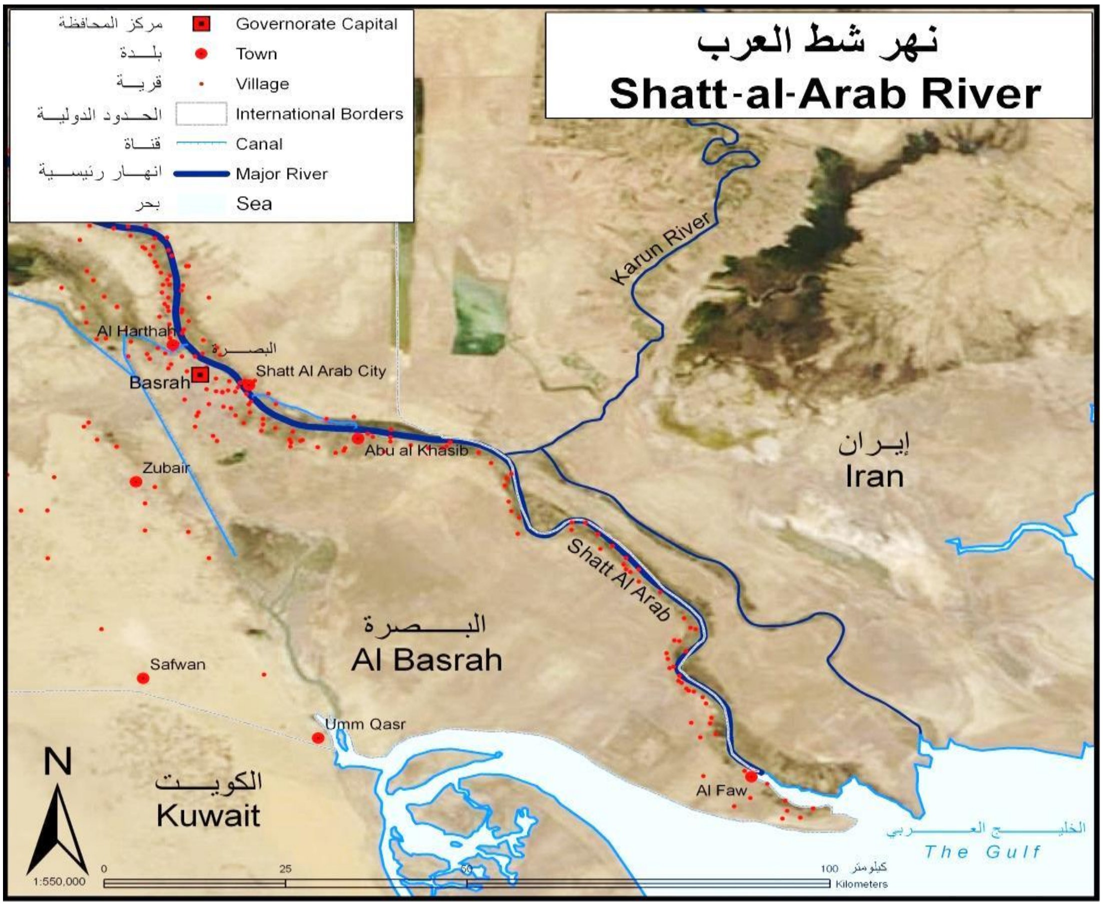


Figure 11: The geographic location of the Shatt Al-Arab River

Source: http://www.google.com/imgres?imgurl.

3.9.2 Shatt Al-Arab Environment

Shatt Al-Arab River is considered as the main source of fresh water to the city of Basrah, so many canals connected to this river is used for irrigation of the palm trees along the river channel. These canals and small rivers are unfortunately very polluted with high organic matters from decaying aquatic plants and algae blooms, mostly with epiphytic algae.

Shatt Al-Arab River is affected by the Arabian Gulf tide twice a day. The water level reach a maximum during high tide from the period April to July, and low levels are recorded from September to December (DouAbul & Al-Saad, 1985).

Domestic sewage enter into Shatt A-Arab River through main branches of Al-Ashaar, Akandak, Al-Rubatt, Al-Kora without any treatments and carrying massive amounts of organic materials and suspended particles, which pollute the river seriously in pollution concerns. This may lead to eutrophication and finally a heavy organic pollution may take place in the river. In general, the water of Shatt Al-Arab has a low concentration of dissolved Oxygen, and PH is also alkaline all year (DouAbul & Al-Saad, 1985).

Due to the organic pollution taking place in Shatt Al-Arab River, the dominant algae is the diatoms and in general they show low algal species diversity, and most of the plankton algae in benthic forms floated from the bottom and substrate by the currents. The phytoplankton biomass shows two peaks during summer and fall (DouAbul, Al-Saad & Al-Rekabi, 1987).

3.9.3 Sources of pollution in Shatt Al-Arab River

Among the first published studies on oil pollution in Shatt Al-Arab estuary was by Al-Saad (1983), in which the baseline data for total hydrocarbons in the upper part of the estuary were determined, while DouAbul (1984) studied the lower part of the estuary. DouAbul & Al-Saad (1985) estimated that this river transported about 48 metric tons of oil residues to the Arabian Gulf annually. Bedair & Al-Saad (1992) studied the dissolved and particulate adsorbed hydrocarbons in the upper part of the estuary on samples collected during 1985.

The Shat Al-Arab is now facing a very dangerous situation because of contamination of sewage being directly discharged into the main rivers of Euphrates, Tigris and Shatt al-Arab River, and industrial waste, oil products and parts of ammunitions being dumped in to the river in the 1980s during the Iran-Iraq war (DouAbul & Al-Saad, 1985).

3.9.3.1 Iraqi Iranian war in 1980

During the Iraqi Iranian war, which started in 1980, many commercial and oil tanker vessels were grounded to the bottom of Shatt Al-Arab and even on the north west of the Arabian Gulf near the Iranian costal border. These vessels had different kinds of fuels in large quantities and this caused many oil spills spreading over the river along with the coastal zone. This may result in serious impacts on the water body and affect the whole marine environment in Shatt Al-Arab River (Al-Saad, 1998).

3.9.3.2 The two Arab Gulf wars

Iraq again faced massive destruction with two wars in 1991 and 2003 which severely affected the entire environment and left a big impact on the marine water body, especially in southern Iraq, mainly in Shatt Al-Arab River. Moreover, the river still suffers from the organic pollution from untreated sewage, because Iraq does not have efficient sewage treatment plants and planning in these cities. The other fact is that Iraq does not have any effective environmental protection legislation, and this definitely increases the pollutants impact on the river. After the war, Shatt Al-Arab Channel again became very important in trading because it has Al-Makal commercial port on the north side of the river and increasing channel traffic may cause oil pollution in this area of the river and obviously affect the water quality everywhere in this channel (Zhang, et al. 2004).

3.9.4 A previous study for the dissolved oil hydrocarbon in Shatt Al-Arab River

This study was done from 2004 to 2005 by the scientist of Marine Science Center, Basrah University and the following conclusion was drawn from this study:

The residue of the oil, hydrocarbons from the oil industry related constructions and refineries in north of Shatt Al-Arab river and the oil pollutants directly added to the channel traffic, as well as by ships and many of the fishing boat operations. Furthermore, the pollutants came from factories around the river and untreated domestic sewage, so all these are considered as the main source of pollutants for Shatt Al-Arab River and North of Arabian Gulf (Naser, 2005).

3.9.4.1 Field stations for the study:

Surface water samples were collected seasonally from six different locations in Shatt Al-Arab River for the period from April 2004-January 2005, as follows:

- Station 1 (Al Qurna location).
- Station 2 (Sinbad Island location).
- Station 3 (Al Ashaar Location).
- Station 4 (Abu Flous location).
- Station 5 (Al Saybah location).
- Station 6 (Al Faw location).

3.9.4.2 Results and discussion:

Dissolved hydrocarbons show low concentration during autumn season from station six (See Figure 12) which is considered as marine environment, and was due to the dilution effect of water coming from different branches of the river; while, high concentration appears on stations number 3 and 4, because the high channel traffic and highly polluted sewage near the city center.

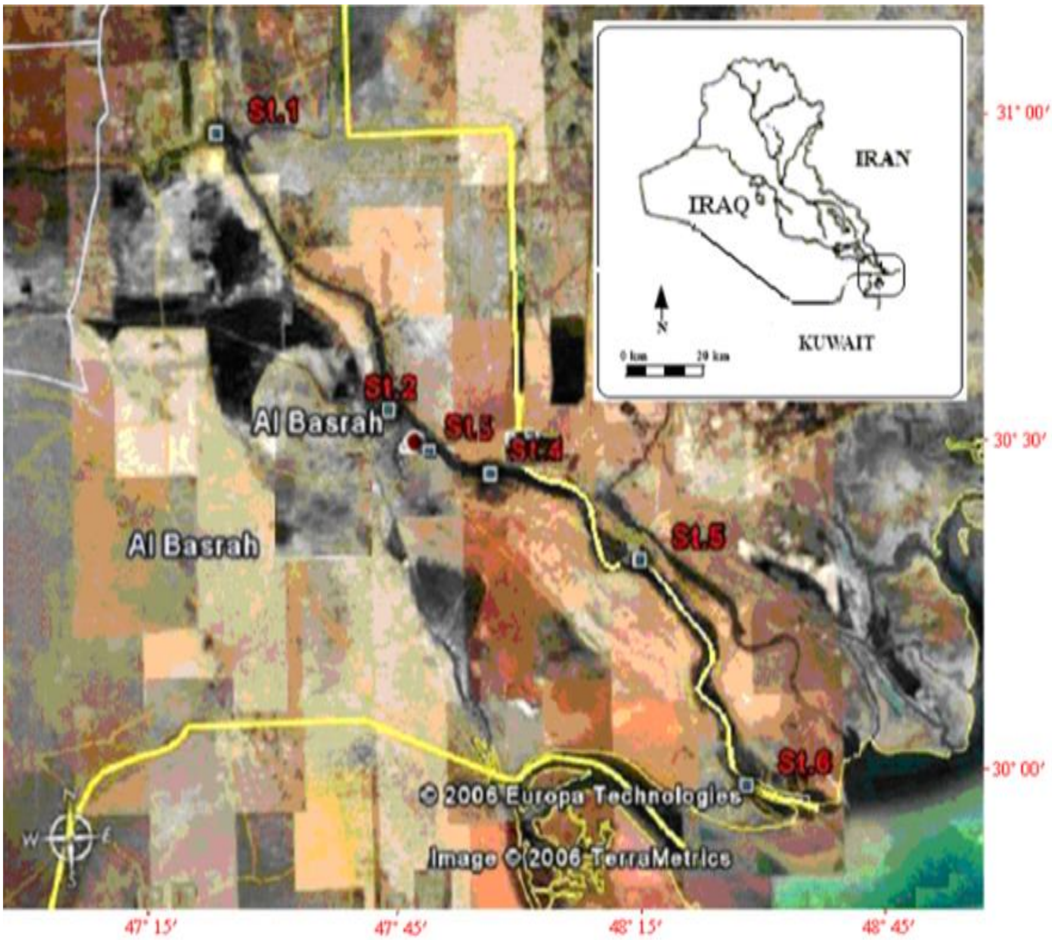


Figure 12: The geographic location of water samples

Source: Iraqi Ocean Science Center 2005

Oil hydrocarbon compounds dissolve more rapidly in water with high temperatures during the hot season; moreover, oil spills can take many forms in water such as tar balls and in dissolved form.

High concentration of oil hydrocarbons in station number 3 reached 50.232 µg/ l. during fall season while it shows low values during the end of winter reaching 15.0 µg/ l.

Very low concentration of oil hydrocarbons was recorded during spring season in both stations number 1 and 2 and it reached 2.24 µg /l. This was recorded during the flood season. In the hot season during summer, high temperatures speeded up evaporation of low molecules of oil hydrocarbons from the water body which was also the effect of the biodegradation process lowering the concentration of hydrocarbons in water.

Fat content of the suspended particles shows a percentage of 2.8% in station 1 during winter, while stations number 3 and 6 was higher in concentration and reached 44.9% and 42% respectively.

Table 6: The average seasonal variation and statistical analysis of the dissolve oil hydrocarbon concentrations in Shatt Al-Arab channel (µg /l).

Station	Seasons								Average of Seas.
	SD	winters	SD	Fall	SD	Summer	SD	Spring	
Station 1	1.286	6.383	1.703	31.543	0.639	2.283	0.958	2.247	10.614
Station 2	.651	4.39	3.581	22.712	.643	3.465	.690	2.509	8.273
Station 3	2.762	17.552	2.160	50.232	1.335	8.284	.511	5.531	20.400
Station 4	.977	7.373	1.498	34.488	1.881	6.937	1.205	20.323	17.280
Station 5	1.233	7.090	2.412	34.923	1.311	8.451	2.340	21.239	17.926
Station 6	1.205	7.432	2.665	41.970	1.290	11.620	2.507	38.140	24.791
Average of location	8.372		35.979		6.840		14.898		

Source: Iraqi Ocean Science Center 2005

3.9.4.3 Results of comparison with other previous studies;

The 2005 study results of the Iraqi Ocean Science Center were compared with other previous studies at Shatt Al-Arab River and North West Arabian Gulf. The 2005 study shows an increase in water pollution by oil hydrocarbons in the Shatt Al-Arab channel water, which can be explained by the following Table 7.

Table 7: Present studies shows increase on water pollution by oil hydrocarbon in the water channel of Shatt Al-Arab

Location	Concentration (µg /l.)	Reference
Shatt Al-Arab	86.7 – 12.0	DouAbul, (1984)
The mouthed of Shatt Al- Arab	56.0 – 10.0	
North west Arab Gulf	68.0 – 2.70	
Shatt Al-Arab	14.20 – 5.20	DouAbul & Al-Saad, (1985)
North west Arab Gulf	65.20	El-Samra & El-Deeb, (1988)
Shatt Al-Arab	23.5 – 6.50	Al-Saad & Bedair, (1989)
North west Arab Gulf	4.0 – 1.0	Al-Imarah & Al-Timari, (1995)
Khawr Abd Allah	9.0 – 1.0	
Shatt Al-Arab	38.29 – 3.97	Al-Saad, (1995)
North west Arab Gulf	9.80 – 2.60	
Shatt Al-Arab	14.0 – 4.0	Al-Saad, 1(995)
Mouth of Shatt -Arab	7.0 – 6.0	
North west Arab Gulf	3.70 – 2.60	
Shatt Al-Arab	35.0 – 1.30	Al-Saad, (1998)
Shatt Al-Arab	47.0 – 2.50	Temare, (2003)
The mouthed of Shatt Al- Arab	80.0 – 31.0	
Shatt Al-Arab	6.83 - 0.01	Awad, (2004)
Iraqi territorial waters	46.4 – 49.92	Naser, (2005)
Shatt Al-Arab	**50.232 – 2.247**	**study (2004-2005)**

Source: Iraqi Ocean Science Center 2005

3.9.5 Iraqi preparation for any oil spill crises

Iraq is considered as one of the largest oil countries in the world; the total daily products from crude oil reach 3 million barrels and this may raise a big challenge to the water environments in Iraq. Many incidents happened which caused a very serious impact on the environment.

In 2010, the Iraqi Ministry of Environment and General Company for Ports of Iraq have an agreement with Japan International Cooperation Agency (JICA) to put an contingency plan for any oil spills incidence that could happen in Umm- Qasser and Kor Al-Zubair ports; this may be considered as the first step in the agreements.

Iraq is also a member of the Regional Organization for the Protection of the Marine Environment (ROPME).This organization has a specialized center for protection and treatment of any oil spill happening to in the marine environment (General Company for Iraqi Ports, personal communication, July 15, 2012; A. Al-saidy, personal communication, July 10, 2013).

3.10 Present study (June-July 2013)

3.10.1 Materials and methods for the water and sediment analysis

3.10.1.1 Sampling equipment of water

A device such as that illustrated in Figure 13 was used for collecting water samples. It consists of a weight of 20 Kg bottle holder with a clean amber-glass bottle of 5 liters capacity. The bottle has a small mouth (2-3 cm inside diameter); so that it will fill slowly and have time to sink below the water surface before filling. Prior to use, the bottle was thoroughly cleaned and rinsed. The bottle cap was lined with a piece of solvent cleaned aluminum foil with the dull side of the aluminum foil down. This prevents contamination of the sample by the usual bottle cap liners. When ready for deployments, the cap was removed and the bottle was attached to float by a 1m long line. A second retrieving line was attached to the float and was used to pull the bottle back onboard after collection of the sample.

3.10.1.2 Separation of water

Hydrocarbons in water were solvent extracted following the procedure of the Pilot Project on Marine Pollution (Petroleum) Monitoring in 1976. In this, 100 ml of Nano-grade carbon tetrachloride (CCl_4) was used in two successive 50 ml extractions and the extracts were combined. The mixture was vigorously shaken to disperse the CCl_4 thoroughly throughout the water samples. The shaking is repeated several times before decanting the CCl_4. small amount of anhydrous sodium sulfate was added to break any emulsion in these extracts and to remove excess water. The CCl_4 extract was reduced in volume to less than 5 ml by using a rotary evaporator .The reduce extract was carefully pipetted into a pre-cleaned 10ml volumetric glass, making sure any residual particles of sodium sulfate were excluded and evaporated to dryness by a stream of pure nitrogen. Although CCl_4 is an ideal solvent for the extraction process, it is not suitable for spectrofluorescence analysis; therefore CCl_4 must be replaced by a solvent, such as n-hexane, which does not absorb light in 300-400 nm range. The flask was then rinsed with fresh hexane and the rinsing used to make the samples volume up to exactly 5ml prior to ultraviolet fluorescence (UVF) analysis.

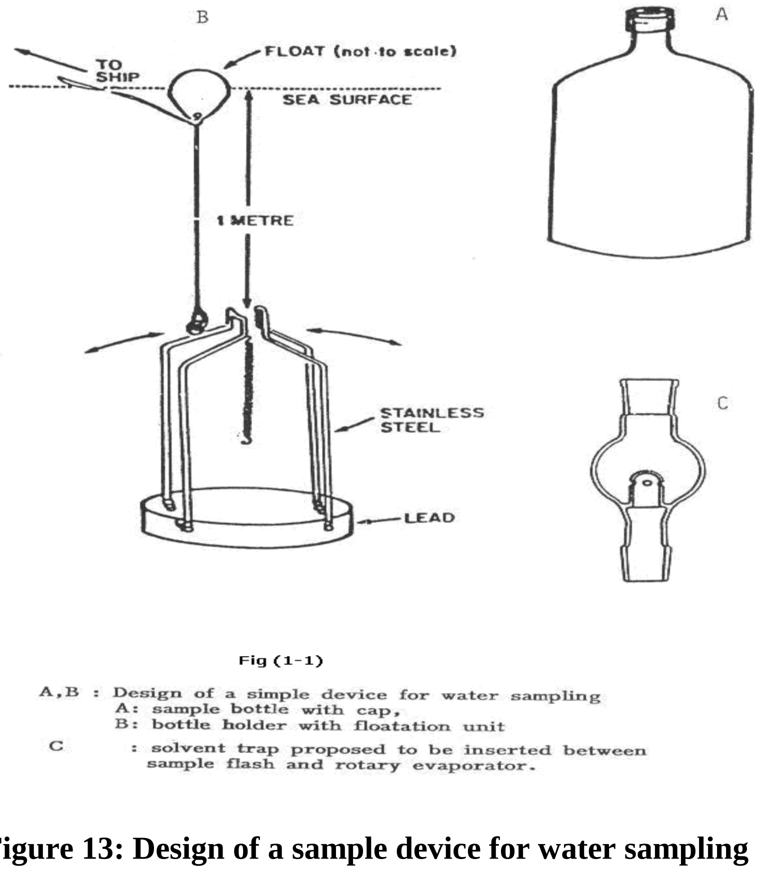
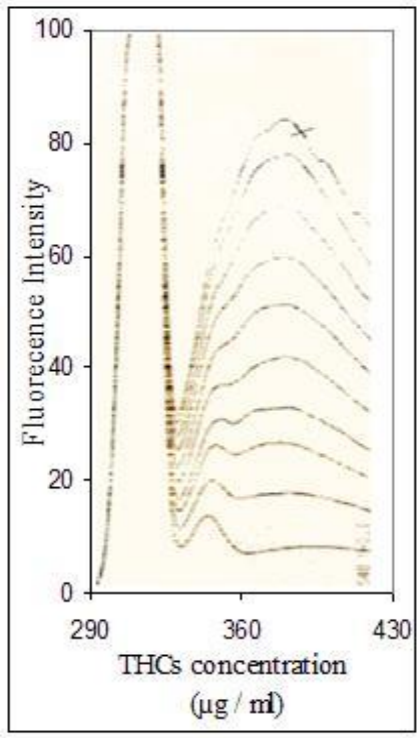


Figure 13: Design of a sample device for water sampling

3.10.1.3 Fluorescence measurement

The residue was dissolved in aromatic free n-hexane (checked by fluorescence analysis) and transferred quantitatively into a 5ml volumetric flask. From the volumetric flask a sample of the extract was dissolved in n-hexane. Liquid of the hexane solution of the sample was pipetted into a Teflon capped 1cm silica fluorescence cell. The basic quantitative measurements were made by measuring emission intensity at 360 nm with excitation set at 310 nm and monochromator slits of 10. All blanks, standards and samples were run at identical instrumental conditions. For this work a Shimadzu RF-450 spectrofluorometer equipped with a DR-3 data record was used



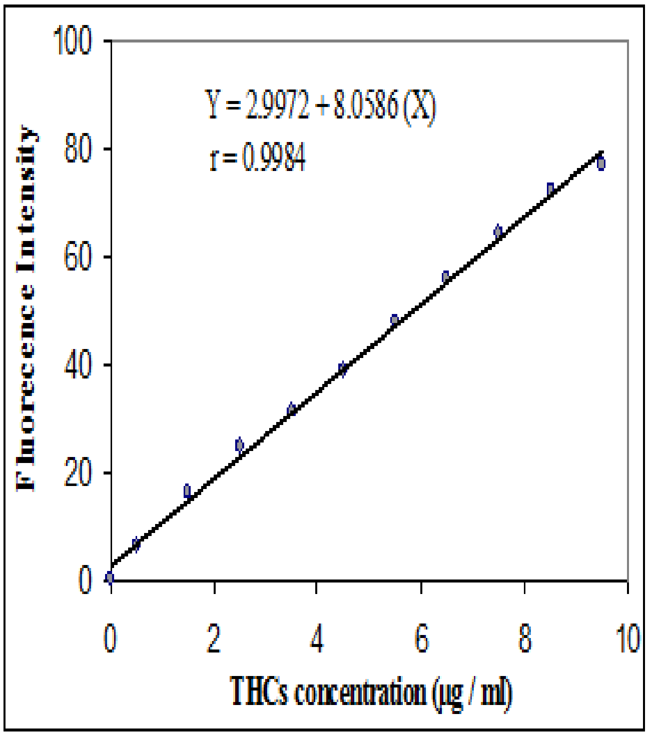


Figure 14: Fluorescence Spector with calibration curve of standard crude oil (Basrah Regular)

3.10.1.4 Background test (blank)

Strenuous efforts were made to minimize contamination of the samples, which would otherwise yield erroneous result. Throughout the procedure great care was taken to ensure that samples were not being contaminated, for example avoiding unnecessarily exposure of the samples, the solvent or the final extract to the atmosphere or other potential sources of contamination. However, procedural blanks consisting of all reagents and glassware used during the analysis were periodically determined. It was preferred to eliminate sources of contamination rather than adjusting or correcting the data actually obtained according to the blank value.

3.10.1.5 Sediment sampling

Sediment samples were also collected from the same locations in the study area by means of a stainless steel Van Veen grab sampler (See Figure 15). Undisturbed, triplicate samples were taken. After retrieval of the sampler, the water was allowed to drain off, avoiding disturbing the surface layer of the samples. As soon as the samples were retrieved, they were wrapped in aluminum foil and immediately frozen at -20 ºC. Before analysis, sediment samples were freeze-dried, grind finely in agate mortar and sieved through a 63µ meter (stainless-steel) sieve.

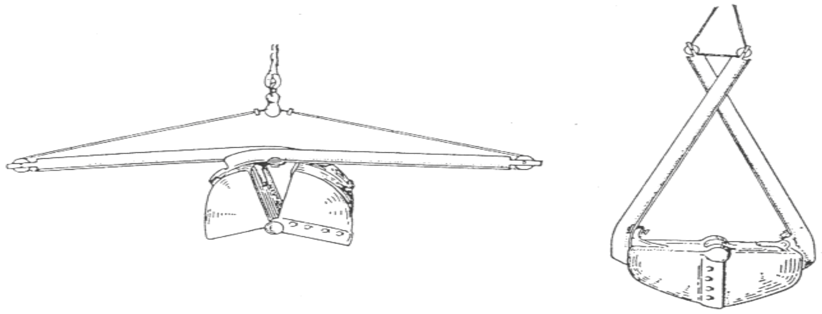


Fig (3-2): Van Veen grab for sediment sampling

Figure 15: Van Veen grabs for sediment sampling

3.10.1.6 Separation of sediment

Before separating sediment, samples were freeze-dried in a freeze-dryer. The extraction and clean-up procedure for the determination of petroleum hydrocarbons in the sediment is based upon Goutx & Saliot (1980). Sediment was placed in a pre-extracted Cellulose thimble and soxhlet, extracted with 150 ml Methanol: Benzene (1:1) mixture for 24 hours. At the end of this period, the extract was transferred to a storage flask and the samples were further extracted with a fresh solvent. The combined extracts were reduced in volume to 10 ml in a rotary evaporator. Then it was saponified for 2 hours with a solution of 4 N KOH in 1:1 methanol: benzene.

After extracting the unsaponified matter with hexane, the extract was dried over anhydrous sodium sulfate, concentrated by a stream of N_2 for UVF analysis.

The concentrated extract was cleaned up by column chromatography. The column was filled with 8 gm of 5% water deactivated alumina (100-200 mesh) on the top, and silica (100-200 mesh) in the bottom. The extract was then applied to the head of the column and eluted (washed) with 50 ml of n-hexane to isolate the aliphatic fraction, and 50 ml of benzene to isolate the aromatic fraction. The aromatic fractions were then reduced to a suitable volume prior to analysis for PAHs by means of capillary gas chromatography. The samples were injected in the “split less mode” on to a “50 m * 0.25 mm” (Internal Diameter) SE-30 (Methyl Silicone) fused silica capillary column, at an initial temperature of 50°C and following temperature regimen programmed at 4°C min, to 280 °C max, then held at the final temperature for 30 min.

3.10.2 Results and Discussion

Analysis of total petroleum hydrocarbons in water from Shatt Al-Arab estuary and in UM-Qasser, Khor Al-Zubair and Shatt Al-Basrah indicated that background concentrations of petroleum hydrocarbons in both areas were rather evenly distributed (See Table 8).

Table 8: Concentration of petroleum hydrocarbons in water

Locations	Conc. µg/l
Qurna	1.077
Paper mail	1.377
Mashab, shatt-al-Arab	48.715
Ashar, shatt-al-Arab	11.816
Seba, shatt-al-Arab	5.482
Shatt Al-Basrah	12.642
Khor Al-Zubair	4.656
Um-Qasser	2.178
Fao, shatt-al-Arab	32
Khor-Abdulla	41

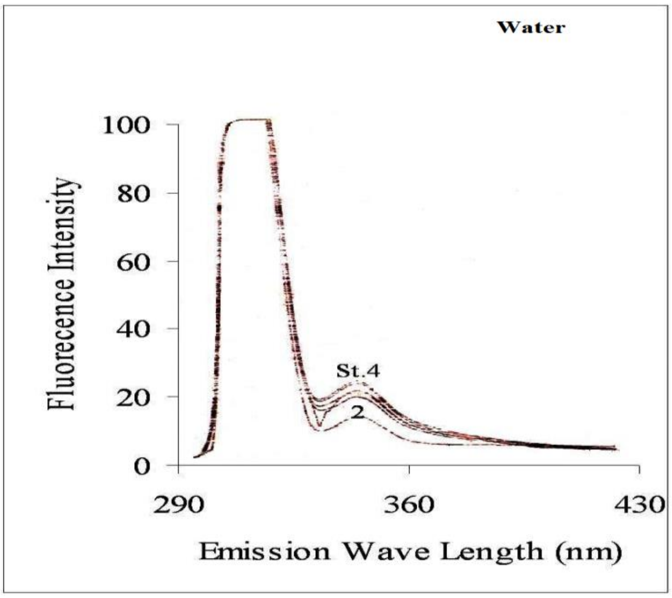


Figure 16: The Fluorecence intensity in the water sample test

However, the results showed higher concentrations of petroleum hydrocarbons in Shatt Al-Arab River than those in water of the other stations. This implies that the contributions of oil through shipping activities are significantly high, at present. The results also showed high concentrations of hydrocarbons in the vicinity of Abadan oil refinery and in the rich fishing areas of Al-Fao, Khor Al-Zubar and Shatt Al-Basrah along the coast. Most seawater samples presented their maximum fluorescence at 340-380nm. This peak is believed to derive primarily from diesel oil which is commonly used in vessel operations in the channel, small transport and fishing boats (Al-Saad & Al-Timari, 1989; Wattayakorn, 1991).

For the past 14 years, and due to the war, the normal activities seized; recently some industrial developments along the estuary were reestablished, and may cause an observed change in the concentration of hydrocarbons by especially oil transportation activities and increasing commercial shipping in Iraq.

Higher concentrations were found near oil refineries on the banks of the Shatt Al-Arab, such as Muftyia and Abadan. Fluorescence emission spectra for water were similar to those of lubricating and fuel oils indicating that similar sources of pollution were involved. Most of the water samples collected during this study showed emission peaks in the range of 340-380 nm and higher; this indicates the presence of highly condensed aromatic ring (2-5), which is typically found in crude oil. Petroleum hydrocarbons in the estuary were likely to have originated from boating activities, runoff from land and introduction via sewage out falls (Bedair& Al-Saad, 1992). Boats with outboard motors uses a mixture of gasoline and lubricating oil as fuel and most of the oil is discharged with the exhaust into the water (Al-Mudaffar, Fawzi & Al-Edanee, 1990). Storm water contained higher levels of hydrocarbons derived from lubricating oils as pyrolytic products released by automobile traffic. This may also constitute a major source of hydrocarbons found in the estuary, since used motor oil from automobiles may be discharged discriminatory into the environment and reach the estuary via run-offs (Al-Saad, 1995).

Indicated that oil pollution in Shatt Al-Arab River had possibly originated from diverse sources, such as oil refineries, rural run-offs, electricity generating stations, sewage and river transportation activities. Sewage discharge and urban run-offs were the most significant sources of oil entering the Shatt Al-Arab River. Presently the UVF determined concentrations were either lower or similar to those found in the surface water of the Arabian Gulf (Ehrhardt & Burns, 1993), Arabian Sea (Sen Gupta, et al., 1993), Musa Bay, Iran (Hashim, et al., 2013), Langkawi Island, Malaysia (Nasher, et al., 2013), the estuaries in the U.K (Cefas, 1997) and Gulf of Thailand (Wattayakorn, 1991). **(**See Table 9)

There is some exception to those that were that was near oil refineries, where higher values were recorded. In general, the present study revealed lower concentrations than those measured by DouAbul (1984) and El-Samra (1986) for samples collected from the Arabian Gulf. A comparison between the present values and those reported for other rivers and estuaries elsewhere will be presented. The present data indicated that the level of oil residues encountered in the waters of Shatt Al-Arab River and UM-Qasser, Khor Al-Zubair and Shatt Al-Basrah lie within the range of values reported for comparable areas. According to the information available on hydrocarbon levels in water, it could be said that on a large scale the Shatt Al-Arab estuary are still relatively uncontaminated by oil pollution. Problems may arise in localized areas relating to petroleum industry activities or effects from waste discharge, oil transportation activities and commercial shipping. The phenomena of oil pollution occurs mostly in waters near densely populated areas, such as Basrah, Abadan, Fao, major ports and locations of oil activities.

Some preliminary investigations by Floodgate (1995) demonstrated the presence of hydrocarbon degrading bacteria in samples from water, sand and mud from several collecting points within the Arabian Gulf region and indicated that protozoa very actively grazed the bacteria keeping total numbers low.

Moreover, the photo-oxidation too effectively helps the presence of petroleum components in the water where Lipophilic dissolved material was concentrated by in-situ liquid-solid adsorption on Amberlite XAD-2 resin from glass-fiber-filtered coastal seawater in the upper Arabian Gulf in the fall of 1986. The concentrated elute petroleum components were characterized and quantified by GC-MS as were ketonic photo-oxidation products of alkyl benzenes. Concentrations of the latter exceeded those of unaltered petroleum components by roughly a factor of 10 (Shamshoon, et al., 1989).

Table 9: Comparison of oil equivalent in coastal and open sea waters estimated by fluorescence spectroscope

Location	Concentration (µg/l)	References

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)
Winyah bay (USA)	0.23 - 25	Bidleman (1990)
Gulf of Thailand	1.9 - 72	Wattayakorn (1991)
River Humber (U.K)	9.3	CEFAS (1997)
River Mersey (U.K)	11	CEFAS (1997)
River Tees (U.K)	48	CEFAS (1997)
River Tyne (U.K)	31	CEFAS (1997)
River Wear (U.K)	13	CEFAS (1997)
Cortiou (France)	104	Marchand et al., (1988)
Gulf of Lion	18 - 23	Marchand et al., (1988)
Arabian Sea	1.6 -11.1	Sen Gupta (1993)
Shatt Al-Arab River	5.6 -14.2	Al-Saad (1983)
Shatt Al-Arab & NW Arab Gulf	2.7 - 86.7	DouAbul (1984)
Langkawi Island, Malaysia	6.1- 46	Nasher et al., (2013)
Shatt Al-Arab	2.247- 50.232	Iraqi ocean science center (2005)
(Ashar) Shatt Al-Arab, Um- Qasser & Khor Al-Zubiar	1.07- 48.7	Present study (2013)

The distribution of petroleum hydrocarbons in surface sediments, particularly in the 0-5cm segment, is of importance to studies of oil contamination, and in understanding temporal variations in the aquatic environment. This section reflects concentrations in sediments for a few years (Sen Gupta, et al., 1993). Experimental evidence suggested that about 56 % of spilled oil is adsorbed onto seabed sediment

(Knap & Williams, 1982). Thus, the degree of oil pollution in the aquatic environment may be more represented by measuring oil in sediment.

Petroleum concentration in sediment collected during 1993-1994 from Shatt Al-Arab and North-West Arabian Gulf was as low as or even lower than those measured previously in earlier studies. This observation may be partially related to reduce inputs in this region. For example, oil pollution inputs into the Northern Gulf from normal operations have been estimated to an average of approximately 2 million barrels per year (IOC, 1992). Given the drastic reduction in oil-related activities, such as tanker vessel traffic and associated defalcation between 1990 and 2000 in the region of the Gulf, the relatively high levels recorded in these years probably reflect the much lower chronic input during that period. Some general comparisons can be made, i.e., the range of 28.4-63.1 µg/g dry weight of total petroleum hydrocarbons in sediments from Shatt Al-Arab and Um-Qasser, Khor Al-Zubair and Shatt Al-Basrah increased within the range of concentration 2.871-37.077µg/g dry weight See Table 10) measured in this area during the period 2005 (See Table 11). These observations strongly suggest that Shatt Al-Arab and its estuary were significantly perturbed by the oil transportation activities and this lies within the range of concentrations in sediments in other sites of the world (See Table 11). There is an exception as the relatively high concentration of petroleum hydrocarbons (>28 µg/g) was found near refineries and ports areas of Basrah, Abadan and Fao. The reason for these high concentrations in sediments could be a combination of several factors including chronic influx from aquatic activities (Al-Saad & Al-Timari, (1993).

Table 10: Hydrocarbon concentrations in sediments of Basrah habitats

Locations	Conc. µg/g
Qurna	28.8765
Paper mill	31.7678

Mashab	47.0508
Ashar, shatt Al-Arab	63.1598
Seba	28.4634
Shatt Al-Basrah	41.2681
Khor Al-Zubair	38.3767
Um-Qasser	30.5287
Fao	34.6592
Khor-Abdullah	45.3986

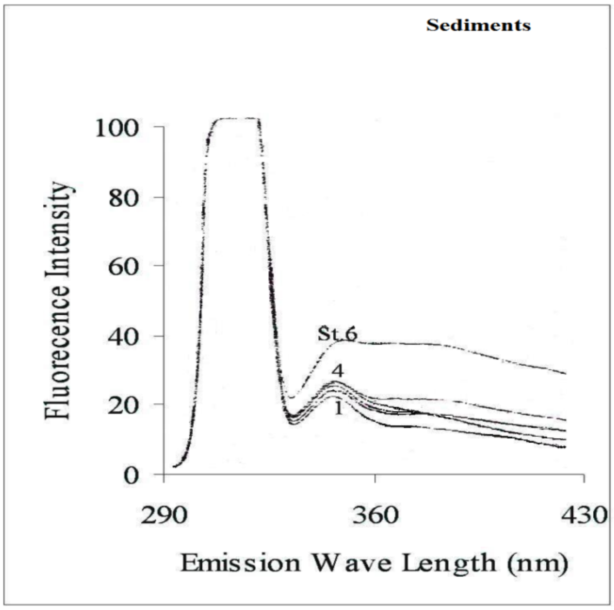


Figure 17: The Fluorecence intensity in the sediment sample test

Table 11: Comparison of petroleum residues in polluted sediment measured spectrofluorometrically in different areas

Location	Concentration	References

	µg/g	
Gulf of Lion	3.0 - 420	Marchand, et al. (1988)
Bay of Marseilles	132	Marchand, et al. (1988)
Tyne River (U.K)	53 - 750	CEFAS (1997)
Mersey River (U.K)	1.1 - 240	CEFAS (1997)
Shatt Al-Arab River	2.6 - 20.5	Al-Saad (1983)
Shatt Al-Arab & NW Arabian Gulf	0.4 - 40	DouAbul (1984)
Kuwait	1 - 291	Zerba, et al. (1985)
Bahrain	20 - 103	Fowler (1993)
UAE	0.10 - 1.7	Fowler (1993)
Saudi Arabia	13 - 540	Ehrhardt & Burns (1993)
Oman	1.0- 12	Fowler (1993)
Saudi Arabia	62 - 1400	Fowler (1993)
Bahrain	6.0 - 14	Fowler (1993)
UAE	5.7	Fowler (1993)
Southeast Beaufort Sea, Arctic Ocean	48.856	Tolosa & Gasser (2013)
Musa Bay, Iran	16.48-97.15	Hashim (2013)
Shatt Al-Arab	2.871-37.077	Iraqi Ocean Science Center (2005)
Um Qasser, Khor Al-Zubair, Shatt Al-Basrah and Shatt-al-Arab	28.4-63.1	Present study (2013)

Chapter IV

4 Conclusion and recommendation

4.1 Conclusion

Marine pollution in the Shatt Al-Arab is drastically changing from many years as was explained with the facts and figures in previous chapters in this dissertation. Studies that have been done by the many professionals and relevant institutions as well as this dissertation, through many of those sources of information in this regard have proved that the main causes of marine pollution are many. However, what is important conclude that there is oil pollution from ship operations and fishing boats operating in this area as this marine environment is strategically important for both oil industries and fisheries.

It was further highlighted that the importance and strength of applications and implementation of legal instruments which should be aligned with international conventions, codes and procedures, as this area poses existing high and potential demand for oil transportation considering the Gulf region. In this event, it is quite important to point out the relationships on a legal platform with nearby countries to have a common understanding of these legal agreements and the local Iraqi governance should be complying with the international standards. In addition, the requirements for formulation and implementation of an oil pollution contingency plan a two different levels, i.e. local and regional, are essential and emphasized to minimize the risks from oil contamination and spills in this region. Special the attention should be given to protect the marine biological environment having given its due recognition to the development of the maritime industry in the area.

Unfortunately, the lack of this type of legal framework within the country as well as in the region, to some extent resulted in the major obstacle to eliminate these sources of pollution in operational ships and other facts were highlighted which were a high risk to the marine environment.

As for the outcomes of this research, it could be suggested that it is important to implement this legal framework and decentralize the authorities to the relevant institutions for the purpose of efficiently and effectively do the required operations within these organizations to protect the marine environment not only in Iraqi waters but also in whole region for the benefits all stakeholders.

The first implementation is the requirement to become member state of IMO to get the required assistance, guidance and benefits to improve the local capabilities, building up the capacities and skills of the people and all stakeholders related to Iraq for the future successes by maximizing the protection of marine environment and minimizing the potential and existing risk in this regard.

4.2 Recommendations

Oil pollution in oceans appeared during the middle of the last century and since that time, the world community seriously looked for how to find the best solutions for oil pollution control mechanisms and treatments. The season is that kind of pollution can seriously damage not only at the marine lives in the ocean environment but also the other lives in the same food chain, and in turn affect the entire food chain.

The most important measure taken by the international community to solve this problem is to adopt a set of conventions and a series of codes and amendments to consider many factors, such as technological development, and environmental disasters that take place in a timely manner. It was noticed that reduction of oil pollution in the oceans during the period between the 1970s and 2000s as stated in the second chapter of this dissertation. This means that the efforts of experts from international organizations, such as IMO have succeeded in reducing oil pollution in the seas and oceans from any kind of accidents by implementing these legal instruments.

Therefore, the international conventions, codes and amendment that have been introduced since that time by giving relevant amendments to fit in to the current situations are the main in instruments to address similar problems caused by oil pollution. This can be done by working with the international community and organizations concerned with this particular and represented by the International Maritime Organization (IMO).

As a solution to this kind of problem of oil pollution in the North Arabian Gulf region and the Iraqi navigational channels, specifically the Shatt al-Arab navigational channel, the same legal implementation approaches with relevant conventions, codes, and procedures could be valid in three ways as follows:

- International approach
- Regional approach
- Local Iraqi approach

4.2.1 International approach

Since the three countries Iraq, Iran and Kuwait share the North Arabian Gulf region, these countries have to deal with high diplomacy and cultural vision to solve any problems of oil pollution that could happen in the waters of the North Arabian Gulf. This can be done through a comprehensive understanding by each country according to the international agreements related to the particular subject areas which are stated in the legal part given in the second chapter of this dissertation.

Furthermore, the clear understanding of the elements of these agreements, which means the full awareness of these agreements and knowing how to deal with the contents given in the legal instruments to control oil pollution. Further, reduction of causes these incidents support to environmental damages through international conventions and codes implemented by the institutions, such as International Maritime Organization (IMO) under the umbrella of UN. It further extended to consider the support of an international legal adaptation of these countries counting with the assistance of their authorities such as Coast Guards, port state controls and maritime authorities with their legislate boundaries of proper understanding to pursue their work under the international framework without any objections from the stakeholders to these events.

The MARPOL Convention and applications were explained briefly in the second chapter of this dissertation. For instance, the countries in the region have to have a close look at the possibility of implementing these legal systems with the relevant addendums and counting with the technological developments and so on in maritime sector to minimize the damages from ships in daily operations, how such series of legal procedures should be followed on board ships.

Another fact is the international engineering design technologies and how it could be used specifically on oil tankers to minimize the marine environmental damage from the incidents of operational ships and maximise its to safety of navigation ship operation. Consequently, this type of international convention remains the important key to solve the problems of oil pollution from ships, which does not currently exist in this region.

The Convention on the compensation gave the right of the member states of the International Maritime Organization (IMO), by asking the owner ship, as it had been proven that his ship was responsible for the incident that caused the contamination of wasted waters or coasts resulting from this pollution. This is to encourage countries that have not ratified the relevant conventions to ratify them for their own benefits on marine environment protection. On the other hand, ship owners are required to ensure that are competent and aware of new technology and modern equipment as both are continuously update, in order to prevent or reduce potential accidents.

Detailed studies of all legal agreements related to oil pollution in region is essential to comply with international instruments. These should be relevant laws to be completed individually or collectively in order to tighten up the controls on solving the pollution problem due to oil spills and environmental damages. The ships in case of pollution, and the state should provide essential facilities in its ports to service the vessels to become operational. On the other hand, ship owners should be granted compensation on damages to the states of the ships that are liable for marine pollution. In case of exceeding some limits on compensation, the “Fund” will support the ship owners to pay compensation to the member states of IMO.

Therefore, the most important thing that the three countries bordering in the North Arabian Gulf region, particularly Iraq, should do is to find a better solution to the problem of oil pollution of the area. This can be done through a detailed study of legal agreements subject to ratification of international conventions that have not been ratified and work with the international community. In this connection, the global information and how it is used in the international community for the benefits of their countries to find better solutions could be used in the Iraqi maritime cadre to upgrade the knowledge and understanding on this topic of marine pollution. The same conventions and relevant international codes are applied to protect the water, the coastal belt, the revival of the seas and oceans of oil pollution from ships in the previous years.

4.2.2 Regional approach

The north side of the Arabian Gulf is a small area considering the number of oil fields and ports of oil exports. Oil exports of these countries through this region are accounted as a high proportion to the global production. Hence, the area is heavily transited by a considerable number of large tankers engaged in the oil trade. On the other hand, this region is facing high winds and waves of movements continuing in most of the seasons throughout the year. This makes the region a potentially high contamination of oil pollution threat (Khonkar, 2009). This means that an incident will lead to the entire region very quickly in a short time period causing potentially high bad impacts to the marine environment in the entire region. The size of an oil spill will be either large or small and could be spread up to the nearby coasts of the three countries or may exceed beyond the area.

A good example is what happened to the countries of the region at the time of the oil spill that occurred in the Iranian Nowruz fields located in the North Arabian Gulf region. The second example is the oil spill, which happened in the first Gulf War, and how limits of the area was overcome until the spill reached the coastal areas of the State of Bahrain as explained in Chapter III of this dissertation.

This could be organised within the region of these three countries or the Gulf States should get together to have a common understanding of some needs to work collectively to achieve the goals through a clear and common vision of how serious the pollution threat is pollution from an accidental spill could happen at any moment, which can be a source of environmental disaster that could last for many years if it is not contained and treated collectively and fast.

4.2.2.1 Working together under the supervision of ROPME

The ROPME organization is concerned with the affairs of the marine environment of the Arab Gulf states working under the umbrella of UNEP and all the Arab Gulf states are ROPME members. Therefore, the countries of the region that would have the collective actions start from creating the understanding and cooperation for joint collaboration to achieve common goals in this regard successfully, efficiently and effectively. Coordination with other relevant organizations, regarding the subject of pollution of the marine environment in the Gulf region for pollution control is important in order to have an effective response and collective cases of oil pollution that may occur in the region; it includes teamwork after these procedures, as follows:

The work of the Port Authority, as port state control is recognised as one of the prime legal institutions by giving powers to the Coast Guard in order to act according to the law imposed by the authorities for the ships that are contrary to the instructions in the territorial waters given by international regimes, such as the International Maritime Organization (IMO). It is important to recognize that the Gulf region is a special area so dumping any material contaminated with oil from the engine room or dirty oil resulting from washing cargo tanks of oil tankers or under should be prevented. Further, this should be implemented through the application of MARPOL control transfers between oil tanks, load reservoirs or place of delivery of contaminated crude oil as a result of washing cargo tanks by Oil Record Book - level 2, while the bilge water or dirty oil in machinery space operations are monitored by Oil Record Book - level 1.

4.2.2.2 Regional Oil Spill Contingency Planning

The occurrence of pollution cannot be predicted and possible to happen at any time, and anywhere. Mistakes or human negligence can lead to an accident and this requires a rapid, well planned response, which is carried act through a plan called the contingency plan. This work staled after the OPRC Convention enteral into force in 1995 (Veiga, 2003). The principal goals of the emergency plan are to combat, prevent, reduce, and control the environmental and economic effects of oil resulting from oil spills. This it could be done by rapid and effective response to the requirements of the plan. The purpose of the plan is to coordinate the work of all the parties concerned to respond to oil spill incidents. The plan mainly consists of three sections:

- strategy section
- operational section
- data directory

The strategic section includes the scope of the plan with the geographical coverage, and the expected risks, the role and responsibilities of all agencies and interested parties, and the proposed response strategy.

Operations Section includes the emergency measures which will allow for the rapid assessment of the oil spill, the equipment and making quick response with their crews.

Data directory consist of all maps and lists of resources and other supporting data required to respond to the oil spill in accordance with the agreed strategy to response plan.

One of the main elements of the success of the plan is to be reviewed in terms of numbers which are updated on an on-going basis according to the requirements of the need for the region. At the same time, the implementation practices for the purpose of checking the efficiency of humans and equipment should be conducted for the rapid response to oil spill incidents. Further, these should be the provision of financial allocation, which covering the modernization and training (IPIECA, 2000).

The agreement of all member states to the regional contingency plan in the Gulf Arab joint action plan requires coordination centres in all countries having effective communication and fast exchange of information. These should be available facilities required for rapid access to the accident location, the size, the date of their occurrence, detailed information about weather conditions and any other information that could contribute to the success of the action plan and quick response to address the problem.

Such a joint action plan agreed upon by the countries of the Arabian Gulf area will be effective in finding solutions to the problem of oil pollution in the region. The success of this joint action plan could save the whole marine environment and make the economic impacts to the lowest possible level for their countries or the Arabian Gulf region.

4.2.3 Local approach

Iraq has two oil terminals in the North Arabian Gulf region, and commercial ports on the Shatt al-Arab channel, Khor Abdullah and Khor Al-Zubair. It is very important to have multiple Iraq procedures to be carried out to face the problem of the high level prevention of oil pollution of waters, as proven by the results of the field study in recent years, which took place in the Shatt al-Arab channel. After comparing the current results of this study with the results of previous studies, it there is continuous rise in petroleum hydrocarbon concentrations in the Shatt al-Arab channel. The sources of pollution of the Iraqi waters is quite few considering the effects caused by the navigation of vessels in the Iraqi waterways, as well as fishing boats that are frequently operating between the Fao area and the North Arabian Gulf according to that study. So it is of let most importance that the Iraqi maritime administration follows these regulations in order to reduce oil pollution in the waters with relevant mechanisms as follows:

4.2.3.1 Legislation local laws

Iraq local legislation laws should be enhanced through international laws, which is to assign and organize the work of all Iraqi maritime institutions. In particular, those organizations should be responsible for the pollution and be able to force foreign ships and Iraqi ships to comply with these laws and regulations in the region or in the global context to prevent marine pollution in these waters.

It is important to communicate the implementations of these laws to all stake holders by publishing on official web-sites on the Internet to be available for all to see the content and how it works out, as well as the work of the media broadcast bulletins for in the coming ships to Iraq or located in the Iraqi waiting area for tankers and commercial vessels. The purpose should be in the definition of Iraqi laws for these vessels to prevent dumping of any type of contaminated materials and to avoid any penalties in this regard.

4.2.3.2 Reception facilities for contaminated materials

Assisting ships and at the same time prevent them from throwing contaminated material into the sea, the Iraq administration must develop the required facilities and equipment for the reception of all kinds of polluted substances from ships, especially water contaminated with oily or dirty oil resulting from the work of the engine room by encouraging the ships not to throw it into the sea. Oil ports need to prepare and develop the necessary plans, procedures and equipment to receive any kind of oil contaminations resulting from the dirty washing cargo tanks in oil tankers.

4.2.3.3 Flag state control and port state control

One of the main regulators of foreign ships is port state control, Iraqi vessels are the authority of the flag State, so the activation of the work under these legal powers will contribute effectively and efficiently to reduce or minimise oil pollution of the Iraqi waters. This can be done through the introduction to the members of these two branches by training and awareness courses designed to raise the confidence by enhancing the knowledge through international and local laws. Further officials should be educated in how those how prevent ships committing from violations.

As result of Iraq's accession to the Riyadh Memorandum of Understanding, it makes the Iraqi port state control capable of coordination with the port state control of neighbouring countries to follow up compliance of the laws of vessels. They should inform the port state control of member states of the Al- Riyadh MoU ports with information pertaining to these vessels for the purpose of accounting for the things agreed upon in these agreements. At the same time, the PSC receives information from the port of departure about a default vessel to Iraqi port state control for the purpose of taking required actions against the disaster made by the vessel.

4.2.3.4 Iraqi organisation of oil pollution control

The Iraq government should develop an organization department that is responsible for combating oil pollution and control, making them an integrated enterprise with all relevant infrastructure such as equipment, materials and buildings, and have the ability to respond rapidly to any kind of oil pollution incidents at any site in Iraqi waters. There should be specialized equipment to lift and clean up the oil to be internationally applicable in line with the nature of water and the coast of Iraq, rivers and cover the size of numbers of incidents likely to occur. The amounts of chemical materials for cleaning operations have to be estimated and stored. As for the people who are dealing with such materials and equipment, their very essential to be well qualified through training courses and practices to perform its roles and responsibilities properly and timely. Therefore, they will have the ability and knowledge to deal with the equipment, materials and chemicals to be used for this purpose.

In addition, the provision of buildings should be available for the storage of chemical materials for the purpose of protection against typical cruel weather conditions in Iraqi, especially in the summer and at the same time protecting the people and the environment from these chemical materials if spilled outside storage containers. It is very important to know where the buildings for storage of materials and equipment are so as to be able distribute these materials and equipment to the site of the accident quickly and easily. The members of the management of this institution must be well-trained and familiar with given skills, and the capacity of the institutional management, making them able to manage any crisis situations correctly, without any delay.

4.2.3.5 Local Oil Spill Contingency Planning

This plan does not differ from the Regional Oil Spill Contingency Planning, it is only administered locally by their members, as stated previously the purpose of this plan is to ensure a rapid response to any oil spill accident in a local context which is supported by the regional plan. Hence, Iraq authorities should have a well-defined contingency plan based on a thorough study in accordance with the nature of marine channels, marine environment behaviours, and Iraqi territorial waters to meet their purpose successfully. This can be achieved by training and practice on the performance of this plan, which will contribute to the event successfully applied to reduce the environmental effects of any oil spill anywhere in Iraqi waters.

4.2.3.6 Contingency Planning of Iraqi maritime facilities

Iraq must have its own contingency plans for ports and the oil business which will support the local or national plan, because each port runs through handling any pollution incident within the port borderers. It should further ensure that each department in these ports should co-ordinate among them for the purpose of mutual cooperation, and the main institutions that are responsible for dealing with oil pollution to ensure rapid response to such incidents.

4.2.3.7 Continuous Surveillance of the ships in Iraqi water

For the purpose of reducing pollution rates resulting from the routine operation of ships or fishing boat operations in Iraqi territorial waters or navigational channels, these control procedures must be monitored by the Coast Guard who cover most of the Iraqi territorial waters. Further, maritime pilots may be involved in monitoring the Iraqi waterways and inform the relevant authorities of any information about oil spills. This information is transferred to the competent authority through VHF radio channels or mobile phones which are effective in Iraqi territorial waters. Furthermore, Iraqi territorial waters can be monitoring from the air by satellites and this works effectively in most of the countries in the world and has proven successful. The location of the accident, the speed of locating oil slick direction and speed of movement can be determined and this make it possible to reduce the time to respond to crises. As for the control of fishing boats, which is the reason for controlling the oil pollution in the Fao area in the channel Shatt al-Arab a specialized centre should be established to monitor the work and performance of the fishing boats, and specialized reception facilities should be providing from the authorities to receive the oils and oily substances from these fishermen to guarantee, they are not thrown into the water or the coastal belt.

4.2.3.8 Cooperation of the ministries concerned

For the success of the process control of the oil pollution in Iraqi waters, there must be a sound coordination and joint cooperation between the ministries concerned, such as the Ministry of Transport, the Ministry of Oil, Ministry of Environment and Ministry of Higher Education (Marine Science Centre) for the purpose of determining the responsibilities and the role of each ministry in the management of its business in the region and monitor the implementation of its institutions for its regulations and laws to limit the oil pollution of the area.

It is better to have regular, periodic joint meetings in order to conduct an assessment of the actual reality of oil pollution of the Iraqi water. Further, evaluating the effectiveness of laws should be evaluated in order to make appropriate adjustments in order to continue to increase the chances of the reduction of oil pollution of the

Iraqi waters. Further evaluation is needed to increase the number of equipment or the latest technological developments of equipment and procedures should be updated to remove and clean the oil from the water and the coast. These measures will reduce the rates of pollution and at the same time contribute to minimizing of the negative effects of pollution in case it happens.

4.2.3.9 Raising cultural awareness of the public

His of utmost importance to raise awareness of the issue of cultural pollution to the public, any general public and especially the schools and university students and so on to define the kinds of pollution and the its impacts. This can reduce the damage and harm to the environment in general perspectives and the marine environment in particular, and contribute effectively to reduce the sources of pollution and its reduction. Moreover, the process of widening awareness by providing information through articles for students and in particular university students in many places such as Basra because most of them reside in this city and do their studies in this subject. This will contribute to spreading environmental awareness to the other people in the city of Basra as Shatt al-Arab is a source of economic, tourist and a source of drinking water for a large number of the population of the city of Basra.

The best of this role is the Marine Science Centre, University of Basra, a specialized centre in environment scientific research, in which professors are competent, able to clarify this problem, mainly the common pollutants of the Iraqi aquatic systems. They work intensively in Iraqi fresh water and they give a prominent attention to the marine environments in different aspects, especially concerning the biodiversity and pollutants monitoring in this area.

Another issue is to raise the cultural awareness of the public using public newspapers in providing environmental awareness which is quite important. A good example is the Journal published by the Marine Science Centre or resorting to all kinds of local newspapers and TV Channels. Originally, the ease of this magazine focus to the general public will contributes to lift up of the environmental awareness of these people.

References

Al-Azab, M., EL-Shorbagy, W. & AL-Ghais, S. (2005). *Oil pollution and its environmental impact in the Arabian Gulf region*. London: Elsevier.

Al-Imarah, F. & Al-Timari, A. (1995). *Spectrofluorometric determination of total hydrocarbons in subsurface waters and sediments from Khor Abdullah*. Basrah: Iraqi Ocean Science Center.

Al-Mudaffar, N., fawzi, I. O., & Al-Edanee, T. (1990). *Hydrocarbons in Surface sediments and Biyalyes from Shatt Al-Arab and its rivers, southern Iraq. Oil and chemical pollution.* Basrah: Iraqi Ocean Science Center.

Al-Saad, H. T. & Bedair, H. M. (1989). *Hydrocarbons and chlorophyll A correlation in the waters of the Shatt Al-Arab River.* Basrah: Iraqi Ocean Science Center.

Al-Saad, H. T., (1995). *Distribution and sources of hydrocarbons in Shatt A-Arab Estuary and NW Arabian Gulf*. (Ph.D. Thesis), Basrah, University, Basrah, Iraq.

Al-Saad, H.T. & Al-Timari, A. K., (1989). *Distribution of polycyclic aromatic hydrocarbons (PAHs) is marsh sediment, Iraq.* Basrah: Iraqi Ocean Science Center.

Al-Saad, H.T. (1983). *A base-line study on petroleum hydrocarbons pollution in Shatt Al-Arab River* (MSc. Thesis), Basrah University, Basrah, Iraq.

Al-Saad, H.T. (1998). *Petroleum hydrocarbon concentration and n-alkanes in the water of Shatt Al-Arab River*. Basrah: Iraqi Ocean Science Center.

Al-Saad, H.T., & Al-Timari, A. A. K. (1993). *Seasonal variation of dissolved normal alkanes in the water marshes of Iraq*. Basrah: Iraqi Ocean Science Center.

Al-Thukair, A. A. (2012). *Management of Marine Environment*. Retrieved July 2013 from http://faculty.kfupm.edu.sa/CHEM/thukair/ENVS%20590/ENVS%20590%20(L6).pdf

Awad, H., Al-Moharamy, M. A., & Al-Eissa, S. A. (1990). *Omanian Land-based oil input to the Gulf of Oman, oil and chemical pollution.* Basrah: Iraqi Ocean Science Center.

Awad, N. (2004*). Determination of total petroleum hydrocarbons and heavy metals in waters and sediments from Shatt Al-Arab River*. Basrah: Iraqi Ocean Science Centre.

Baumann, P. R. (2008). *Environmental warfare: Persian Gulf war*. Retrieved May 2013, from http://www.oneonta.edu/faculty/baumanpr/geosat2/Environmental_Warfare/Environmental%20Warfare.pdf.

Bedair, H. M. & Al-Saad, H.T. (1992). *Dissolved and particulate adsorbed hydrocarbons in the water of Shatt Al-Arab River, Iraq*. Basrah: Iraqi

Bidleman, T. F., Castleberry, A. A., & Foreman, W.T., (1990). *Petroleum hydrocarbons in the surface water of two estuaries in the Southeastern united states*. Retrieved September 2013, from http://publications.gc.ca/site/archivee-archived.html?url=http://publications.gc.ca/collections/collection_2012/mpo-dfo/Fs97-6-2412-eng.pdf.

British Petroleum BP. (2013). *BP Statistical Review of World Energy June 2013*. Retrieved July 2013, from http://www.bp.com/content/dam/bp/pdf/statisticalreview/statistical_review_of_world_energy_2013.pdf

CEFAS (Centre for Environment, Fisheries and Aquaculture Science). (1997). *Monitoring and surveillance of non-radioactive contaminants in the aquatic environment and activities regulating the disposal of wastes at sea, 1994.* Retrieved September 2013, from http://www.cefas.defra.gov.uk/publications/aquatic/aemr47.pdf

Comark, D. (1999). *Response to marine oil pollution review and assessment.* Dordrecht: Kluwer Academic Publishers.

Committee on Energy Futures and Air Pollution in Urban China and the United States National Academy of Engineering National Research Council. (2007). *Energy Futures and Urban Air Pollution: Challenges for China and the United States.* Washington, DC: National Academies Press.

Dawoud, M., & Al Mulla, M. (2012). *Environmental Impacts of Seawater Desalination: Arabian Gulf Case Study.* Retrieved July 2013, from www.sciencetarget.com/Journal/index.php/IJES/article/download/96/25.

DouAbul, A. Z. (1984). *Petroleum residues in the waters of the Shatt Al-Arab River and the North-West region of the Arabian Gulf.* Basrah: Iraqi Ocean Science Center.

DouAbul, A. Z., & Al-Saad, H.T. (1985*). Seasonal variation of oil residues in water Shatt Al-Arab River*. Basrah: Iraqi Ocean Science Center.

Dubai municipality. (2011). *Oil Spill Preparedness and Response*. Retrieved July 2013, from http://www.dm.gov.ae/wps/wcm/connect/120edb4e-33a8-4d0e-94d9-7f1709553a71/Oil+Spill+Response+and+Preparedness-eng.pdf?MOD=AJPERES

Ehrhardt, M., & Burns, K. (1993). *Hydrocarbon and related photo-oxidation products in Saudi Arabian Gulf coastal waters and hydrocarbons in underlying sediment and bioindicators bivalves*. Basrah: Iraqi Ocean Science Center.

El-Samra, M. I. & El-Deeb, K. Z. (1988). *Horizontal and vertical distribution of oil pollution in the Arabian Gulf and Gulf of Oman*. Basrah: Iraqi Ocean Science Center.

El-Samra, M. I., Emara, H. I., & Shunbo, E. (1986). *Dissolved petroleum hydrocarbon in the Northwestern Arabian Gulf*. Basrah: Iraqi Ocean Science Center.

Elshorbaghy. (2005). *Overview of marine pollution in the Arabian Gulf with emphasis on pollutant transport modelling*. Retrieved July 2013, from http://www.academia.edu/2595870/Overview_of_marine_pollution_in_the_Arabian_Gulf_with_emphasis_on_pollutant_transport_modeling

FAO. (2008).*Irrigation in the Middle East region in figures- Aquastat Survey 2008.* Retrieved August 2013, from ftp://ftp.fao.org/docrep/fao/012/i0936e/i0936e08.pdf.

FAO. (2013). *Assessment of environmental hazards and impacts of coastal aquaculture.* Retrieved October 2013, from http://www.fao.org/docrep/t0697e/t0697e06.htm

Fattouh, B. & El-Katiri, L. (2012). Arab Human Development Report. *Energy and Arab Economic Development.* Retrieved July 2013, from http://www.arab-hdr.org/publications/other/ahdrps/ENGFattouhKatiriV2.pdf

Floodgate, G. D. (1995). *Some environmental aspects of marine hydrocarbon bacteriology*. Retrieved September 2013, from http://www.int-res.com/articles/ame/9/a009p003.pdf

Fowler, S.W. (1993). *Pollution in the Gulf: monitoring the marine environment IAEA-Bull.* Retrieved September 2013, from http://www.iaea.org/Publications/Magazines/Bulletin/Bull352/35205980913.pdf

GESAMP (IMO/FAO/UNESCO/IOC-UNIDO/WHO/IAEA/UN/UNEP Joint Group of Expert on the Scientific Aspects of Marine Environment Protection). (2007). *Estimates of oil entering the marine environment from sea- based activities.* Ref. Stud. GESAMP No. 75. London: IMO.

Goutx, M., & Saliot, A. (1980). *Relationship between dissolved and particulate fatty acids and Hydrocarbons, Chlorophyll A and zooplankton biomass in Villefranche bay, Mediterranean Sea*. Marine Chemistry.

Hashim, R., Reza, K. A., & Ahmad, S. (2013). *Environment Protection Engineering.* Retrieved August 2013, from http://epe.pwr.wroc.pl/2013/1-2013/Tehrani_1-2013.pdf

Heubeck, M., Camphuysen, K. C., & Roberto, B., (2003). Assessing the Impact of Major Oil Spill on Seabird Populations. *Marine Pollution Bulletin , 46, 900-902.*

http://oxforddictionaries.com/definition/english/pollution

http://www.acronymfinder.com/Council-of-Arab-Ministers-Responsible-for-the-Environment-(CAMRE).html

http://www.google.com/imgres?imgurl.

Hulsey & Ludivina. (2012). *Marine Pollution.* New Delhi: World Technologies.

IM0. (2012). *List of special areas under MARPOL and particularly sensitive sea areas*. Retrieved from http://www.imo.org/blast/blastDataHelper.asp?data_id=30979&filename=778.pdf.

IMO. (1977). *The International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (1969).* London: Author.

IMO. (1991). *The International Convention on Oil Pollution Preparedness, Response and Co-operation (the "OPRC Convention") of 1990*.London: Author.

IMO. (2002). *MARPOL 1973/1978*. London: Author.

IMO. (2004). *The International Convention on Civil Liability for Bunker Oil Pollution*. London: Author.

IMO. (2005). *Manual on oil pollution section IV*. London: Author

IMO. (2011). *International Convention on Civil Liability for Pollution Damage.* Retrieved from http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-on-Civil-Liability-for-Oil-Pollution-Damage-%28CLC%29.aspx.

IOC (Intergovernmental Oceanographic Commission). (1992). *Determination of petroleum hydrocarbon in sediments. Reference methods for marine pollution.* New York: UNEP.

IPEICA(International Petroleum Industry Environmental Association). (2007). *Oil Spill Compensation: A Guide to the International Conventions on Liability and Compensation for Oil Pollution Damage*. London: Author.

IPIECA (International Petroleum Industry Environmental Association). (2000). *A guide to contingency planning for oil spills on water.* London: Author.

Iraqi Foundation. (2003). *draft report physical characteristics of mesopotamian marshlands of southern Iraq*. Retrieved August 2013,from http://www.iraqfoundation.org/edenagain/publications/pdfs/physicalcharreport.pdf

Iraqi Ocean Science Centre. (2005). *dissolved oil hydrocarbon in Shatt Al-Arab River.* Basrah: Author.

ITOPF(International Tanker Owners Pollution Federation Limited). (2013). *Oil Tanker Spill Statistics 2012*. Retrieved June 2013, from http://www.itopf.com/news-and-events/documents/StatsPack.pdf.

ITOPF. (2002). *Fate of marine oil spill*. Retrieved June 2013, from http://www.itopf.com/marinespills/fate/weathering-process/documents/tip2.pdf.

ITOPF. (2008). *Data and statistics*. Retrieved June 2013, from http://www.itopf.com/information-services/data-and-statistics/statistics/index.html#no

ITOPF. (2011). *Effects of oil pollution on the marine environment*. Retrieved June 2013, from www.itopf.com/.../TIP13EffectsofOilPollutionontheMarineEnvironment.

Jeffrey, J. P., Aarne, P. & Ruth, F. W. (1997). *Environmental pollution and control*. Boston: Heinemann.

Khan, N. Y., Munawar, M., & Price, A. R. (2002). *The Gulf ecosystem: health and sustainability*. Leiden: Baclhuys.

Khonkar, H. (2009). *Complete Survey of Wind Behaviour over the Arabian Gulf.* Retrieved August 2013, from http://www.kau.edu.sa/Files/320/Researches/54555_24880.pdf

Knap, A. H., & Williams, P. J. (1982). *Experimental studies to determine the fate of Petroleum Hydrocarbons from refinery on an estuarine system*. Retrieved September 2013, from http://www.bangor.ac.uk/oceansciences/research/php/publications.php?person=0964

Lavieren, V. H., Bur. J., & David, A. (2010). *Managing the growing impacts of development on fragile coastal and marine ecosystems: Lessons from the Gulf*. Retrieved July 2013, from http://www.inweh.unu.edu/documents/PolicyReport_LessonsFromTheGulf.pdf

Literathy, P., Nasser, A. L., & Zarba, M. A. (1985). *Problem of monitoring bottom sediments and heavy metals in the marine environment. ROMP symposium on regional marine monitoring and research programmes in UAE University*. Basrah: Iraqi Ocean Science Center.

Marchand, J.C., Caprais, J.C., & Pignet, P. (1988). Hydrocarbons and halogenated hydrocarbons in coastal waters of the Western Mediterranean (France). *Marine Environment*. Res., 25: 131-159.

Naser. (2005). *Oil hydrocarbons concentration in the Iraqi territorial water and sediment.* Basrah: Iraqi Ocean Science Centre.

Nasher, E., Yook, L., & Sulif, S. (2013). *Concentrations and Sources of Polycyclic Aromatic Hydrocarbons in the Seawater around Langkawi Island, Malaysia.* Retrieved September 2013, from http://www.hindawi.com/journals/chem/2013/975781/

National Research Council, Committee on Oil in the Sea: Inputs, Fates, and Effects Staff. (2002). *Oil in the* Sea *III: Inputs, Fates, and Effects.* Washington, DC: National Academies Press.

PERSGA. (2013). Retrieved June 2013, from http://www.persga.org/

Pilot Project on Marine Pollution (Petroleum) Monitoring. (1976). *Guide to operational procedures for IGOSS pilot project on marine pollution (petroleum) monitoring, Intergovernmental Oceanographic Commission, Manuals and Guides.* Paris: UNESCO.

Poonian, C. (2003). *The effects of the 1991 Gulf War on the marine and coastal environment of the Arabian Gulf: Impact, recovery and future prospects.* Retrieved May 2013 from http://www.c-3.org.uk/Multimedia/Reports/Gulf%20war_Poonian.pdf

ROPME. (2013). Retrieved July 2013, from http://ropme.org/home.clx

Sadiq, M., & McCain, J. (1993). *The Gulf War Aftermath An Environmental Tragedy*. London: Kluwer Academic.

Sen Gupta, R., Fondekar, S. P. & Alagarsamy, R. (1993). *State of oil pollution in the Northern Arabian Sea after 1991 Gulf oil spill*. Retrieved August 2013, from http://drs.nio.org/drs/handle/2264/2814

Shamshoon, S. M., Zciara, T.S., & Abdul-Rdha, A. N. (1989).*Hetrotroohic bacteira in the north wastrrn rigion of the Arabin Gulf*. Basrah: Iraqi Ocean Science Center.

Shamshoon, S. M., Zciara, T.S., & Abdul-Rdha, A. N. (1991). *Marine bacteria an indicator of oil pollution in the Arabin Gulfe*. Basrah: Iraqi Ocean Science Center.

Tan, A. K.-J. (2006). *Vessel-Source Marine Pollution: The Law and Politics of International Regulation.* Cambridge: Cambridge University Press.

Temare. (2003). *Hydrocarbon Concentrations of oil in the southern Iraqi water*. Basrah: Iraqi Ocean Science Center.

Terhune, K. (2011) .*Tanker technology, limitations of double hulls*. Retrieved August 2013, from http://www.acee-ceaa.gc.ca/050/documents_staticpost/cearref_21799/86129/Tanker_Technology.pdf

Tolosa, S., Fiorini, B., & Gasser, J. (2013). *Carbon sources in suspended particles and surface sediments from the Beaufort Sea revealed by molecular lipid biomarkers and compound-specific isotope analysis.* Retrieved September 2013, from http://www.biogeosciences.net/10/2061/2013/bg-10-2061-2013.pdf

UAE, University. (2006). *The First International AEHMS Conference of The State of The Gulf Ecosystem: Future and Threats.* Retrieved July 2013, from http://www.aehms.org/pdf/1st_Gulf_Conf__2nd_Circular.pdf

UNEP. (2013). Retrieved June 2013, from http://www.unep.org/drc/RegionalOffices/RegionalOfficeforWestAsiaROWA/tabid/6140/Default.aspx

Veiga, M. C. (2003). *Dealing with major oil spills, a comparative study of Measures implemented by countries with emphasis on the polluter pays philosophy.* (PhD thesis), Cardiff, University of Wales.

Wattayakorn, G. (1991). *Petroleum pollution in the gulf of Thailand. Prospects of the coastal offshore engineering in the 21st century proceeding regional seminar an coastal and offshore engineering Dec. 9-11, 1991, Malaysia*. Retrieved September 2013, from http://eprints.utm.my/3639/1/SKMBT_60007052215471.pdf

Zerba, M. A., Mohammed, O. S., Anderlini, V. C., & Literathy, P. (1985). *Petroleum residues in surface sediment of Kuwait*. Basrah: Iraqi Ocean Science Center.

Zhang, T., Liang, Y. & Gong, F. (2004). *Systemic analysis of structures and contents of nitrogen - containing compounds and other non - hydrocarbons in crude oils in conjunction with chemo metric resolution technique.* Basrah: Iraqi Ocean Science Center.