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Research Article

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Assessment of petroleum hydrocarbon concentrations in intertidal surface sediments of Arzew gulf (West of Algeria)

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ABSTRACT

The petroleum hydrocarbons concentration (PHC) along the intertidal surface sediments of eight stations between Mostaganem and Marsat el Hadjadj towns, gulf of Arzew, west of Algeria, was analyzed during 2012, to provide useful information on the potential ecological risk of petroleum hydrocarbon to benthic organisms, human health, and also to check the level of petroleum hydrocarbons in marine sediments. Ultraviolet Fluorescence (UVF) Spectroscopy was used. The concentration of PH in intertidal sediments was in the range of 1773.5 to 7091.4 ppm. Compared with other coast and intertidal zone in the world, the concentration of PH in this study shows important level contamination. Special and urgent dispositions should be taken to remedy this pollution.

Keywords: Petroleum hydrocarbon, coastal pollution, Intertidal sediments, Arzew gulf, Algeria.

INTRODUCTION

Petroleum consists of crude oils and a wide variety of refined oil products that the elemental composition varies over a narrow range 82%–87% carbon, 12%–15% hydrogen, the balance being oxygen, nitrogen and sulfur. Pollution of the sea by petroleum hydrocarbons occurs mainly through marine operations, land based discharges, atmospheric and natural inputs [1]. Information on the distribution of petroleum hydrocarbon concentrations in the coastal environment is necessary to determine the extent of oil pollution input in to the seas. Prevention of petroleum hydrocarbon contamination is extremely important, as it is one of the world's worst kinds of sea's pollutions, because of its randomness, toxicity, large pollutant area and long persistence in the environment. Pollution of the sea by petroleum hydrocarbons occurs mainly through marine operations, land based discharges, atmospheric and natural inputs [1], [2].

The total input of petroleum into the seas through human activities and sources such as atmospheric fallout, natural seepage, etc. is estimated at, 2.37 10^6 × t $year^{-1}$ [3]. Out of these, about 65.2% is discharged through municipal and industrial wastes, urban and river runoffs, oceanic dumping and atmospheric fallout; 26.2% derived from discharge during transportation, dry docking, tanker accidents, and de-blasting. The remaining 8.5% comes from fixed installations like coastal refineries, offshore production facilities, and marine terminals [1]. When petroleum hydrocarbon is released directly to water through spills or leaks, certain petroleum hydrocarbon fractions will float in water and form thin surface films. Other heavier fractions will accumulate in the sediment at the bottom of the water, which may affect bottom-feeding fish and organisms. Some organisms found in the water (primarily bacteria and fungi) may break down some of the petroleum hydrocarbon fractions. Petroleum hydrocarbon released to the soil may move through the soil to the groundwater. Individual compounds may then separate from the original mixture, depending on the chemical properties of the compound. Some of these compounds will evaporate into the air and others will dissolve into the groundwater and move away from the release area [4], [5]. The occurrence of

enhanced levels of hydrocarbons especially in sediments can be a good indication of anthropogenic sources of pollution. Hydrocarbons can be bio-concentrated in sea foods, especially in shellfishes, such as mussels, oysters and cockles to levels in excess of public health standards, thus presenting a health hazard to those eating them [6], [7]. Contamination by petroleum hydrocarbon is a serious problem throughout the world. An increase in petroleum hydrocarbons in the marine environments causes a negative impact not only on the aquatic life but also may be extend to affect human heath through interference in the food web and through contamination of seawater. A large percentage (>30–50%) of spilled hydrocarbons enriched in heavier more recalcitrant compounds deposited in bottom sediments, beaches and soils which then act as long-term reservoirs and secondary sources [8]. Furthermore, one of their major economic impacts is the reducing the recreational utility of coastal waters. Oil in the sea, whether from spills or chronic sources, is perceived as a major environmental problem. According to Amar [9] Arzew gulf is the most important North African industrial area, containing chemicals and petrochemicals industries. Assessment and comparing of petroleum hydrocarbons concentration in surface sediments of the Arzew gulf with other region in the world is very important to inspect the pollution level and protect marine life, human health, and also for achieving a sustainable management and ecosystem preservation

Description of the Study Area

The Arzew gulf (Fig. 1) is one of the major units of the continental Algerian West shelf. It is between the Arzew massif (Carbon cape, 0° 20'W) at the West and the *Cheliff* Delta at the East (Ivi cape, 0° 20'W), which gives a longitudinal development on about 50 km. Two rivers of very unequal importance feed the gulf, the middle *Cheliff* at East and the minor *Macta* at the West [10].

The figure 2 shows, also, the sedimentary map of the concerned area, which is characterized by the following aspects:

- The calcareous sediments clearly presented by calcareous-clay vases, cover a large area of the gulf.
- Sludge siliceous-clay at continental sides, lining the gulf with a large mudflat.
-An alternance with terrigenous sand and sediment mixed or purely organogenic on the coastal fringe from Carbon cape to *Mostaganem*.

The intertidal studied zone extends between *Mostaganem* and *Marsat el Hadjadj* towns on about 30 km (Fig. 3). Many points of discharge of urban and industrial effluents are found along the studied coast. The gulf of Arzew is the place of discharge of the *Cheliff* wadi. The river is 795 km long and carries wastewater from many towns. This part of Mediterranean Sea is characterized by a consequent marine traffic and important fishing activities. Several works demonstrate a high richness of the fisheries resources and benthic communities [11], [12], [13], [14].

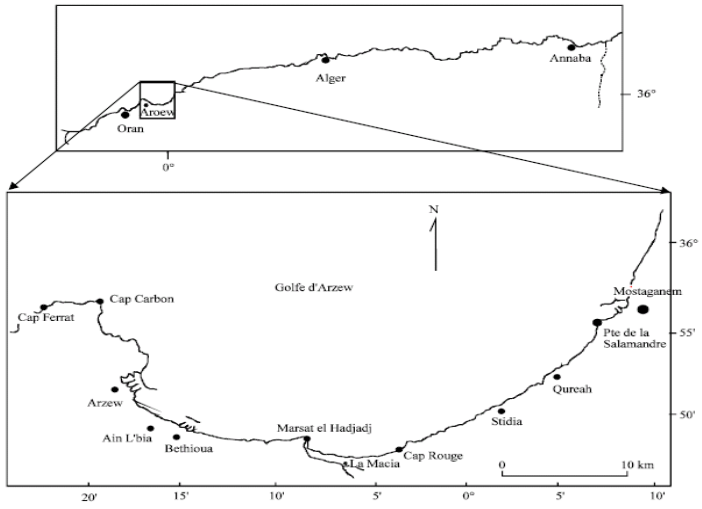

Fig.1 Geographic emplacement of the Algerian Arzew gulf [9]

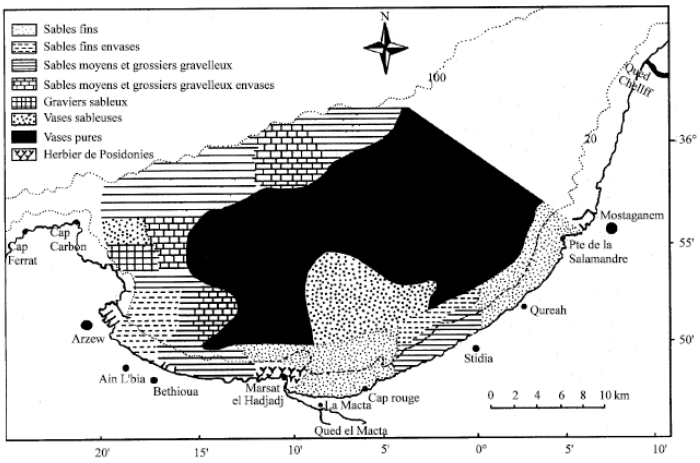

Fig. 2 Sediment distribution in the Arzew gulf [9]

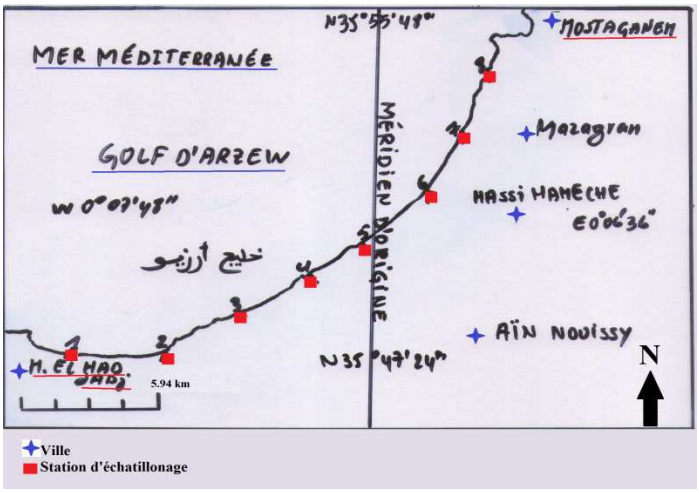

Fig. 3 Map of surface sediment sampling along Arzew gulf

EXPERIMENTAL SECTION

Sample collection

Between January 2012 and January 2013, surface sediment samples at eight stations were collected monthly in the intertidal areas of the Arzew gulf, between *Mostaganem* and *Marsat El Hadjadj towns* (Fig. 3). All samples were carefully collected from surface sediment (0-10 cm) with a clean stainless steel spoon and packed by self-packing polythene bags. Immediately transported to laboratory, samples were stored in refrigerator against light. A homogenous sample was constituted for each station.

Petroleum Hydrocarbons Analysis

The collected sediment was thawed, saponified using KOH methyl alcohol mixture followed by extraction with n-hexane. The concentrated extract, after drying, was separated into alkane and aromatic fractions on an alumina column and the intensity of fluorescence of the aromatic fraction was measured [15]. The samples were analyzed for Petroleum hydrocarbons using Spectrofluorometer.

The fluorescence of the samples was measured at 310nm excitation and at 364nm emission wavelength respectively. All blanks, standards and samples were measured in a Teflon – capped 1 cm silica fluorescence cell under identical instrumental settings and conditions. Duplicates, spikes and blanks were treated identically using Chrysene (Merck) as a standard reference to test precision, accuracy and solvent purity in the analytical procedure and the data were expressed in terms of Chrysene equivalents. Percentage recovery for spiked samples ranged from 96% to 99%, while precision agreed within 5%. Blank values were almost negligible.

All the experiments were conducted in 5 replicates and the average of the values were reported along with standard deviations. Analysis methods and statistical treatment were done according to [16].

RESULTS AND DISCUSSION

Table.1

Station	1	2	3	4	5	6	7	8
Concentration (ppm)	7091.4	6867.8	6449.7	1773.5	5338.6	6532.9	6386.4	6791.7

Table 1 shows that petroleum hydrocarbon concentrations in intertidal surface sediments of the Arzew gulf vary over a wide range (1773.5 ppm to 7091.4 ppm). The highest concentration (7091.4 ppm) occurs at *Marsat El Hadjadj* (station 1) near oil refineries of Arzew). The lowest petroleum hydrocarbon concentration found is at the fourth sampling station. The observed low level of petroleum hydrocarbon from this area is considered as the background level for the present study. Petroleum hydrocarbon concentrations was influenced by the distance from pollutant sources, scales of discharge, river transport and hydro dynamical factors such as current, wave, tide and wind.

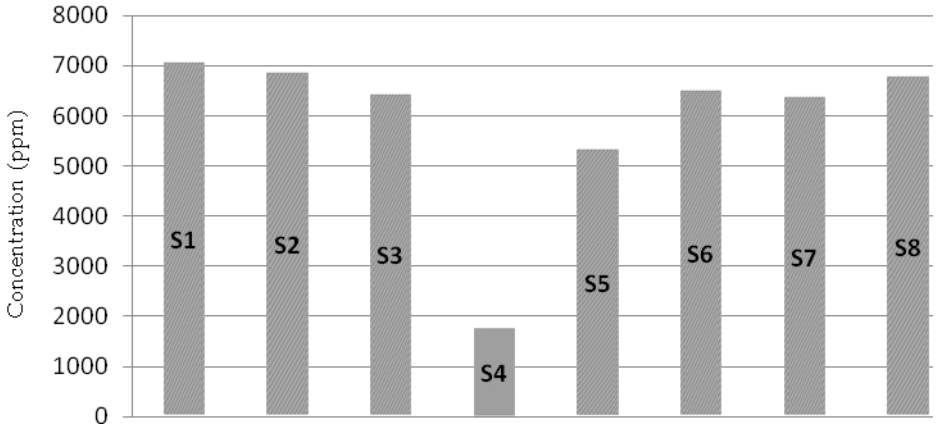

Fig.4 Distribution of petroleum hydrocarbon concentrations in intertidal surface sediments of Arzew gulf, Algeria.

The textural distribution of the surface sediment reveals the predominance of sand along the Arzew gulf. The differences in the textural parameters indicate that they are mainly depending on the dynamic process. The higher mud content is due to the fluvial discharge and better mixing of saline and freshwater that facilitated flocculation and faster settling of suspended particles [17]. The higher sand contents indicating a relatively higher energy regime that prevents sedimentation of fine grained particles. Sediments containing fine particles tend to be good accumulations of organic pollutants presumably because of their greater effective surface area. The clay minerals are highly accumulating the pollutants such as, heavy metals, PHC, PAH, etc. The present petroleum hydrocarbon concentrations values are compared (Table 2) with those reported for selected coastal areas.

Table.2 Comparison of PHC (ppm) in sediments of present study with estuarine and coastal regions of selected sites around the world.

Location	PHC (ppm)	References
Arabian Sea along the Indian coast	0.6 – 5.8	[18]
Shetland Island, UK	7 – 8816	[19]
Straits of Johor, Malaysia	0.7 – 36.7	[20]
Arabian gulf	5.4 – 92.0	[21]
UAE coast	51,000	[22]
Changjiang estuary, China	2.2 – 11.82	[23]
Fraser River Basin, Canada	1.6 – 20.6	[24]
Tamilnadu coast, India	1.48–4.23	[16]
Bassein-Mumbai coast, India	7.0 – 38.2	[25]
Bizerte lagoon, Tunisia	0.05 – 19.5	[26]
Jiaozhou Bay, China	0.54 – 8.12	[27]
Gulf of Fos, France	7.8 – 180	[28]
Abu Dhabi, UAE	6.14 – 62.7	[29]
Arzew gulf, Algeria	1773.5 – 7091.4	Present study

Interpretation of the data reveals that the range of concentrations of petroleum hydrocarbon in the Arzew gulf is comparatively higher than concentration of petroleum hydrocarbon in surface sediment over the world, but lower than UAE coast (Table 2). High petroleum hydrocarbon concentration in UAE Coast may be due to the intense presence of refineries, chemical industries and also heavy oil tanker traffic along the shipping route in the Arabian Sea. Many accidental oil spills were reported near the study (Arzew gulf) area in recent years.

Therefore the elevated petroleum hydrocarbon concentrations in Arzew gulf may be mainly from chemical and petrochemical industries in the study region. Also other sources can occur the high (PHC) such as municipal waste waters, non refinery industrial discharge, refinery discharge, urban runoff, river discharges, seas dumping and fishing vessels operating in the localized area.

Sea water circulation in the Mediterranean basin can allows regional dispersion of petroleum hydrocarbon pollution. The general circulation along the North African coast is created by offsetting entry of Atlantic water through the Strait of Gibraltar. This results in an eastward current plated on the coast by the Coriolis drift [30], [31], [32]. In detail, the presence of the Arzew gulf induces the formation of a cons-westward coastal current [33], [31], and an upwelling phenomenon in the western part of the gulf [34], [35].

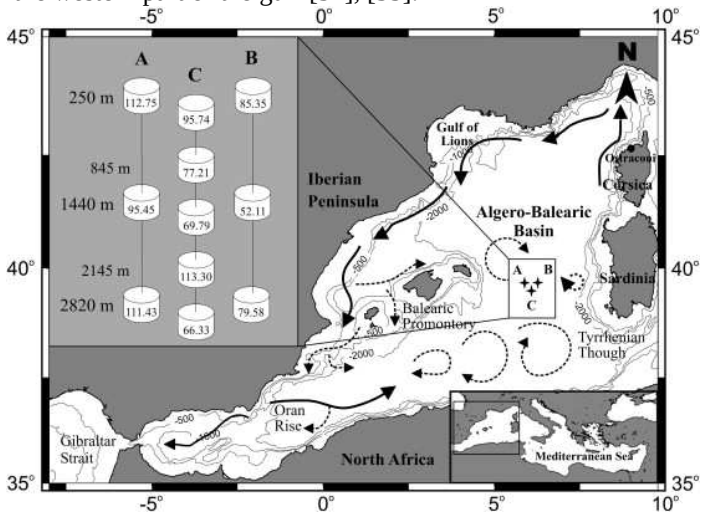

Fig. 5 Circulation of surface water in the West Mediterranean Sea [36]

CONCLUSION

This study provides comprehensive information on the distribution of petroleum hydrocarbon concentrations in Arzew gulf, Algeria. The PHC in Arzew gulf is comparatively higher than in other regions in the world. The results signify that industrial growth has affected the aquatic environments and regular monitoring will help to adopt stringent pollution control measures for better management of the aquatic region. These results of the present investigation and the actual knowledge about the Petroleum hydrocarbon concentration in these sediments indicate that further research about the region of these PHC are certainly necessary in near future.

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