

# Oil Pollution in the Waters of Algeria



Aicha Benmecheta and Lotfi Belkhir

**Abstract** As one of the three top oil producers in Africa, with a coastline of 1,644 km along the Mediterranean south shore, Algeria is a major stakeholder in the oil pollution in the Western Basin of the Mediterranean Sea. In this chapter, we review the major sources and levels of pollution from the three largest oil export terminals of Algeria, which also combine major oil refineries, including the largest refinery in Africa, and their potential impact on the overall pollution of the Mediterranean waters and beyond.

**Keywords** Algeria oil pollution, Algiers oil terminal, Arzew refinery, Hydrocarbon pollution in the Mediterranean Sea, Oil pollution, Skikda oil terminal, Skikda refinery

## Contents

|     |  |     |
|-----|--|-----|
| 1   | Introduction .....   | 248 |
| 2   | State of Pollution in Algerian Waters and Major Sources and Culprits ..... | 250 |
| 2.1 | Skikda Bay .....   | 250 |
| 2.2 | Arzew Bay .....  | 254 |
| 2.3 | Algiers Bay .....  | 256 |
| 2.4 | Dispersion of Pollution .....  | 257 |

---

A. Benmecheta (✉)

Physics Department, University of Science & Technologies at Oran (USTO), El Mnaouer, BP 1505 Bir El Djir, Oran 31000, Algeria  
e-mail: [abenmechta@gmail.com](mailto:abenmechta@gmail.com)

L. Belkhir

W. Booth School of Engineering Practice, McMaster University, 1280 Main Street West, ETB 504, Hamilton, ON L8S 0A3, Canada  
e-mail: [belkhir@mcmaster.ca](mailto:belkhir@mcmaster.ca)

A. Carpenter and A. G. Kostianoy (eds.), *Oil Pollution in the Mediterranean Sea: Part II - National Case Studies*, Hdb Env Chem (2018) 84: 247–262,  
DOI 10.1007/698\_2016\_57, © Springer International Publishing Switzerland 2016,  
Published online: 11 September 2016

|   |     |
|---|-----|
| 3 Oil Pollution Preparedness and Response ..... | 259 |
| 4 Conclusion .....                              | 261 |
| References .....                                | 261 |

## 1 Introduction

Algeria is the largest country on the African continent, and with a coastline of 1,644 km, it holds the lion's share of the southern shore of the Western Basin of the Mediterranean Sea. Algeria is also the top producer of natural gas in Africa, the second largest natural gas supplier to Europe, after Russia, and is among the top three petroleum producers in Africa. Algeria is also estimated to hold the third largest reserve of shale gas in the world [1]. In 2015, the country produced about 1.7 million barrels per day (bpd) of total petroleum products, with roughly a 2:1 split between crude oil and refined petroleum products. Also, more than 75% of this production was exported by sea through oil tankers. Algeria does not currently have any transcontinental export oil pipelines allowing it to export directly to its northern Mediterranean neighbors.

Algeria uses six coastal terminals for the export of its petroleum products conveniently distributed throughout its long coastline and which are located, going from west to east, in Oran, Arzew, Algiers, Bejaia, Skikda, and Annaba. Also, Algeria has five oil refineries with a total capacity of 652,500 bpd, three of which, Skikda (352,700 bpd), Algiers (63,400 bpd), and Arzew (58,500 bpd), are in coastline cities, while the other two are in the Saharan cities of Hassi Messaoud (163,500 bpd) and Adrar (14,400 bpd). The Skikda refinery is ranked no. 1 in Africa and no. 3 in the world and processes more oil than all the other four refineries combined. It's estimated that about 76% of Algerian crude oil is exported to Europe with the remainder sent to the Americas (17%) and Asia and Oceania (7%) [1]. Clearly, these facts make Algeria a very significant stakeholder and player in the oil pollution of the Mediterranean Basin, and the impact of its near and onshore oil operations is a subject deserving a careful assessment. We count in those operations two major sources of oil pollution to the Mediterranean Sea:

1. The first comes from the traffic of oil tankers at the six export terminals, through illegal discharges, tank cleaning, runoffs, etc. It's estimated that 35% of the oil that enters into the sea waters in general is due to tanker traffic and other sea shipping operations [2].
2. The second and perhaps more important source of water pollution coming from Algerian petroleum operations is the three oil refineries in Skikda, Arzew, and Algiers in order of importance (see Fig. 1).

To precisely assess the oil pollution level in the Mediterranean Sea, it would have been extremely helpful to have some direct estimates of the input of oil from the different sources in the Mediterranean. This unfortunately is not practically



**Fig. 1** The three major sources of hydrocarbon pollution in the Algerian Mediterranean Basin. *Source:* Adapted from Google Earth

possible, mainly due to the lack of appropriate statistics from the different countries as well as to the lack of coherent monitoring figures on oil in the area. Instead, we will have to rely on some specific and rigorous field studies that have shed valuable insight on this serious problem.

Oil refinery effluents contain many different chemicals at different concentrations including ammonia, sulfides, phenol, and hydrocarbons. The exact composition cannot however be generalized as it depends on the refinery and which units are in operation at any specific time. It is therefore difficult to predict what effects the effluent may have on the environment. Toxicity tests have shown that most refinery effluents are toxic but to varying extents. Some species are more sensitive and the toxicity may vary throughout the life cycle. Sublethal tests have found that not only can the effluents be lethal but also they can often have sublethal effects on growth and reproduction. Field studies have shown that oil refinery effluents often have an impact on the fauna, which is usually restricted to the area close to the outfall [3].

In this chapter, we will offer a state-of-the-art review of the most extensive studies of the impact of Algerian hydrocarbon on Mediterranean waters, originating from either the near-shore refinery activities or the oil exports. Since much of the data collected and the studies conducted were made on sites, such as Skikda, Algiers, and Arzew which serve as both export terminals and refinery sites, it is quite difficult to determine for certain the specific source of that pollution.

The rest of this chapter will consist primarily of Sect. 2 which will describe in fair details the most recent and thorough studies of the oil pollution levels in each of the three sites, namely, Skikda, Arzew, and Algiers. Each site will be the subject of its own study and hence its own section. The methods used, which consist of in-field studies as well as remote sensing using satellite imagery, will also be described in fair details. In the final subsection of Sect. 2, we will discuss the important and serious consequences of the findings from these various studies.

## 2 State of Pollution in Algerian Waters and Major Sources and Culprits

The Mediterranean Sea has the notable peculiarity of having a water deficit, which, notwithstanding the impact of mesoscale eddy currents that can cause regional and global dispersion of pollutants, tends to prevent any outflows of surface waters through the Strait of Gibraltar into the Atlantic Ocean. This, in essence, makes the level of hydrocarbons in the Western Basin one of the highest in the world. This also raises the fear of seeing an increased level of less biodegradable pollutants, such as organochlorines and other surfactants, lead to the progressive degradation of the pelagic and offshore ecosystems [4]. Also, the high level of near-shore hydrocarbon pollution is further aggravated by the lack of significant tides, which limits significantly the dilution and diffusion of those pollutants across larger areas and their faster biodegradation.

The main sources of oil pollution in Algeria waters are the effluents of the on-shore refineries and the various discharges and runoffs from the oil export terminals. We focus in this section on the state of pollution of near-shore Algerian waters in the vicinities of Skikda, Arzew, and Oran. All of three cities serve as export terminals as well as host major refineries.

### 2.1 *Skikda Bay*

#### 2.1.1 Level of Contamination

Skikda bay is located in the east-northern part of Algeria, about 470 km east of the capital Algiers. The area is in contact with an enormous petrochemical industrial complex, where raw petroleum and refined hydrocarbon products contaminate the surrounding areas via atmospheric pollution as well as effluents, which are dumped into seawaters. An important study conducted by Boutefnouchet, Bouzerna, and Chettibi helped establish the effects of these pollutants and waste disposal on the vicinity of the bay [5].

Several samples were taken at six (6) different sites along the bay and the outfall pipes of the industrial complex (see Fig. 2).

Several chemical analyses were made to analyze the concentrations of hydrocarbons,  $\text{CO}_2$ ,  $\text{Ca}^{+2}$ , and  $\text{Mg}^{+2}$ , chlorides and phosphates, and the alkalinity present into the samples. Table 1 shows a summary of the results on all six (6) sites and compares them with their clean water counterparts. As can be seen from the data, all of the six sites show very elevated levels of contamination in most of the chemicals (to the exception of phosphates) as compared with clean water. This level of pollution is attributed mostly to the effluent dumping from the petrochemical complex [5].



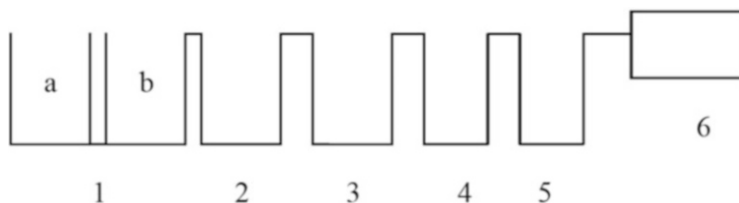
**Fig. 2** Studied littoral zone of Skikda bay (Algeria): (1) Fishing port located at the Stora Gulf. (2) Ancient port located in the center of the town. (3) New port located at the entry of the industrial zone. (4) Effluents dumping from the petrochemical complex of Skikda. (5) Ben Mhidi Bathing station. (6) The Marsa Platanes. *Source:* [5]

**Table 1** Different chemical constituents expressed in ppm and corresponding to six different sampling points

| Site                          | 1               | 2               | 3     | 4     | 5       | 6     | Clean water |
|-------------------------------|-----------------|-----------------|-------|-------|---------|-------|-------------|
| Hydrocarbons                  | 10              | 10              | 19    | 188   | 2       | 260   | $10^{-2}$   |
| CO <sub>2</sub>               | 10 <sup>4</sup> | 10 <sup>3</sup> | 1,340 | 1,200 | 700     | 1,400 | N/A         |
| M-Alkalinity                  | 550             | 625             | 123   | 147.5 | 122.5   | 165   | 50          |
| Total hardness                | 5,000           | 5,500           | 5,280 | 4,660 | 5,000   | 4,860 | 50          |
| pH                            | 8.7             | 8.7             | 8.5   | 8.8   | 8       | 8.9   | 6.5–8.5     |
| Cl <sup>-</sup>               | 2,492           | 2,279           | 3,227 | 3,582 | >24,000 | 3,339 | 250         |
| Po <sub>4</sub> <sup>-3</sup> | 0.01            | 0.014           | <0.02 | <0.02 | <0.02   | <0.02 | 0.025       |
| T (°C)                        | 28              | 28              | 26    | 28    | 26      | 28    | N/A         |
| COD (chemical oxygen demand)  | 4.24            | 6.72            | 5.36  | 8.4   | 4.5     | 9.6   | N/A         |

### 2.1.2 Cleaning and Biodegradation of Oil Pollutants

Another notable study also by Boutefnouchet et al. looked at the biodegradation process of pollutants as a function of time in the Skikda bay [6]. In this study, the researchers sought to identify and assess the effectiveness of selected



**Fig. 3** Schematics of the various basins of the Skikda refinery effluent treatment unit. Basin 1 (*a*) and (*b*) are used for the screening of big chunks; basin 2 is primarily for decantation and scraping off of the precipitated elements; basin 3 is used for the flocculation of the effluents; basin 4 is the microbiological basin where the biodegradation of the effluents starts using microorganisms solutions, aided with proper oxygenation and clean water source; basin 5 is a secondary decantation basin; and finally basin 6 is a sand filter

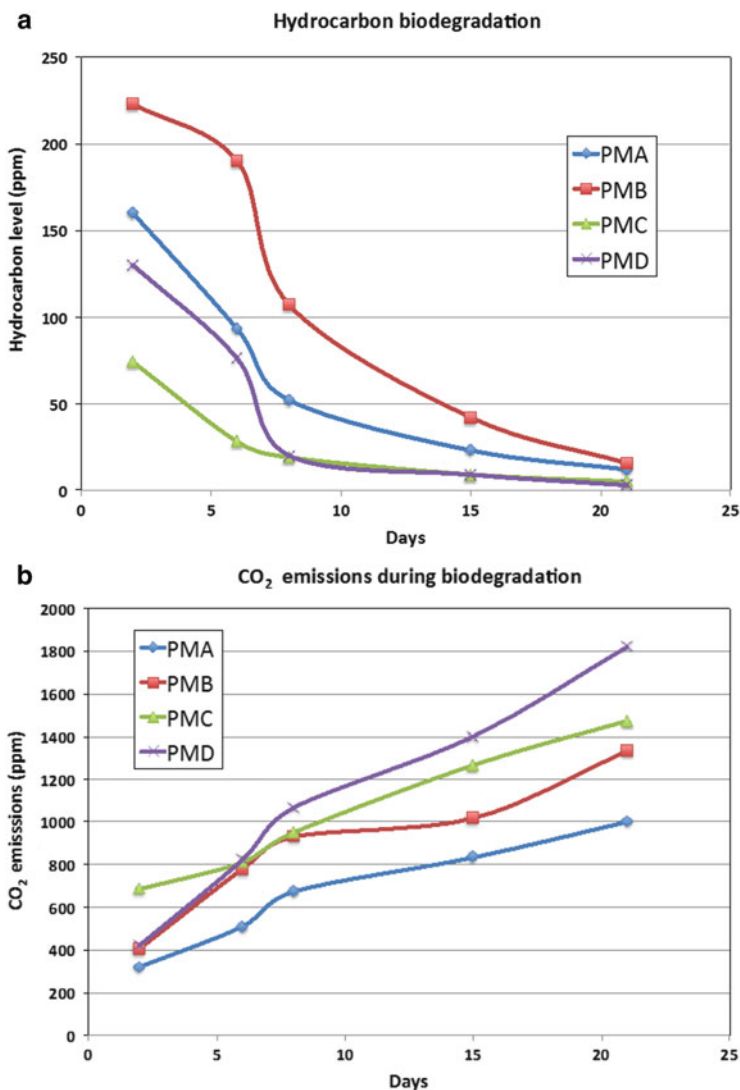
microorganisms for the cleaning and prevention of pollution by biological means, as a potential mitigating solution to the elevated level of pollution they previously uncovered.

In addition to the study of the biodegradation within the natural contaminated environment at some specific sites shown in Fig. 2, they also studied the biodegradation rate at the level of the effluent distillation and treatment unit of the Skikda refinery. The unit is composed of six (6) separate basins as shown in Fig. 3.

The researchers collected four (4) separate microbial populations and named them as follows: (1) PMA from basin 4 (Fig. 2); (2) PMB from the contaminated ground of the refinery; (3) PMC from uncontaminated position 3 (Fig. 2) corresponding to the new port located at the entry of the industrial zone; and (4) PMD from position 4 (Fig. 2) corresponding to the dumping site from the petrochemical complex. Each of the four (4) microbial populations was found to have its own distinctive composition. The effectiveness of these four (4) mixtures on the biodegradation of the same type of hydrocarbon (NAFTA B form of petrol from Hassi Messaoud oil wells), using the same conditions of oxygenation and clean seawater, was then evaluated as a function of time from 0 to 21 days.

Figure 4a shows the time evolution of the hydrocarbon biodegradation as a function of time over a 21-day period. Note that the biodegradation curves for PMA, PMB, and PMC all seem to achieve a 93% reduction in hydrocarbon, while PMD achieved a 98% reduction. All populations seem to exhibit a rate-limiting behavior as expected from these kinds of processes. The researchers also measured the CO<sub>2</sub> production by these bacterial populations during the degradation process.

Figure 4b shows the emissions curve as a function of time during the 21-day period. Again, the PMD population shows a significantly higher CO<sub>2</sub> emission level, confirming its more potent efficiency at biodegrading the hydrocarbon. Finally, we remind the reader that the PMD population was collected from the position (4) in Fig. 2, which corresponds to the effluent dumping from the petrochemical complex of Skikda. This is also the same position that shows the second highest level of hydrocarbon contamination (188 ppm) across all the six (6) sites that were assessed and shown in Table 1. In other words, despite the apparent



**Fig. 4** (a) Hydrocarbon biodegradation for four different bacterial populations as a function of time over a 21-day period. (b) CO<sub>2</sub> emissions for four different bacterial populations as a function of time over a 21-day period

effectiveness of the PMD bacterial population in biodegrading the hydrocarbon from the effluents, there is nonetheless a very elevated level of contamination that is still present.

| Dates | 15/07/2003 | 17/11/2003 | 02/12/2003     | 07/12/2003        | 16/12/2003        | 22/12/2003        |
|-------|------------|------------|----------------|-------------------|-------------------|-------------------|
| Sites | 1,2,3,4,5  | 6,7,8,9    | 10,11,12,13,14 | 15,16,17,18,19,20 | 21,22,23,24,25,26 | 27,28,29,30,31,32 |

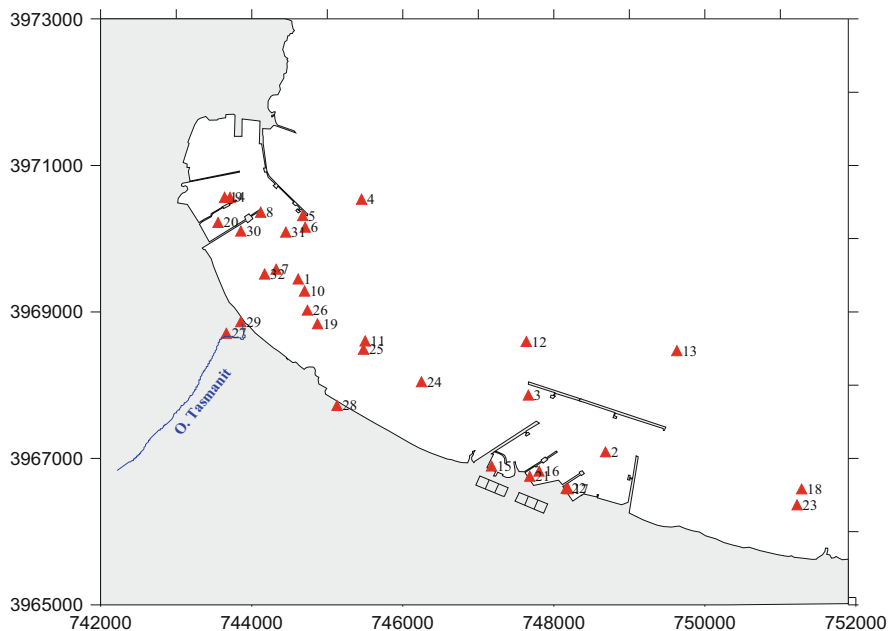


Fig. 5 Dates and sites of seawater samples taken from the Arzew Bay

## 2.2 Arzew Bay

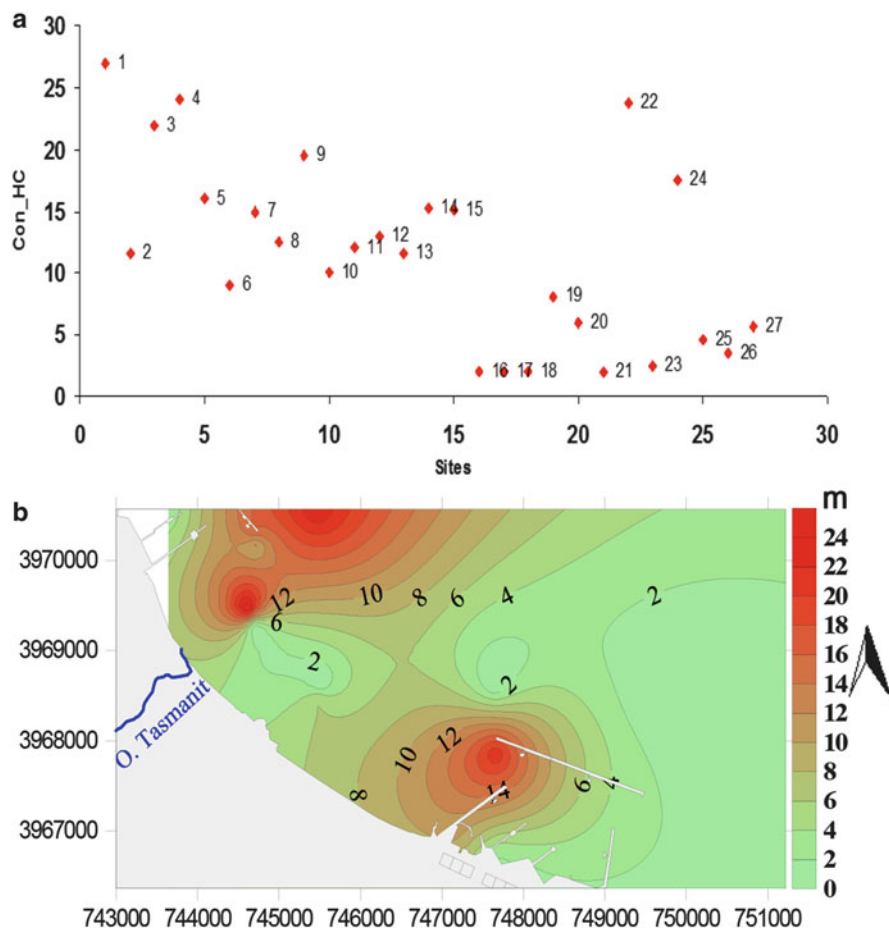
Arzew Bay is situated in the northwestern part of Algeria and is about 400 km west of the capital Algiers. In other words, it's almost equally distant to the Skikda bay from Algiers and on the opposite, western side of the country.

Some of the most pertinent work on the assessment of hydrocarbon pollution in Arzew Bay was led primarily by Benmecheta and her team in 2005 [7]. The assessment was done using both extensive in situ sample collection and analysis combined with remote sensing assessment using satellite imaging.

Benmecheta conducted a sample analysis on the Arzew bay from thirty-two (32) separate sites on six (6) different days over a period of spanning July–Dec 2003. The selected sites and timeline are shown in Fig. 5. The samples were all collected at 1-meter vertical depth from the water surface and were carefully protected in airtight bottles lined with aluminum foil pre-washed in carbon tetrachloride to prevent any oxidation. Also, to prevent any spurious postharvesting microbial activity, the researchers acidified the samples that were not immediately analyzed to a pH <3 with a solution of hydrochloric acid (HCl).

The assessment of the hydrocarbon (HC) content in the samples was conducted using the UV/Vis (ultraviolet–visible) spectroscopy to measure their absorbance





**Fig. 6** (a) HC pollution content for each of the 32 sampled sites in Arzew Bay. (b) HC content per location showing the dispersion gradient of the pollution

spectrum in a chloroform solvent. The HC content in mg/l (equivalent to ppm) was obtained with the reading of the 400 nm wavelength. The key results of the study were as follows:

- The highest values of HC content tended to be localized around (1) site 1 which is the direct recipient of the effluent discharges from the large petroleum and gas-processing complex at Arzew which flow through Ouadi Tasmanit (Tasmanit river shown in blue in Fig. 5) and (2) from sites 4, 5, and 9 and sites 2, 22, and 24 which fall in the oil tankers areas on the western and eastern sides, respectively (see Fig. 6a).
- There was a high level of variability of the HC pollution over time and over space on a relatively small scale, as shown in Fig. 6b, with HC content ranging from 2 mg/l to a maximum of 27 mg/l.

- The effect of dilution is very strong, suggesting a very rapid dispersion of the pollution in the neighboring regions and beyond.
- When taking into account the dispersion effects, these levels of sea pollution are consistent with the levels of hydrocarbon concentration (90–180 mg/kg) in surface sediments originating from the Arzew shores, as reported in [8].

### 2.3 Algiers Bay

Last but not least in our review of the pollution levels in the Algeria seas is the review of the Bay of Algiers, the capital and largest city of Algeria. The most comprehensive study of this bay was done by Houma-Bachari in her Ph.D. thesis [8]. Figure 7 shows the location of the beautiful Bay of Algiers along with some unfortunate images of the pollution and effluents entering that bay on an ongoing basis.

Bachari's study is characterized by the fact that she relied almost exclusively on the remote sensing techniques of satellite imaging to study the level of pollution of the Bay of Algiers, along with another pertinent regions such as the Bays of Bousmail, El Djamilia, and Zemmouri. This allowed her to assess the pollution level on a much larger area, but at the same time restricted her to rely on proxy metrics such as turbidity and suspended matter (SM), rather than a direct assessment of the hydrocarbon levels as was done in the field studies conducted in the bays of Arzew and Skikda. Figure 8 shows a SPOT satellite imagery in three XS spectral channels (often referred to as SPOTXS images) of the variation of suspended matter in the Algiers Bay (10 April 2009).

Figure 9 shows the level of turbidity at the surface of the Bay of Algiers on the NTU (nephelometric turbidity units) scale. Turbidity was found to vary from 80 to 116 NTU at the water surface. The highest values were registered at the Port of Algiers and El-Harrach, while the lowest were near El Hamma. This is quite consistent with the fact that both Oued El-Harrach (River of El-Harrach) and the Port d'Alger are by far the two largest sources of effluents in the region.

In addition to the turbidity measurement using satellite imagery, Bachari and her team conducted three in situ campaigns to measure the amount of suspended matter (SM) at several depth levels across the whole bay and calibrate their remote sensing data. Table 2 shows the mean and standard deviations of the SM levels measured in campaigns 1 and 2. The two campaigns are conducted about 1 month apart and were characterized by very similar weather conditions, such as temperature, wind, and sea current speeds.

Notice in Table 2 the large difference in the SM levels between campaign 1 and campaign 2, which shows a level of SM more than 4.5 times larger than the campaign 1 level. This high variability in sea surface pollution is believed to be due to the rapid dispersion that is characteristic of the powerful sea currents of the Mediterranean Sea as explained below.

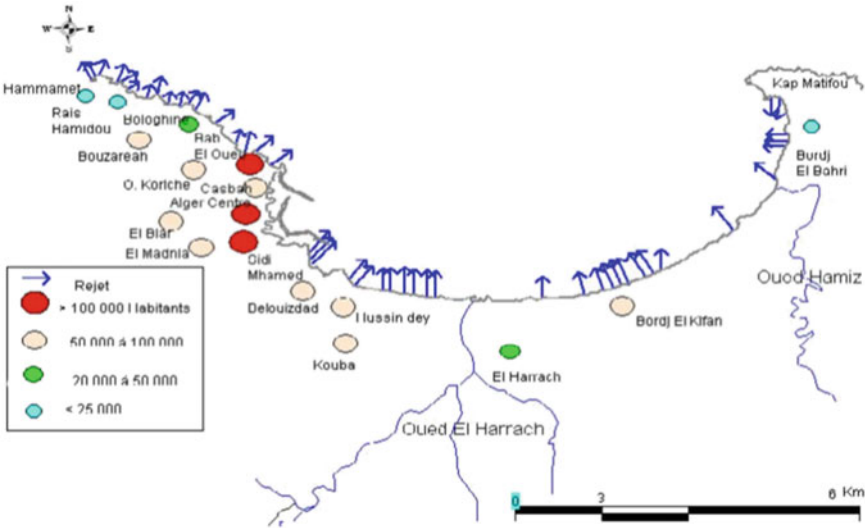


Fig. 7 Schematic of Algiers Bay showing (blue arrows) the main sources pollution and effluents, along with some sample pictures of those pollution sources (Courtesy of Houma-Bachari [8])

### 2.4 Dispersion of Pollution

We have seen from the above review of the HC pollution levels in the bays of Skikda, Arzew, and finally Algiers that the levels of HC and suspended matters range from about 30 mg/L in the Bay of Arzew to more than 250 mg/L in the Bay of Skikda and vary from 20 to 95 mg/L in the Bay of Algiers. Notwithstanding the fact that all these values are unacceptably high, what is even more disturbing is the degree of variability of these pollution levels, which is indicative of the dispersion effect of this pollution on both a regional and even global level.

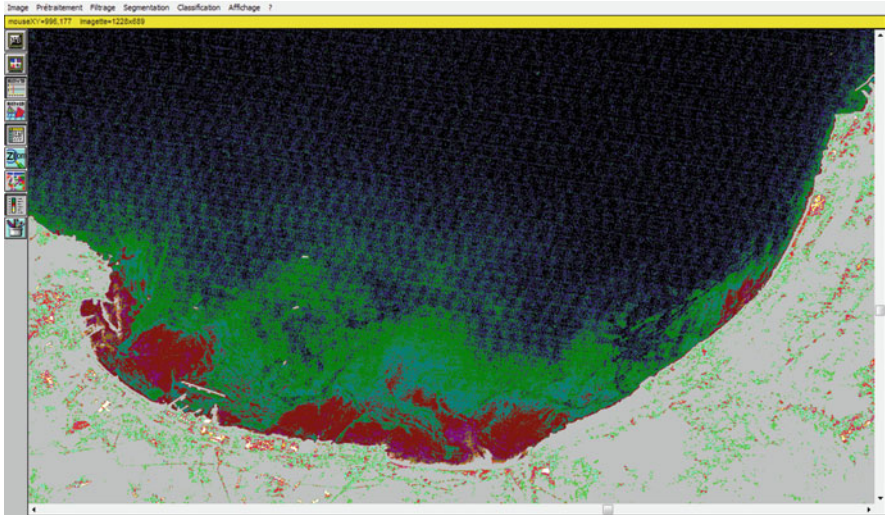


Fig. 8 Variation of suspended matter on a SPOTXS satellite image made of the Algiers Bay (10 April 2009) [9]

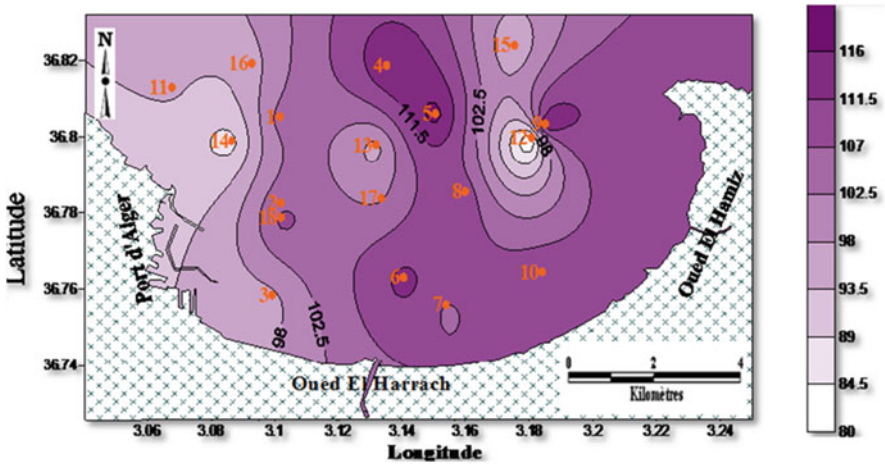
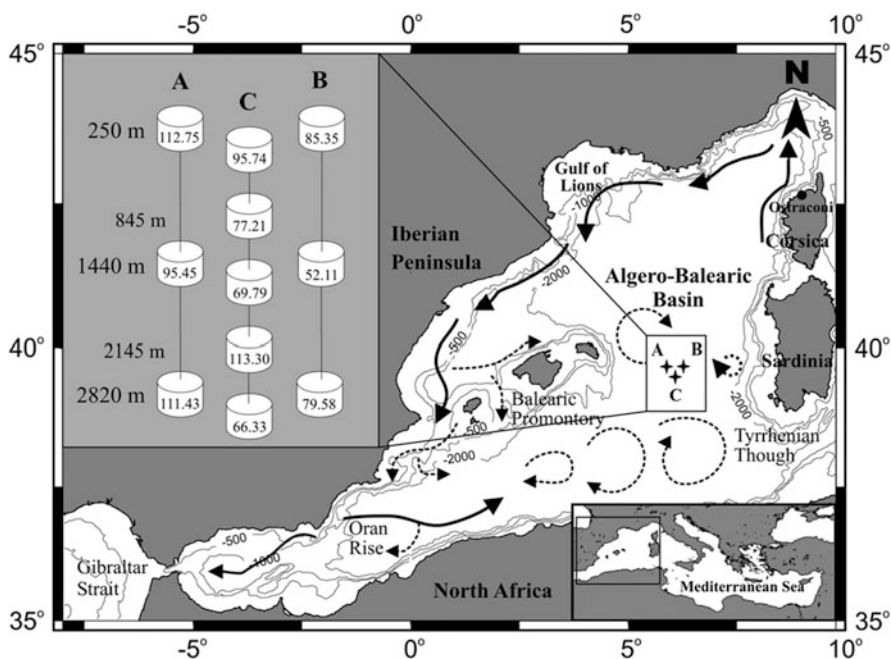


Fig. 9 Turbidity map in the Bay of Algiers (Courtesy of Bachari [8])

The water circulation in the Mediterranean Basin is known to cause regional dispersion of pollution [10]. Also, Arzew Bay is less than 300 nautical miles away from the Strait of Gibraltar and the Atlantic Ocean. Furthermore, the Algerian Current is one of the most energetic flows in the Mediterranean Basin. One branch of this current reaches the coast and returns to the western direction (Fig. 10). This current is formed by a series of mesoscale eddy currents at different scales. The buoys, released upstream and across a coastal meander between 0°E and 1°E

**Table 2** Suspended matter measured at or near the surface level of the sea across the Bay of Algiers during two separate campaigns

| Suspended matter (SM) (mg/L at 1 m below surface) |               |                         |               |
|---|---------------|-------------------------|---------------|
| Campaign 1 (March 2009)                           |               | Campaign 2 (April 2009) |               |
| Mean  | Std deviation | Mean                    | Std deviation |
| 19.71   | 5.92          | 94.76                   | 6.85          |



**Fig. 10** Surface water circulation in the Western Mediterranean Basin [11]

longitude, were followed for 3 months and found to travel an average speed of 14 cm/s (0.5 km/h) showing high energetic fluctuations related to several mesoscale eddies. More specifically, these are equivalent to 66 km in four (4) days along the zonal component and about 26 km in two (2) days along the meridional component [12]. This surface current is the main factor of dispersion of pollutants, such as HC, mercury, and others, to other coastal areas in western Algeria and beyond [13].

### 3 Oil Pollution Preparedness and Response

Algeria is a bona fide member of the Barcelona Convention (ratified in February 1981) and REMPEC (Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea) and is one of the seventeen (17) countries out of the

twenty-one (21) coastal countries surrounding the Mediterranean Basin that received approval from REMPEC for its National Contingency Plan [14].

REMPEC has provided its assistance since its establishment in 1976 in the field of national systems for preparedness for and response to marine pollution, to the competent national authorities of Algeria among fourteen (14) other Mediterranean countries. In addition to assisting individual coastal country in developing their contingency plans, REMPEC has also been involved since 1992 in the development of subregional systems for preparedness and response to major marine pollution incidents. Such subregional arrangements, called sub-regional contingency plans (SRCP), for mutual assistance in case of marine pollution emergencies significantly extend the spill response capacities of individual countries by providing a mechanism for pooling resources and jointly conducting response operations.

The first SRCP was in the South-Western part of the Mediterranean and included Algeria, Morocco, and Tunisia. It has been financed by the International Maritime Organization (IMO) and developed by REMPEC, in close cooperation with the national authorities of these three countries and signed in Algiers on 20 June 2005. The agreement and the plan entered into force on 19 May 2011 [15].

Separately from REMPEC, Algeria also ratified a National Contingency Plan with the International Tanker Owners Pollution Federation (ITOPF) effective 1994 [16]. This plan requires the three marine districts of Alger, Oran, and Jijel to maintain a response plan for combating pollution at sea and on shore and local authorities to have suitable arrangements in place. These are overseen by a national committee presided over by the Minister of the Environment. A review of the National Contingency Plan is under way; this will include arrangements for HNS response (Information as of May 2011).

In the event of an incident, command is allocated according to the size of the spill. The Minister of the Environment will assume control at a national level. At a regional level, command is assumed by the commander of the relevant marine district. Local authorities have a responsibility for minor incidents. The coast guard has operational responsibility for response at sea. The relevant administrative districts are in charge of cleanup on shore. In practice, Civil Protection Units under the Ministry of Defense will undertake any shoreline cleanup [15].

Finally, in June 2000, Algeria successfully completed an Oil Pollution Management Project funded by the World Bank's Global Environment Trust Fund [17]. The primary objectives of the project were to reduce the quantity of petroleum hydrocarbons entering the international waters of the Mediterranean and to comply with MARPOL 7 3/78 Convention requirements. The project also achieved, among other objectives, development of a comprehensive and integrated system for the management of oil pollution caused by marine sources, thus ensuring commonality of approaches and methodologies, promoting exchange of information and coordination, enhancing monitoring capability among the countries in the region for preventing and combating oil pollution, and improving the quality of the marine environment.

These objectives were successfully attained and deemed to be appropriate and in line with the government's international commitment to monitor compliance with international conventions related to marine pollution. They were clear and realistic with regard to national policies and regional agreements (Union du Maghreb Arabe-UMA agreement) [17].

To this date, there are no records of any major spills or pollution incidents that were caused by either an oil tanker or any one of the three major refineries studied in this chapter.

## 4 Conclusion

We have given in this chapter a succinct yet fairly thorough review of the current state of hydrocarbon pollution in the Algerian waters of the Mediterranean Basin. In particular, we have reviewed the most recent and pertinent field and remote sensing studies conducted on the three largest sources of oil pollutions of the Algeria sea waters, namely, the ports of Skikda, Arzew, and Algiers. We have found that the pollution levels are in all cases very significant and range from 30 mg/L in the Arzew waters to more than 250 mg/L in some spots of the Skikda Bay and vary from 20 to 95 mg/L in the Algiers Bay.

Perhaps even more disturbing than the actual levels at any particular spot is the very high level of dispersion of those HC pollutants across the whole Mediterranean Sea and even beyond into the Atlantic Ocean through the Gibraltar Strait, and this despite the fact that the Mediterranean Basin has a water deficit that limits the outflow to the Atlantic Ocean. Indeed, the Algerian Current is driven by highly energetic mesoscale surface currents in the Mediterranean Basin, which are known to cause regional dispersion of pollution.

## References

1. US Energy Information Administration (2016) Country analysis brief: Algeria. Report, March 2016. [https://www.eia.gov/beta/international/analysis\\_includes/countries\\_long/Algeria/algeria.pdf](https://www.eia.gov/beta/international/analysis_includes/countries_long/Algeria/algeria.pdf). Accessed 31 May 2016
2. World Ocean Review (2015) Oil pollution of marine habitats. <http://worldoceanreview.com/en/wor-1/pollution/oil/>. Accessed 31 May 2016
3. Wake H (2005) Oil refineries: a review of their ecological impacts on the aquatic environment, *Estuar Coast Shelf Sci* 62(1):131–140
4. Peres J (1978) Vulnérabilité des Ecosystèmes Méditerranéens à la Pollution. *Ocean Manage* 3 (3):205–217
5. Boutefnouchet N, Bouzerna N, Chettibi H (2005) Assessment of the petrochemical industry pollution on the Skikda Bay, Algeria. *Int J Environ Res Public Health* 2(3):463–468
6. Boutefnouchet N, Bouzerna N, Chettibi H (2006) Biodégradation des hydrocarbures en eau de mer: Cas de Naphta B. *Sci Study Res* 7(2):1582–1595

7. Benmechta A (2005) Hydrocarbon pollution in Bay of Arzew. Master's thesis, National Center of Space Techniques, Oran, Algeria
8. Houma FB (2009) Modélisation et cartographie de la pollution marine et de la bathymétrie à partir de l'imagerie satellitaire. Ph.D. thesis, Paris Est
9. Houma F, Samir B, Bachari N, Rabah B (2013) Contribution of satellite measurements to the modeling and monitoring of the quality of coastal seawater, perspectives in water pollution. In: Ahmad I, Ahmad Dar M (eds) InTech. doi:10.5772/53375. Available from: <http://www.intechopen.com/books/perspectives-in-water-pollution/contribution-of-satellite-measurements-to-the-modeling-and-monitoring-of-the-quality-of-coastal-seawater>. Accessed 22 June 2016
10. Millot C, Taupier-Letag I (2005) Circulation in the Mediterranean Sea. The handbook of environmental chemistry, volume 5: water pollution, pp 1–30
11. Zúñiga D, Calafat A, Heussner S, Miserocchi S, Sanchez-Vidal A, Garcia-Orellana J, Canals M, Sánchez-Cabeza JA, Carbonne J, Delsaut N, Saragoni G, 2008 (2008) Compositional and temporal evolution of particle fluxes in the open Algero–Balearic basin (Western Mediterranean). *J Mar Syst* 70(1–2):196–214
12. Salas J, Garcia L, Font J (2001) Statistical analysis of the surface circulation in the Algerian Current using Lagrangian buoys. *J Mar Syst* 29(1–4):69–85
13. Bouchentouf S, Tabet D, Ramdani M (2013) Mercury pollution in beachrocks from the Arzew gulf (West of Algeria). *Travaux de l'Institut Scientifique, Rabat, Série Zoologie* 49(1–5)
14. REMPEC. <http://www.rempec.org/index.asp>. Accessed 22 June 2016
15. REMPEC. [http://www.rempec.org/rempec.asp?theIDS=2\\_86&theName=RESPONSE&theID=9&daChk=1&pgType=1](http://www.rempec.org/rempec.asp?theIDS=2_86&theName=RESPONSE&theID=9&daChk=1&pgType=1). Accessed 22 June 2016
16. ITOPF. <http://www.itopf.com/knowledge-resources/countries-regions/countries/algeria/>. Accessed 22 June 2016
17. World Bank (2000) Implementation completion report (28607; 28650) on a grant from the global environment trust fund to the democratic and popular republic of Algeria for an oil pollution management project. Report No: 20557, 12 June 2000. [http://www.thegef.org/gef/sites/thegef.org/files/gef\\_prj\\_docs/GEFProjectDocuments/M&E/Documents%20and%20data/DatabaseContent/TE/2000/WB%20IW/68%20Oil%20Pollution%20Management%20Project\\_Algeria.pdf](http://www.thegef.org/gef/sites/thegef.org/files/gef_prj_docs/GEFProjectDocuments/M&E/Documents%20and%20data/DatabaseContent/TE/2000/WB%20IW/68%20Oil%20Pollution%20Management%20Project_Algeria.pdf). Accessed 22 June 2016