Impact of the anthropogenic activities on the deterioration of the coastal ecosystem of Beirut city

Impact des activités anthropiques sur la détérioration de l'écosystème côtier de la ville de Beyrouth

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Abstract

The city of Beirut counts almost the third of the Lebanese population and more than fifty percent of economical, industrial and touristic activities in Lebanon. The littoral, about 20 km, is affected by these activities from which the most important consequences are: i) the outflows of wastewater directly in the sea without any previous treatment ii) the public dump of Dora which is the source of aesthetical and chemical pollution iii) the embanking of 135 hectares of this littoral that has serious consequences on marine habitats and living communities of the Levantine Mediterranean basin.

Résumé

La grande ville de Beyrouth concentre le tiers de la population libanaise et plus de la moitié des activités économiques, industrielles et touristiques du Liban. Son littoral de 20 km subit l'effet néfaste de ces activités anthropiques dont les conséquences les plus importantes son : i) le rejet des eaux usées directement dans la mer sans traitement préalable, ii) la présence d'un immense dépotoir qui pollue esthétiquement et chimiquement l'eau de mer, iii) le remblaiement d'une surface de 135 hectares de la mer qui a détruit des habitats et des communautés vivantes spécifiques du bassin levantin de la Méditerranée.

INTRODUCTION

The big city of Beirut (figure 1), capital of Lebanon, counts about 1,500,000 inhabitants, almost one third of the Lebanese population and stretches along a 20

km coast line (ECODIT-IAURIF). The Beirut coastal line supports, for almost twenty years, the impact of illegal construction projects for industrial development and the effluents of industrial and domestic wastewater.

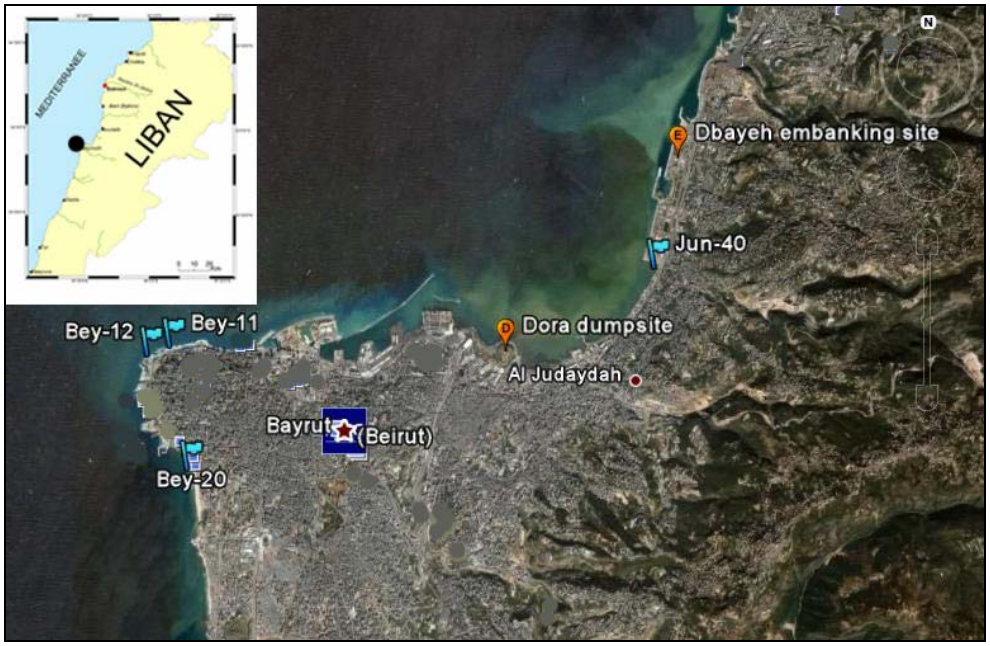

Figure 1: Google map showing the location of the different sites, Dora dumpsite and embanking site

Other touristic projects, seaside resorts, embanking, oil terminals and public dumps as well as the approvals for using the public sector, have abused and destroyed quite a large part of the coastline along with many beaches (ECODIT-IAURIF).

All these morphological changes as well as the ongoing human activities compromised, irreversibly, the coastal habitats along with the floral and faunal wealth of the marine environment.

This paper aims at presenting the observed impact of three sources of degradation of the coastal ecosystem; i) the wastewater effluents ii) public discharges in Dora iii) the uncontrolled management of the northern coast of Beirut.

PRESENTATION OF THE MAIN SOURCES OF THE COASTAL ZONE DEGRADATION

Wastewater

Apart from the wastewater treatment station of El Ghadir which is located in the south of Beirut and which treats the wastewater of 250,000 inhabitants according to primary and secondary technique, Lebanon is devoid of an appropriate wastewater treatment system and of a sewer collection network. This is why all liquid, industrial and domestic wastes are finally discharged to the sea.

In addition to the two rivers Nahr Beirut and Nahr Antelias, which are considered as the two main pathways for transferring polluted water from the interior zone of the country towards the sea, thirty three other sewers, of different flow intensities, are shed into the Lebanese coastal water (Khalaf *et al.*, 2001 ; Saad *et al*., 2004).

The monitoring program of the coastal region implemented by the Marine Research Centre of CNRSL[1], shows that polluted waters have an impact on the variability of the physicochemical and bacteriological parameters and perturb the fauna and flora communities.

The dumpsite of Dora (North of Beirut bay)

It was opened at the end of the Eighties of the last century, it received 1500 -2000 tons of solid and urban industrial waste per day, until its closedown in 1998 (ECODIT-IAURIF). Its total surface is 18 hectares and its height about 50 m. Besides its visible aesthetical consequences due to daily release of solid wastes caused by the action of the waves, wind and rain, this huge discharge releases from its lower parts a brown liquid of very unpleasant smell, contaminating the marine environment in several ways, especially by trace metals (Abi-Ghanem, 2008; Nassif, 2006; Nakhlé, 2003).

Embanking of the littoral

At the beginning of the Eighties of the last century and because of the anarchy that reigned in the country due to the civil war, illicit promoters had undertaken a project to embank part of the littoral in the north of Beirut. A few years later, this project was legalized and privatized. With a total surface of 135 hectares, this protrusion in the sea had serious consequences on marine fauna and flora, and on their habitat (Abboud-Abi Saab & Nader, 2005).

ECOLOGICAL CONSEQUENCES

Organic water pollution

The contamination level of 4 sites along the coast of Beirut (figure 1) was studied.

Code	Longitude (E)	Latitude (N)
JUN-40	35º 34.970’	33º 55.020’
BEY-11	35º 28.518’	33º 54.120’
BEY-12	35º 28.225’	33º 54.024’
BEY-20	35º 28.760’	33º 52.767’

Table 1. The coordinates of the 4 studied sites along the littoral of Beirut

[1] Centre National de la Recherche Scientifique du Liban/Lebanese National Council for Scientific Research

The mean values of the different physicochemical and biological characteristics (Table 2) allowed us to classify these sites as close to normal to extremely contaminate.

	TºC	Salinity	$N\text{-}NO_2^-$ µmol.L^{-1}	$N\text{-}NO_3^-$ µmol.L^{-1}	$P\text{-}PO_4^{2-}$ µmol.L^{-1}	FC[2]	FS[3]
JUN-40[a]	22.56	37.29	0.411	5.686	1.784	11599	19778
BEY-11[b]	22.39	39.21	0.099	0.486	0.200	145	182
BEY-12[c]	22.32	39.03	0.264	1.016	0.600	5141	2722
BEY-20[c]	22.52	38.90	0.319	1.498	0.874	5018	3803

[a] *sites close to normal;* [b] *sites moderately contaminated;* [c] *sites heavily contaminated*

Table 2. The mean values of the different physico-chemical and bacteriological parameters at the 4 studied sites along the littoral of Beirut

	TºC	**Salinity**	**$N\text{-}NO_3^-$ µmol.L^{-1}**	**$N\text{-}NO_2^-$ µmol.L^{-1}**	**$P\text{-}PO_4^{2-}$ µmol.L^{-1}**	**FC**	**FS**
TºC	1	0.129	-0.235*	-0.020	-0.002	-0.025*	-0.012
Salinity		1	-0.930***	-0.595***	-0.854***	-0.594***	-0.838***
$N\text{-}NO_3^-$ µmol.L^{-1}			1	0.552***	0.817***	0.594***	0.735***
$N\text{-}NO_2^-$ µmol.L^{-1}				1	0.659***	0.593***	0.535***
$P\text{-}PO_4^{2-}$ µmol.L^{-1}					1	0.751***	0.847***
FC						1	0.588***
FS							1

*P<0.05; **P<0.01; ***P<0.001

Table 3. Correlation matrix of the physicochemical and bacteriological parameters in 4 sites along the littoral of Beirut

The correlations among the different physicochemical and bacteriological parameters at the 4 studied sites (table 3) are conclusive as regards the pollution which is of organic origin. This organic pollution has a direct impact on the eutrophication of the marine environment (Abboud-Abi Saab *et al*, 2008), and also caused a disturbance on the level of meiobenthic fauna causing a fall in specific diversity and an abundance of some species of nematodes: *Rhabditis marina*, *Oncholaimus campylocercoides* (Mouawad 2005).

[2] FC = Fecal coliforms
[3] FS = Fecal streptococcus

Sediment chemical pollution

Samples of Dora sediment have high concentrations of Pb, Cd and Hg (table 4). These values, compared to other sediments in the world and to some uncontaminated Lebanese coastal sediments, reflect large anthropogenic inputs.

High Pb concentrations in the sediments of Dora were previously detected (Nassif, 2006). These high concentrations are consistent with the high Pb level in water, up to 360 $ng.L^{-1}$, measured by Nakhlé (2003), while natural concentrations in Mediterranean waters are lower than 50 $ng.L^{-1}$.

Cd concentrations are also superior to the average value of Cd in marine sediments 0.2 $\mu g.g^{-1}$ (Abi-Ghanem, 2008). These findings reflect large anthropogenic inputs mainly originating from i) the nearby enormous waste discharge, ii) thermoelectric centrals (Zouk central) which generates 1100 g Cd day^{-1} and from iv) Antelias river that receives industrial and urban waste water from Beirut and Dora and whose waters present a concentration of particulate Cd equal to 0.4-1.01 $ng.mg^{-1}$ (Nakhlé, 2003).

High HgT[4] concentrations which are typical of a contaminated environment are also expected. Samples of marine water from Dora site are especially contaminated with mercury (7-8 ng L^{-1}) (Nakhlé, 2003; Nassif, 2004). Mercury presence in Dora Bay is probably due to the nearby huge dumpsite, which is in direct contact with marine water.

Site	Pb ($\mu g.g^{-1}$)	Cd ($\mu g.g^{-1}$)	Hg ($\mu g.g^{-1}$)
Dora	70 - 101	0.6 - 0.94	0.1 - 0.5
Akkar	6.2 - 15.7	0.14 - 0.19	0.01 - 0.03

Table 4. Pb, Cd and Hg concentrations in sediments of two sites of the Lebanese coastal zone: Dora heavily contaminated by a dump site and Akkar away from direct sources of contamination (from Abi-Ghanem, 2008)

Dora polluted sediments can act as a source of trace metals that can bioaccumulate through the food chain. This trace metal behaviour was confirmed by Nakhlé (2003) who found high Pb concentrations in *Hippospongia communis* and in the mussels *Brachidontes variabilis*.

Direct consequences from littoral embanking

The most important direct consequences of the embanking of the littoral were i) the total destruction of the vermetid terraces characteristics of the Mediterranean Levantine basin which lodge a specific Lebanese fauna and flora (Abboud-Abi Saab & Nader, 2004), ii) the disappearance of sandy beaches, places of turtle nesting (Khalaf & Abboud-Abi Saab, 2005) and iii) the absence or the reduction of

[4] HgT : total mercury

several pelagic and benthic species like the herbarium *Cymodocea nodosa* or the brown algal *Stypopodium zonal* (Khalaf & Abboud-Abi Saab, 2005).

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