State of Art about water uses and wastewater management in Lebanon

Darine Geara-Matta, Régis Moilleron, Antoine El Samarani, Catherine Lorgeoux, Ghassan Chebbo

State of Art about water uses and wastewater management in Lebanon

Darine GEARA-MATTA[1]*, R. MOILLERON*, A. El SAMARANI**, C. LORGEOUX* and G. CHEBBO***

[1]* Leesu (ex-Cereve), Université Paris-Est, AgroParisTech, 6-8 avenue Blaise Pascal, Cité Descartes, Champs sur Marne, 77455 Marne la Vallée Cedex 2 (France) ; Lebanese Atomic Energy Commission, Airport Highway BP 11 82 81, Riad El-Solh1107 2260, Beyrouth (Lebanon) gearad@cereve.enpc.fr ; darinegeara@hotmail.com
* Leesu (ex-Cereve), Université Paris-Est, AgroParisTech, 61 Avenue du Général de Gaulle, 94010 Créteil Cedex (France) moilleron@cereve.enpc.fr , lorgeoux@cereve.enpc.fr
** Lebanese Atomic Energy Commission, Airport Highway BP 11 82 81, Riad El-Solh1107 2260, Beyrouth (Lebanon) ; Faculté de Sciences, Université Libanaise, Beyrouth (Lebanon) antoineelsamrani@ul.edu.lb
*** Leesu (ex-Cereve), Université Paris-Est, AgroParisTech, , 6-8 avenue Blaise Pascal, Cité Descartes, Champs sur Marne, 77455 Marne la Vallée Cedex 2 (France) ; Faculté de Génie, Université Libanaise, Beyrouth (Lebanon) chebbo@cereve.enpc.fr

Abstract

This paper shows the real situation about management of water and wastewater in Lebanon and focuses on problems related to urban water pollution released in environment. Water and wastewater infrastructures have been rebuilt since 1992. However, wastewater management still remains one of the greatest challenges facing Lebanese people, since water supply projects have been given priority over wastewater projects. As a consequence of an increased demand of water by agricultural, industrial and household sectors in the last decade, wastewater flows have been increased. In this paper, the existing wastewater treatment plants (WWTP) operating in Lebanon are presented. Most of them are small-scale community-based ones, only two large-scale plants, constructed by the government, are currently operational. Lebanese aquatic ecosystems are suffering from the deterioration of water quality because of an insufficient treatment of wastewater, which is limited mostly to pre-treatment processes. In fact, domestic and industrial effluents are mainly conducted together in the sewer pipes to the WWTP before being discharged, without adequate treatment into the rivers or directly into the Mediterranean Sea. Such discharges are threatening the coastal marine ecosystem in the Mediterranean basin.

This paper aims at giving the current state of knowledge about water uses and wastewater management in Lebanon. The main conclusion drawn from this state of art is a lack of data. In fact, the available data are limited to academic researches without being representative on a national scale.

Keywords

Water Quality, Management, Wastewater, WWTP

INTRODUCTION

Lebanon, with a total area of 10,452 km² and a coastline length of 210 km from North to South, is located along the eastern coast of the Mediterranean Sea (Figure 1). It is known as one of the countries in the Mediterranean region having abundant water resources (El-Fadel *et al.* 2000). However it is commonly accepted that the water sector in Lebanon suffers from different technical and management constraints, creating serious adverse socio-economic impacts and a depletion of water resources (El-Fadel *et al.* 2000). Lebanese people might undergo water

shortages, depending on the increase of the demand and the degradation of water resources (MoE/LEDO/ECODIT 2001).
The population was estimated to be 3.3-3.8 million inhabitants in 2000 and is projected to reach about 4.5-5.2 millions in 2015 (ESCWA 2007; Sarraf *et al.* June 2004). The annual population growth rate will be less than 1% in 2015. Lebanese population resides mostly in urban areas, especially along the coast. 59% of its population live in coastal areas, i.e. 8% of the national territory (Atlas-du-Liban 2004), with a population density of around 420 inhab/km^2 (Sarraf *et al.* June 2004). Greater Beirut hosts one third of the total population.
The climate of Lebanon is typically Mediterranean. About 90% of all precipitation are between late November and early April, i.e. the wet weather season (Sene *et al.* 1999). The coastal plain is characterized by moderate temperatures and an annual rainfall averaging between 700 and 800 mm. The mountains are cooler, and receive between 1,200 and 2,000 mm of precipitation. The Bekaa valley is the warmest and driest area; its annual rainfall ranges between 250 and 750 mm (MoE/LEDO/ECODIT 2001; ACS 2007). The warming in temperature and a drop in precipitation causes low water level in rivers during the dry season (Korfali and Davies 2003).

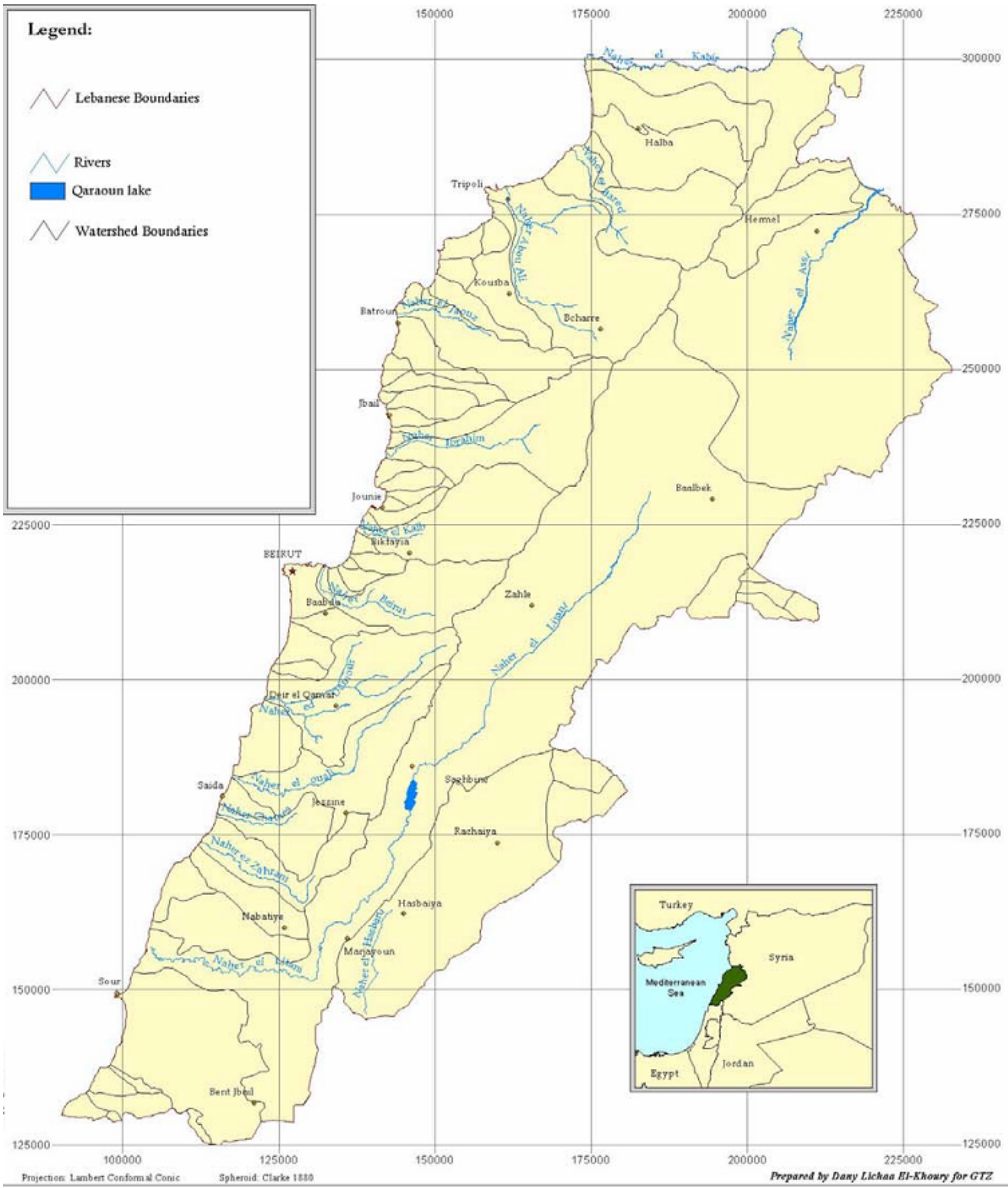

Figure 1: Major rivers and basins in Lebanon (Map no. 2.6 Source: National Center of Remote Sensing/ National Council of Scientific Research).

Several studies have been conducted to estimate the hydrological budget of Lebanon. Though results differ from study to study, as shown Table 1, it is generally accepted that approximately 50% of the average yearly precipitation is lost through evapotranspiration, additional losses to neighbouring countries (estimated at 8% by the Litani River Authority) and groundwater oozing. Despite these losses, a minimum of 2,280 Mm^3 of surface water are potentially available.

TABLE 1 : Hydrological Budget of Lebanon (Mm3/year)

Factors	Water Budget according to Mallat (1982)[a]	Water Budget according to Abdallah, C., FAO2001; Jaber, 1994[b]	Water Budget according to the Litani River Authority (MoE/LEDO/ECODIT 2001)[a]
Precipitation	+ 9,700	+ 8,600	+ 8,600
Evapotranspiration	- 5,070	- 4,300	- 4,300
Percolation to groundwater and losses to sea	- 600	- 880	- 880
Flow into neighbour country Hasbani River	- 140	- 160	- 160
Groundwater flow to Hauleh and neighbour country	---	- 150	- 150
Flow into neighbour country (Assi River)	- 415	- 415	- 415
Flow into neighbour country (Kabir River)	- 95	- 95	- 95
Allocation to Lebanon from El Assi	---	+80	---
Exploitable groundwater	---	-400	---
Net Available Surface Water	+ 3,375	+ 2,280	+ 2,600

[a] (MEDAWARE *et al.* mars 2004)
[b](MoE/LEDO/ECODIT 2001)
[b](NAPCD 2002)

Therefore, this paper aims at providing (i) an overview of national water resources and (ii) uses of water, (iii) and a focus on the water quality and the wastewater treatment. It shows that despite a relative abundance of water sources a crisis might be looming where demand for water, by agricultural, industrial and household sectors, is outstripping available supply. The paper then details the degradation of water quality affected by agriculture runoff, released of untreated industrial effluent and untreated sewage.

WATER BALANCE

National water Resources

Water resources of Lebanon are derived mainly from rainwater and snow smelting. The country is divided into two hydrologic regions: the Mediterranean region and the inland region. The first one with a surface of 5,500 km^2, gives rise to thirteen perennial rivers, flowing from East to West and ending in the Mediterranean sea .The second one of about 4,700 km^2, forming the source of the three following rivers Litani, Assi and Hasbani (Abdulrazzak and Kobeissi 2002; Amery 2003). The total length of rivers is 730 km, with an annual flow between 2,569 and 3,900 Mm^3 per year (Comair 1997; MoE/LEDO/ECODIT 2001). Some of these rivers receive industrial and domestic effluents resulting from the development of the urban (domestic and industrial) activities (CDR/LACECO 2000). With respect to the capacity of wastewater treatment in Lebanon, these effluents might have a major impact on water quality; this peculiar point will be discussed later on.

The estimates for the groundwater quantity available for exploitation range from 400 to 3,000 Mm^3/year depending on the source of information (MoE/LEDO/ECODIT 2001; ACS 2007) are based on old measurements (1960s and 1970s). The excessively high extraction rate of groundwater, to meet irrigation and industrial demand, surpassed the natural recharge rate creating serious salt water intrusion problems requiring urgent actions to prevent the over-pumping in the coastal areas (El Fadel and Sadek 2000).
For instance, the 1970 UNDP study reported that exploitable amount of groundwater might reach 3,000 Mm^3 and groundwater recharge is estimated at 600 Mm^3 (Abdulrazzak and Kobeissi 2002). Since the 1970s, the quality of data available on water resources did not improve. Consequently, they do not consider several factors including the influence of changes in land use, deforestation on aquifer recharge and surface runoff, the decrease, in spring, of river base flows and borehole yields due to irrigation, and some other water uses (Sene *et al.* 1999).

Water uses

Lebanon exploits an average of 1,000 Mm^3/year through the Establishments of Waters and 250 Mm^3/year by the private dwellings (33,410 individual wells) (ACS 2006; ACS 2007). Water demand is shared between three sectors: agricultural, industrial and household (domestic). The projected water demand depends on the reference (Table 2). In fact, many factors explain the gap between the reported figures, including the timing for establishing the assessment, the methods of calculation... Every seven to ten years, Lebanon does experience a drought, sometimes lasting for three or more years (Amery 2003). Naturally, this can lead to a decrease in stream flows; water pollution becomes more acute, due to a higher impact of effluent releases to rivers.
From 2010, the projected water demand will overcome the actual exploited water volume. This trend will become critical by 2020 when the demand increases by a factor of two (Table 2) reaching the volume of net available surface water (2600 Mm^3/year, Table1). By 2020, they will be a need to assess a solution leading to saving of water.

TABLE 1 : Estimated water consumption and projected water demand in Lebanon for 2015-2030

Year	*Domestic*	*Industry*	*Agriculture*	*Total*	*Source*
	Mm^3/an				
1990	271	65	875	1,211	(NAPCD 2002)
2007	195 – 405	36-65	670 – 875	901-1345	(ACS 2007)
2010	310	440	1,540	2,290	Environnemental Ressources Management, 1995[a]
2010	900	240	2,160	3,300	Fawwaz, 1992[a]
2010	460	445	1,000	1,905	(El-Fadel *et al.* 2000)
2015	900	240	1,700	2,840	(MoE/LEDO/ECODIT 2001)
2015	650	240	1,410	2,300	(NAPCD 2002)
2015	900	240	1,300	2,440	Jaber, 1994[a]
2015	570	519	1,200	2,286	(El-Fadel, Zeinati et al. 2000
2020	850	250	1,500	2,600	Al Hajjar, 1997[a]
2020	660	598	1,350	2,608	(El-Fadel, Zeinati et al. 2000
2025	876	693	1,500	3,069	(El-Fadel, Zeinati et al. 2000
2025	1,100	450	2,300	3,850	(Abdulrazzak and Kobeissi 2002)
2030	720	491	1,700	2,911	Amhaz et al., 1992[a]
2030	900	598	2,160	3,658	(Abdulrazzak and

				Kobeissi 2002; Amery 2003)

a. mentioned in (El Fadel and Sadek 2000)

Agriculture demand

There is a general consensus that the share of agriculture is between 60 and 70% of total water consumption and it is likely to decrease over coming years as more water is diverted for domestic and industrial consumption (MoE/LEDO/ECODIT 2001; NAPCD 2002; Amery 2003). The irrigation water mainly derives from groundwater (52%) and surface water (48%). In addition, a large number of farms use water from private well; however there are no data to support this fact.

Industrial water demand

Few data are available on the industrial water demand. The main sources of water for industrial purposes are groundwater and pumping directly in rivers. In 1996, it was estimated that 71.4% of all industrial water used in the country derived from underground sources (Amery 2003), while surface water was used to cooling and food processing (Abdulrazzak and Kobeissi 2002). Most industries, besides receiving water through the public water distribution system, are equipped with private and unmonitored water wells from which they tap underground water at liberty. A large number of industrial establishments (82%) are located outside industrial zones. In addition, the existing industrial zones are poorly equipped to collect and/or treat industrial wastewater. Such infrastructure is completely lacking outside industrial zones. Several industrial zones have been established and made official by decree afterwards, although they are located near residential areas or natural sites, creating serious hazards to public health and to the environment (LDK-ECO 2006). In the absence of special facilities and services devoted to industrial pollution management, industrial wastewater (about 12% of total wastewater: urban and industrial) is discharged into the urban sewage system without treatment (MoE/LEDO/ECODIT 2001; MEDAWARE *et al.* mars 2004). It is difficult to estimate the total pollutant load discharged into waterways by the industrial sector due to the lack of data concerning both the quantity and the quality of effluent. Based on industry employment statistics, it was estimated that the industrial sector will generate about 200,000 m^3 of wastewater per day in 2020 (MoE/LEDO/ECODIT 2001).

Household water demand

The household water demand consists of human water consumption, administrative and public buildings water needs. To meet that demand, water is drawn from the flow of major rivers, springs, and groundwater sources (MoE/LEDO/ECODIT 2001; Abdulrazzak and Kobeissi 2002). The demand is influenced by the community size, standards of living, social habits, and system pressure (Abdulrazzak and Kobeissi 2002). The figures used nowadays to estimate current level of domestic water supply are based on inquiries from 1950-1960, while the last official census was realized in 1932 (MoE/LEDO/ECODIT 2001; Makdisi 2007). Several sources, as shown Table 3, indicate that the domestic water supplied was 165 L per capita in the mid-1990s and is expected to be between 190 (Abdulrazzak and Kobeissi 2002) and 215 L by 2000 and to reach 260 L by 2015 (Jaber 1997) and 300 L by 2025 (Abdulrazzak and Kobeissi 2002).

TABLE 2: Predicted maximum population, water supply and wastewater for Lebanon

Year	Population		Water supply		Wastewater flow	DBO
	Million	Reference	L/c/d	Reference	Mm^3	Tons
2000	3,3 - 3,8	(ESCWA 2007; Sarraf *et al.* June 2004)	190 - 215	(Abdulrazzak and Kobeissi 2002)	227 - 298	------

2001	4,3	(MoE/LEDO/ECODIT 2001)	160	(MoE/LEDO/ECODIT 2001)	249	99,600
2015	4,5 - 5,2	(ESCWA 2007; Sarraf *et al.* June 2004)	260	(Jaber 1997)	426 - 493	-----

The actual target capacity, reflecting significant improvements that have been achieved in the water supply sector since 1995, is estimated to be 160 L/c/d and is presumably much lower, perhaps as low as 64 L/c/d in some areas, due to losses of the large share of water in public distribution systems through system leakages, estimated at 40% in 1984 and assumed to fall to 30% by the year 2000 and 20% by the year 2010, and the presence of most unlicensed and not monitored private wells which ends up in the sewage flow (MoE/LEDO/ECODIT 2001; Yamout and El-Fadel 2005; MEDAWARE *et al.* mars 2004). The delivery rates may vary from 100 (for Baalbeck and Qoubayat) to 200 L/c/d (for Beirut and Kesrouane).

The percentage of buildings connected to water supply networks varies according to the references. Between 76.5% and 79% of buildings were connected to water supply networks in 1996-1997 and only 60% can access to fresh water (CDR 2005; ACS 2006; Makdisi 2007; MEDAWARE *et al.* mars 2004). The remaining people purchase bottled water (31.5%) and tap private sources (8.3%), which can be of poor quality (CDR 2005; ACS 2006; Makdisi 2007; MEDAWARE *et al.* mars 2004). The highest rates of connection were recorded in urban areas such as Beirut and Kesrouan (93 and 94%, respectively), while the lowest were in the rural areas like Hermel and Akkar (41 and 49%, respectively).

Domestic wastewater flow is directly related to water supply and consumption. Since both the networks of production and distribution are inadequate and irregular, the data of the flow of wastewater generated remains inacurate since the average water supply delivery rate (detailed above), which is approximately 160 liters per capita per day (l/c/d), is influenced by additionally water supplied from private water wells and ultimately ends up in the sewage flow (MoE/LEDO/ECODIT 2001). Besides, the accelerated rate of urbanism does not matched with an adequate construction of sewer networks, and the average wastewater generation rate fluctuate with location and season (CDR/LACECO 2000). Based on the estimated population projection and water demand data for 2015, the approximate amount of untreated wastewater is evaluated at 493 Mm^3 per year, the same amount was evaluated at up to 227 Mm^3 in 2000, generated from urban water consumptions. Significant amounts of this untreated wastewater may percolate to the shallow groundwater from cesspools especially in the inland villages (Abdulrazzak and Kobeissi 2002; Amery 2003) . The BOD load has been evaluated in 2001. Assuming a BOD concentration of 400 mg/L in raw sewage, the yearly outflow results in a BOD load of 99,690 tonnes (MoE/LEDO/ECODIT 2001).

However, this concentration is twice the average in France for the same year (IFEN, French database on wastewater treatment available on www.ifen.fr); in fact the BOD concentration in 2001 was 200 mg/L for an average water supply delivery rate of 258 L/c/d.

The problem caused by the irregular fresh water supply and the outbreaks of waterborne illnesses due to the break of sewer lines are especially pronounced during the summer, so the country has to restore and expand its infrastructure of wastewater management.

WATER QUALITY

Water quality in Lebanon is influenced by various anthropogenic factors including agriculture, and domestic and industrial wastewater discharges (Saad *et al.* 2000; Khalaf *et al.* 2007). With a thermal mapping, (Faour *et al.* 2004) have identified 49 major sources of pollution of the marine environment of Lebanon based on discrimination between the thermal temperatures of sea water and polluted water. Most are related to uncontrolled human activities such as sewage outfalls, refineries and factories. Currently, 53 outfalls (very closed to coast) are identified along the Lebanese coast, of which 16 are located between Dbayeh (north of Beirut) and Ghadir (South

Beirut) (CDR/LACECO 2000). However, they are not characterized in terms of length, size, flow, etc. The urban and agricultural pollution affected large parts of the rivers in Lebanon and led to eutrophication of surface water (Saad *et al.* 2003)

The excessive use of fertilizers especially in areas of intensive agriculture practices has lead to nitrate leaching in high levels and impinged the groundwater quality mainly in the coastal plain (Saad *et al.* 2003). A report demonstrates a clear connection between groundwater pollution and drinking water quality (MoE/CDR/MVM 2000). The nitrate concentration reach a high level at Nahr Ibrahim River (2-5 mg/L) (Saad *et al.* 2003). In addition, 7.3 mg/L ((El-Fadel *et al.* 2000) and 7.1 mg/L (Houri and El Jeblawi 2007) of nitrate are identified in the major rivers of Lebanon and could be attributed to increasing agricultural fertilizing activities especially between July and August. Moreover, a study on the river Berdawni identified the presence in significant amounts of hydrocarbon compounds and chlorinated organic substances including alkyl naphthalene showing the presence of pesticide residues (MoE/CDR/MVM 2000).

The industrial pollution takes place through surface and subsurface release of untreated effluent wastes contenting heavy metals and organic liquid effluents infiltrating through the fractured bedrocks into the groundwater system (Abdulrazzak and Kobeissi 2002). Limited information on the chemical quality of Lebanese waters have been collected and published. Some studies identify the impact of industries on Lebanese river quality. (Saad *et al.* 2004) assessed the impact of industrial effluent during the summer period on Nahr Antelias River and identified that increases in major ion, especially sulphate (17.8 mg/L), were mainly due to anthropogenic activities. According to (Korfali and Davies 2003), the increase in water concentration of Fe (3200 µg/L), Mn (17 µg/L), Zn (700 µg/L) and Pb (40 µg/L) at Nahr Ibrahim River was expected to be from the excessive industrial discharge from the industrial zone (galvanization, steel works, electroplating, battery factory, paint, and furniture and PVC factories). Moreover, (Nakhlé 2003) notes that the concentration of dissolved Pb reach a high value of 165 ng/L from samples peaked at Antelias River due to the presence of several discharges of sewage and industrial effluents in the catchment of the river. In addition, the concentration of particulate Pb, in this river, was very high and comparable to the most contaminated rivers such as Seine River (285 mg/kg) and Danube River (142 mg/kg) (Nakhlé 2003). According to (El-Fadel *et al.* 2000), the coastal waters, from Tyre to Akkar, are contaminated by industrial wastewater discharges as they found high concentrations of Ni (max 41 µg/L), Cu (max 33 µg/L), Cr (max 160 µg/L), especially near the industrial complex of Dora (six tanneries), and As (max 48 µg/L) at several locations.

Domestic wastewater in Lebanon is being discharged into the Mediterranean Sea as well as into the river system without treatment. As a result the coastal waters, inner rivers and drinking water sources are contaminated with bacteria indicating a great harm to the environment leading to potential public health related hazards. All perennial Lebanese coastal rivers were found to be clearly polluted with faecal coliform indicating significant raw wastewater input (Houri and El Jeblawi 2007). Two studies assessing the water quality in the major rivers in Lebanon (El-Fadel *et al.* 2000; Houri and El Jeblawi 2007) showed that water samples presented very high concentrations of BOD5 (69.7-79 mg/L for (El-Fadel, Zeinati et al. 2000) 12.8-62.8 mg/L for (Houri and El Jeblawi 2007). The fecal and total coliform concentrations indicate that domestic wastewaters are discharged into water bodies without treatment. Moreover, total coliform and Escherichia coli were observed in 44% of well samples in Ras Beyrouth, a coastal vital sector of Beirut City with 80,000 citizens. This is the consequence of either wastewater intrusion and/or leaks from sewer pipes. In fact, the sewer pipes in old buildings are above the drinking water pipes (Korfali and Jurdi 2007). Consequently, 60 to 70% of natural sources are contaminated by chemicals and germs. This contamination increases by 10% during the dry season (MoE/LEDO/ECODIT 2001). Moreover, raw wastewater is being reused for irrigation in several regions of Lebanon such as in Akkar and Bekaa (Ras El Ain, Zahleh) (MEDAWARE *et al.* mars 2004). In fact, in the Bekaa region some of the sewers are purposely blocked to allow sewage to be diverted for irrigation (CDR/LACECO 2000). Based on data from a Ministry of Health report

(1996), (Sarraf *et al.* June 2004) estimated that about 260 children die (10 percent of all child deaths) every year in Lebanon from diarrheal diseases associated with inadequate drinking water, sanitation and poor hygiene conditions.

WASTEWATER MANAGEMENT

According to the census of buildings and establishments of 1998 conducted by the Central Administration of Statistics (ACS), less than 60% of the buildings have access to public sanitation. Beirut has the highest rate of connections to the sewage network (98.3%), followed by the suburbs of Beirut (89.3%) and by the North (53.5%), South (42.1%) and Bekaa (41.1%) regions, while Mount Lebanon has the lowest (33.9%). The remaining areas use septic tanks or drain wastewater in wells (MoE/LEDO/ECODIT 2001; Makdisi 2007; MEDAWARE *et al.* mars 2004). Municipal wastewater management in Lebanon has been absent during many years. Because of civil war, the existing treatment plants were destroyed and/or made inoperative. Untreated wastewaters were directly dumped into rivers, irrigation channels, valleys, and ravines as well as into septic systems. Nowadays, the government through its ministries (Energy and Water, Interior and CDR) is working on the construction of wastewater treatment plants. These plants must be designed for the treatment of forthcoming wastewater flows and the quality, these latter being directly proportional to water consumption. In this regard, a national balance of water is helpful to some extent in order to provide monitoring data on population and on average water consumption per capita (El Fadel and Sadek 2000). Moreover, the design of wastewater collection, treatment and disposal must take into account the flow and the quality of wastewater from domestic and commercial activities as the number of industries existing in Lebanon is limited (MoE/LEDO/ECODIT 2001; MEDAWARE *et al.* mars 2004). The industrial wastewater management is ineffective in most areas and the phenomenon is exacerbated by the absence of effective auditing. In fact, illegal dumping into sewage might occur and then the wastewater from industry will be drain to the treatment plants planned for commercial and domestic wastewater (CDR/LACECO 2000). However, 96% of the industrial stream, except the tanneries, is non-hazardous and 66 % could be treated as domestic waste; whereas the remaining should require some pre-treatment before discharge into domestic sewer networks (CDR/LACECO 2000).
So far, Lebanon has thirty-one wastewater treatment plants that are producing around 16,000 m^3/day and are achieving secondary wastewater treatment with a specific objective, the reuse of treated wastewater stream for irrigation. (MEDAWARE *et al.* mars 2004) They are comprised of small community-based plants (MEDAWARE *et al.* mars 2004). Effluent quality from these plants does not satisfy the national standards for discharge into surface or sea water (MEDAWARE, Ayoub et al. mars 2004). Therefore their reuse for irrigation practices is highly undesirable. In addition, they generate relatively small quantities of effluent which fluctuate depending on seasons. Furthermore, the cost of transport of the effluent to the areas to be irrigated is unaffordable. Only two plants, in a very limited extend, have their effluent used for irrigation. The first one located in Jabboule (a village in the Bekaa Mohafaza region) was designed in 1998 to provide a wastewater treatment capacity of 90m^3/d for a population of 600 people, and was planified to run till 2020. It receives only domestic wastewaters since there is no industry on the watershed (Hidalgo and Irusta 2004; MEDAWARE *et al.* mars 2004). The second one, Hasbaya plant, is operational since 2002 with a wastewater treatment capacity of 240 m^3/d (Hidalgo and Irusta 2004). Unknown portions of the treated wastewater are used for irrigating trees grown around the perimeter of the plant in order to improve landscape conditions.

Two large-scale wastewater treatment plants, the Ghadir pre-treatment plant and the Tripoli secondary treatment plant, are currently operational. The first one primarily serves the southern suburbs of Beirut and its surroundings; it receives also influents from sewage trucks from areas not connected to the station. The quantity of wastewater at the entrance of the station is

equivalent to 100 tanks of a total capacity of about 2,000 m^3/d. This plant currently operates at its half–capacity (46,000 m^3/d). The planned connected population to this plant should be about 800,000 inhabitants. The El-Ghadir plant was the first in operation in Lebanon. After preliminary treatment, the concentrations of pollutants in the effluent discharged into the sea do not match with Lebanese standards of discharge of sewage into the sea. In fact, the level of COD, BOD5, TSS, ammonia and organic phosphorus are 559, 257, 353, 115 and 38 mg /L, respectively. The concentrations after treatment should be 125 mg/L for COD, 25 mg/L for BOD5, 60 mg/L for TSS, 10 mg/L for ammonia and 5 mg/L for organic phosphorus. However, the preliminary treatment of this station reduced by 25% COD and TSS (Deghali 2006). The high concentrations of nitrogen and phosphorus underline the fact that the influent received by El Ghadir plant does not derive only from domestic origins (Deghali 2006). The Ghadir outfall is a 1,200-mm diameter submersed pipeline which extends 2.6 km into the Mediterranean Sea. The outlet point is approximately 60 meters deep thereby achieving some dilution of the disposed wastewater. The secondary Tripoli plant became functional this year (2009). It outfall should reject to the sea treated water with the highest cleaning requirements (BOD5 <25 mg / L, TSS <35 mg / L and H_2S <0.1 ppm) with a daily average flow of 135,000 m^3/d (CDR 2005).
Thirty-three wastewater treatment plants, coastal and inland, presented in Table 4 are currently planned or under construction (according to CDR Karam, personal communication). With the construction of the twelve wastewater treatment plant located along the coast, Abdeh, Tripoli, Chekka, Batroun, Jbeil, Kesrouan, Dora (Beirut North) Ghadir (South Beirut), Chouf (coastal zone), Saida, Tire, population in and around major urban centres should be connected to sewer network and 65% of the wastewater problem in Lebanon should be resolved by 2020. Apart from the coastal stations, twenty-one plants are proposed to be built in the inland. These plants will be located near major cities such as Zahle, Baalbek and Nabatiyah. The achievement of the construction of the major large-scale treatment plants should allow the treatment of around 80 % of wastewaters by 2020, i.e., around 1 million m^3/day of treated wastewater (MEDAWARE *et al.* mars 2004). The remaining 20% should require the construction of about 100 small wastewater treatment plants (MEDAWARE *et al.* mars 2004).

TABLE 3: Current situation of planned secondary wastewater treatment plant in Lebanon

Zone	*Caza*	Location	*Implementation Status*		
			Under Execution	Under Preparation	No funding secured
Costal	Akkar	Abdeh		X	
Inland		Michmich		X	
Inland	Minieh-Dinnieh	Bakhoun		X	
Costal	Tripoli	Tripoli	X		
Inland	Becharre	Becharre		X	
Inland		Hasroun			X
Inland	Koura	Amioun		X	
Costal		Chikka	X		
Costal	Batroun	Batroun	X		
Costal	Jbeil	Jbeil	X		
Inland		Kartaba		X	
Inland	Kesrouane	Harajel		X	
Costal		Kesrouane/Tabarja			X
Costal	Metn	Dora			X
Inland		Khanchara		X	
Costal	Beabda	Ghadir*			X

Costal	Chouf	Chouf (Abi younes)	X		
Costal	South	Saida	X		
Costal		Sour		X	
Inland	Hermel	Hermel		X	
Inland	Baalbeck	Laboue		X	
Inland		Yammouneh	X		
Inland		Baalbeck	X		
Inland	Zahle	Zahle	X		
Inland		Aanjar		X	
Inland	Bekaa (Ouest)	Jib Jinnine/Deir Tahnich	X		
Inland		Karoun	X (no realised by CDR)		
Inland		Sohmor/Yohmor		X	
Inland	Hasbaya	Hasbaya		X	
Inland	Nabatiyeh	Jbaa		X	
Inland		Nabatiyeh	X		
Inland	Bint Jbeil	Shakra		X	
Inland		Bint Jbeil		X	

* limited to preliminary treatment and its expansion to secondary is yet unknown

Source: CDR, 2008

CONCLUSION

The water sector in Lebanon suffers from a lack of infrastructure. Wastewater from urban area is mostly being discharged, without adequate treatment or monitoring into the river system or directly into the Mediterranean Sea, creating a potential public health and raising a serious geo-environmental problem that might affect the coastal shoreline of the eastern Mediterranean Sea, threatening the coastal marine ecosystems. Moreover, the efficiencies of the operating plants, which are in majority small-scale community-based wastewater treatment plants except the two large-scale in Ghadir (preliminary treatment) and in Tripoli (secondary treatment), are not adequate to comply with the Lebanese standards for treated wastewater.

Little information on the wastewater quality in Lebanon is available and in most case they derive from academic researches without being representative on a national scale. As a consequence, an urgent need for both evaluating the quality of wastewater and controlling its release to the Mediterranean Sea is emphasized. That’s why; a screening of wastewater of sewage collectors located along the Lebanese coast should be monitored. A project aims to establish a database, not yet existing, on the wastewater quality in Lebanon is in progress. This project should serve as a reference point to assess the efficiency of planned wastewater treatment plants and provide the best technical alternatives to the future construction of WWTP in Lebanon. It would also enable the estimation of the flow of pollutants towards the Mediterranean Sea. Moreover, it would allow a comparison between the levels of pollutants measured in Lebanon to those observed in France, linking them to regulation in both countries. The monitored parameters would include general water quality parameters, metals and emerging pollutants, such as triclosan and parabens, known as endocrine disruptors. Meanwhile, the efficiency of wastewater treatment plants currently in operation will be established.

REFERENCES

- Abdulrazzak, M. and L. Kobeissi (2002). UNDP-ESCWA Initiative on National Framework for Water Resources Management in Lebanon UN. UN- House-Beirut, Lebanon.

- ACS (2006). Compendium Statistique National sur les Statistiques de l'Environnement Au Liban 2006. L. République Libanaise Présidence de Conseil des Ministres. Beyrouth.
- ACS (2007). "Compendium Statistique National sur les Statistiques de l'Environnement Au Liban 2007, République Libanaise Présidence de Conseil des Ministres, Beyrouth, Liban.".
- Amery, H. A. (2003) "Assessing Lebanon's Water Balance." The International Developpment Research Centre (Workshop) Volume, DOI:
- Atlas-du-Liban (2004). Atlas du Liban : Patrimoine Bati et Paysager, Occupation du sol, Densités, Equipement, Eau, Consommation d'espace, Domaines Agricoles et Naturels, Risques, Ammenagement du territoire, Defis, Problématique, Vacation des sols, Organisation du Territoire, Administration, Données Physiques, Déménagement, Logement, Emploi, Infrastructure. C. e. c. a. l. D. G. d. l'urbanisme.
- CDR (2005). Council for Development and Reconstruction 15-Year Maste Plan URL: http://www.cdr.gov.lb/2005/english/Ewater.pd.
- CDR/LACECO (2000). Coastal pollution and water supply project: preparation of an environmental monitoring plan, Council for Development and Reconstruction.
- Comair, F. (1997). "Water map of Lebanon. Seminary on water and waste water management in industry." 19 p.
- Deghali, A. (2006). Etude de l'impact des rejets de la station de traitement des eaux usées de Ghadir sur l'environnement marin FACULTÉ D'AGRONOMIE-UL, Université Libanaise, Beyrouth. Master en Sciences et Technologies de l'Environnement : Génie de l'Environnement 122.
- El-Fadel, M., R. Khoury, A. Abou Ibrahim, M. Zeinati, H. Sbayti and E. Bou Zeid (2000). Preliminary Characterization of Lebanese Coastal Waters. Analysis conducted at Water Resource Center (AUB). R. s. t. U. S. A. f. I. D. (USAID).
- El-Fadel, M., M. Zeinati and D. Jamali (2000). "Water resources in Lebanon: Characterization, Water Balance, and Constraints " J. of Water Res. Devel. 16 619-642.
- El Fadel, M. and S. Sadek (2000). "Wastewater Management along the Mediterranneen Coast : A treatement Application Decision Case Study " J. of Nat. Res. Life Sci. Educ. 29: 116-124.
- ESCWA (2007). ESCWA Water Development - Report 2- State of Water Resources in the ESCWA Region. U. Nation. New York: 68.
- Faour, G., A. Shaban and J. J. (2004). "Apport de la bande infrarouge thermique du capteur ETM+ de Landsat-7 dans la détection de la pollution de l'eau de mer sur le littoral libanais." Télédétection 4 (2): 197-209.
- Hidalgo, D. and R. Irusta (2004). The cost of wastewater reclamation and reuse in agricultur production in the Mediterraneen countries. Envionmental Division, Cartif, Parque Technologico de Boecillo, 205. Valladoid 47151, Spain.
- Houri, A. and W. S. El Jeblawi (2007). "Water quality assessment of Lebanese coastal rivers during dry season and pollution load into the Mediterranean Sea." Water and Health 5(4): 615-623.
- Jaber, B. (1997). Water in Lebanon: problems and solutions. . Public lecture given in the Department of Hydrology, Purdue University, Lafeyette, IN, USA, Apr 1997.
- Khalaf, G., K. Slim, Z. Saad and K. Nakhle (2007). "Evaluation de la qualité biologique des eaux de Nahr el Jaouz (Liban) : application des méthodes indicielles." Bull. Mens. Soc. Linn. Lyon 76: 255-268.
- Korfali, S. and M. Jurdi (2007). "Assessment of domestic water quality: case study, Beirut, Lebanon." Environmental Monitoring and Assessment 135(1): 241-251.
- Korfali, S. I. and B. E. Davies (2003). " A comparison of metals in sediments and water in the river Nahr Ibrahim, Lebanon " Environmental Geochemistry and Health . 25(41-50).
- LDK-ECO (2006). Soutien à la DG Environnement pour la mise au point de l'Initiative de Dépollution de la Méditerranée « Horizon 2020 ». C. E. C. N. 070201/2006/436133/MAR/E3.
- Makdisi, K. (2007). "Towards a Human Rights Approach to water in Lebanon : Implementation beyond Reform " Water Resources Developmnent 23(2): 369-390.
- MEDAWARE, G. M. Ayoub, M. El Fadel, L. Naamani, R. Fayyad and L. Abi Esber (mars 2004). MEDAWARE E. C. E.-M. PARTNERSHIP.

- MoE/CDR/MVM (2000). Ministry of Environment and Council for development and Reconstruction. Enviromental Master plan for Litani River and Lake Qaraoun Catchment area. Prepared by MVM Consult AB.
- MoE/LEDO/ECODIT (2001). "Lebanon state of the environment report. ." Prepared by ECODIT,: 246pp + Appendixes.
- Nakhlé, M. (2003). Le mercure, le cadmium et le plomb dans les eaux littorales libanaises : Apports et suivi au moyen de bioindicateurs quantitatifs (Eponges, Bivalves et Gastéropodes). These Interactions Toxiques dans les Ecosystemes, Université Paris 7: 255.
- NAPCD (2002). National Action Programme to Combat Desertification - Chapter Two Environmental Status in Lebanon Part I: Natural Factors Available at www.moe.gov.lb/pdf/.../National%20Action%20Plan%20to%20Combat%20Desertifi... Ministry of Agriculture - National Council for Scientific Research - Center for Public Sector Projects and Studies (C.P.S.P.S)
- Saad, Z., V. Kazpard, K. Slim and P. Nabhan (2003). "Natural and anthropogenic influence on the quality of Ibrahim River Water Lebanon. ." Journal Européenne d'Hydrologie 4: 85-100.
- Saad, Z., K. Slim, G. Khalaf and O. El Samad (2004). "Impact des rejets des eaux résiduaires sur la qualité physico-chimique et algologique du Naher Antelias." Bulletin de la société Neuchâteloise des sciences naturelles 127: 69-82.
- Saad, Z., K. Slim, M. Nasreddine and Z. Kattan (2000). "Chemical composition of rain water in Lebanon." Journal Européenne d'Hydrologie 31(2): 105-120.
- Sarraf, M., B. Larsen and M. Owaygen (June 2004). Cost of Environmental Degradation - The Case of Lebanon and Tunisia. T. W. B. E. Department. Washington, D.C. 20433, U.S.A.
- Sene, K. J., T. J. Marsh and A. Hachache (1999). "An assessment of the difficulties in quantifying the surface water resources of Lebanon." Hydrol. Sci. J. 44(1): 79-96.
- Yamout, G. and M. El-Fadel (2005). "An Optimization Approach for Multi-Sectoral Water Supply Management in the Greater Beirut Area." Water Resources Management 19(6): 791-812.

WWW_YES-Geara-Paper-Edited-2010-04-08.doc