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Evaluation of the Physicochemical Characteristics of Water in the Lower Litani Basin, Lebanon

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ABSTRACT

The physicochemical characteristics of water in the Lower Litani River Basin (LLRB) were evaluated. It concerns with analyzing six representatives sites which are investigated over three seasons of the year 2011. The *principal component analysis* (PCA) method was used to interpret the elemental concentrations in the river water. Many variables were evaluated, especially the components or metals Fe, NO_2^-, $CaCO_3$, Cu. Three groups were identified and differentiated by PCA according to the seasons. The first group is rich in Fe and NO_2, and low in NH_4 and EC (in the mid rainy season). The second group formed in dry season and the third group with low concentration of K^+, PO_4^{3-} and Cl^- (in mid rainy). However, no critical pollution has been reported in this part of the river; except the high concentration of Fe and NO_2^- in all investigated sites due to the reject of wastewater and touristic activities.

Introduction

Globally, demands for freshwater resources are increasingly developed due to population growth, and thus in the increased per capita, which is influenced also by industrial, tourist and agricultural activities, as well as due to the large chaotic settlements built along watercourses. This is accompanied with poor maintenance of the municipal sewage disposal system (Hao *et al.* 2008). Rivers are the most important surface water resources used for different human domestic, agricultural and industrial purposes. Hence, it is important to have reliable information on trends of water quality for effective water management approaches (Hajar 2008).

Water resources in Lebanon are limited and even being decreased lately. The whole region, including Lebanon is witnessing a drastic change in climate that has led to significant drought over the past three years. In addition, water quality deterioration has reduced the effective availability of fresh water for drinking as well as for irrigation. (USAIDS 2005, Haddad 2001).

The Litani Basin has an area of 2.186 km^2 extends between the geographic coordinates: latitude 33°50´–34°50´ N and longitude 35°15´–36°25´ E and has an annual average discharge of about 700 millions m^3/year (Abd EL-Al 1953). According to this study, the average discharge of the LBL during the year's 2011 is 164.946 m3/year, Figure 1 shows the monthly discharges of the three selected station in LLBR, The high levels of discharges in this year is observed from February till May, while a low discharge is present from September to August. For that we can conclude that during the mid rainy season, we have decreasing in the concentration of pollutant and this is confirmed with the result of the data.

It also shows a January discharge lower than that of the average year despite having a peak monthly discharge twice that of the average water year (Figure 1).

The average annual precipitation on the LLRB ranges between 800 mm and 1200mm (ONL 2012). The evaporation coefficient is estimated to reach 68.2% due to the dry nature of the climate in southern Bekaa region (Nimah et al. 1999).

The Litani River Basin (LRB) can is divided into two major hydrologic units. These are the upper and lower units which are separated by the artificial lake of Qaraoun (Amery 1993; FAO1994; Hamed et al. 2008). The Qaraoun dam has been constructed in 1956, with a 110m long and 61m height (Jurdi et al. 2001), and thus forming the Qaraoun Lake (Figure 2).

The investigated area in this study is the LLRB, extends from the Qaraoun Lake, downstream to the Qasmieh outlet at the Mediterranean Sea, and thus compassing has a total surface area of 616 km^2. The Litani River altitude gradually decreases from 300 to 50 m, until it reaches the sea outlet. Three principal geological formations exist in the area of study, with carbonate rocks as the major lithological component. They are attributed to the Jurassic, Cretaceous, and Eocene ages (Beydoun 1972, Beydoun 1988, BouKheir et al. 2006).

There are 23 surveyed major springs in LLRB. Some of these springs do not belong to the Litani Basin, but they contribute significantly to the river water; especially in the region of Khardale, and at Qasmieh. Monitoring discharge data related to such contribution is not available (Khoury et al. 2008).

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The demographic change in the area of the LLRB is characterized by an abrupt decrease in population size from year 1980 until year 1994 because of the political conflicts that have prevailed during this period (Doumar et al. 2008). Now the Lower Litani River Basin (LLRB) encompasses eight district or administrative caza (Bekaa West, Marjeyoun, Nabatieh, Saida, Tyre, Jezzine, Hasbaya, and Bent Jbail) hosting a population of about 133,000 capita living in 104 communities (Statistics 2005, Raad 2004).

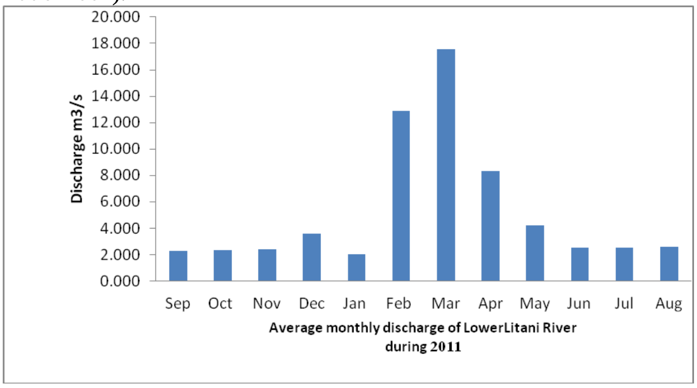

Fig. 1 - Average monthly discharge of lower litany river during 2011

Accordingly, water for agriculture occupies the most amount of consumed water and estimated at 65-70% of the total water use. The agricultural activities are not equally developed all along the LLRB. The Bekaa plain, as the flat terrain of the LLRB and with fertile soil, is considered as the most important irrigated areas of the LLRB. The crops consist mainly of banana and citrus found at the coastal stretches from both sides of the Litani River, in addition to olive trees, fruit trees, vineyards, and protected agriculture existing in the Inner LLRB (Khoury et al., 2006).

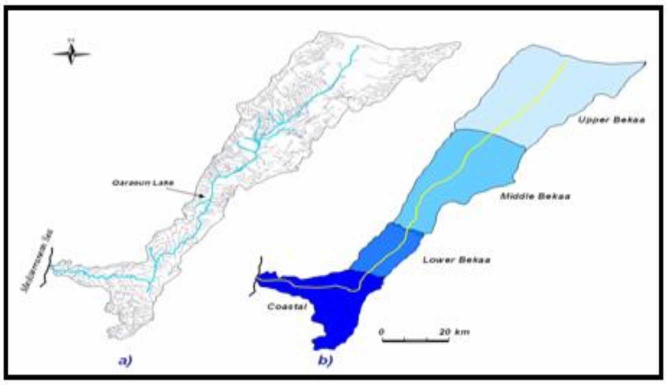

Fig.2 - map of the Litani River Basin *(a)* and its sub-units map *(b)*

According to the Litani River Autority (LRA), the lower part of the Litani River is used to supply an irrigation open canal for agriculture use (the so-called El-Qasmieh Canal) with a capacity of about 26 Mm^3 of water for the areas located along the coast, in the neighborhood of the outlet of Qasmieh. Domestic consumption ranged from 2000 and 4000 m^3/day (FAO 1970).

There are currently 1281 subscribers to the Qasmieh water conveyor, which is providing water for an area of 3,220 hectares of citrus and banana. Additionally, a volume of 13.5 Mm^3 of water is provided from the Qaraoun Lake, which is located outside the area of study to fulfill the water shortage existing in the summer.

Many others activities occur in the LLRB such as: Progressive urbanization (metals such as Fe, Zn, Cu, Pb, bacteria), Tourist pollution (bacterial, metals: Pb, Fe, …). The study area shows us that there is no major infrastructure on the Litani River Lower Basin. All the pollutants and wastes are directly rejected into the river without any treatment near the selected sites.

Materials and Methods

The study area

This study covers the LLRB and it targets to monitor the seasonal variations in water quality at the selected six sites (figure 3 and table 1). These sites are described as: S1 (Qelia), S2(Kardali), S3 (Kakaeyat aljisr), S4 (Tair Flsaiy), S5 (Abou Abdellah), S6 (Qasmieh).

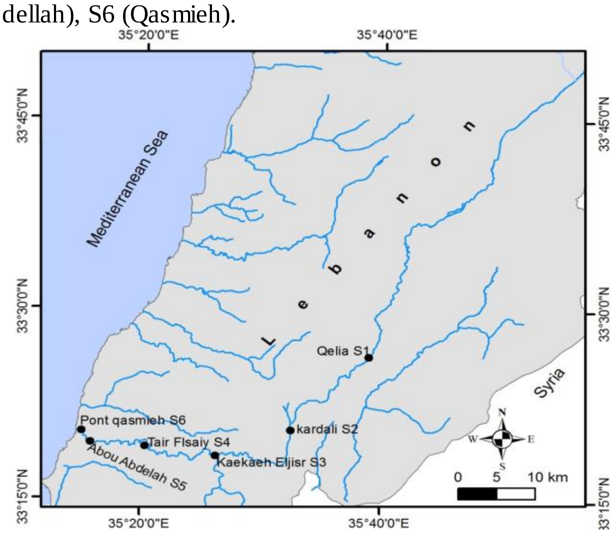

Fig. 3 - The study area of the Lower Litani River Basin

Sample and data collection

Eighteen water samples were collected in a 1-l polyethylene bottles soaked overnight with 10% (v/v) nitric acid was used for water sampling collection. Water samples (300 ml) were also collected in borosilicate glass bottles for bacteriological analysis. The samples were filtered through Wathman Millipore of 45mm. Each sample was divided into two small bottles. The method of sampling and collection are in accordance with Standard Methods APHA, AWWA, WPCF (1992). The samples were transported to the laboratory in portable coolers. Thus, temperature, pH, Eectrical Conductivity and Total Dissolve Solid were estimated directly at the sampling sites. While the other nutrients parameters were measured in the laboratory.

Water samples collection was conducted thrice during 2011 in the rainy season (February), the early rainy season (May) and the dry season (September). This is performed in accordance with standard methods followed by (WHO 2006).

Samples were analyzed for water quality indicators including: temperature (T), pH, total dissolved solids (TDS), conductivity (EC), bio-chemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate (NO_3^-), nitrite (NO_2^-), phosphates (PO_4^{3-}), sulfates (SO_4^{2-}), potassium (K^+) , sodium (Na^+) and calcium carbonate ($CaCO_3$) .

Since concentrations of nearly all metals determined during the sampling year including (Cr, Cu, Ni, Fe, Cd, Mg, Mn ,Al ,Ba, Zn ,PO_4^{3-}), thus they were analyzed by Atomic Absorption.

Physico-chemical analysis

In-situ analytical methods

Parameters sensitive to environmental changes were measured *in-situ*. A field digital pH meter (Model no. HI 98129, HANNA instruments) was used to measure both pH and temperature of water at <1.0 m depth. Electrical conductivity (EC) was measured using a digital EC/TDS meter (Model no. HI 98129, HANNA instruments,).

Experimental analysis

The following steps were applied in the laboratory analysis:

-Alkalinity, as calcium carbonates $CaCO_3$, was determined by phenolphthalein method (ISO 7980:1986).

-IRI spectrophotometer Method EPA 352.1, was used to measure Nitrate. Nitrites was determined by EPA 354.1; and the total Phosphates (ISO 6878:2004), the Sulfate was determined by AOAC 973.57.

The Analytical methods used for monitoring parameters were:

- Aluminum, Barium, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Sodium, Potassium, Nickel, Zinc were investigated by Atomic Absorption Spectrophotometric method, (Spectrophotometer (RAYLEICH –MFX-210) with an air/acetylene flame and background correction and a deuterium lamp to remove solid impurities before testing (AOAC 974.27).

-Arsenic, Selenium Mercury was determined by Hydride generator Mercury vaporizer unit.

-The biochemical oxygen demand was analyzed within 5 days after sampling, BOD_5 as oxygen (EPA 405.1) and the chemical oxygen demand, as oxygen (ISO 6060:1989).

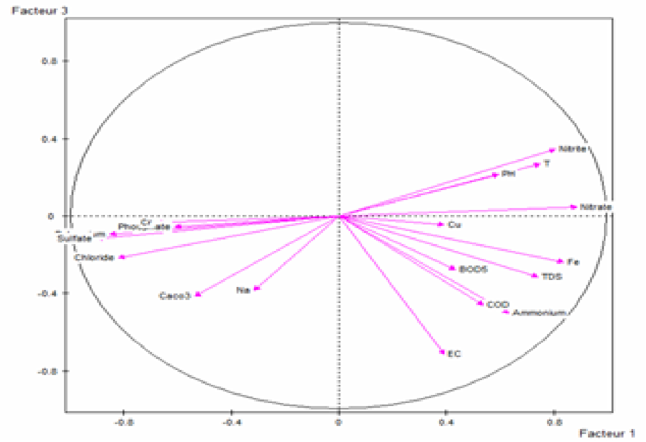

Fig. 4 - Circle of correlation of different variables in C1 and C3

Software used in analysis

The statistical analysis of the physic-chemical parameters was performed using the SPSS software (SPSS for Windows, version 16, correlation matrix), and the spad v 55 software for data analysis by Principal Component Analysis (PCA).

Results and Discussion

Table 2 shows the physic-chemical (mg/L) characteristic results with seasonal variations of water in the LLRB.

The results of the physico-chemical properties obtained in this study are fluctuated with the standard values of water quality given by WHO (2006) and Libnor (Lebanese Institute for Norms, 1999) to categories the sites according to their characteristics and degree of pollution.

The correlation of parameters

The correlation parameters will be discussed according to the priority of importance for each parameter:

Physicals parameters

pH: The pH values of water range are 8-9 of LLRB in the three seasons and it is almost basic.

The Libnor (1999) limits of pH for drinking water are 6.5-8.5. The pH of LLRB water samples in rainy season was found to be in the range of 7 to 8.4 and in early rainy 7.7 to 8 and in a range of 8.5-9 in the wet season as shown in Table.1. pH showed high positive correlation with, TDS ($r = 0.52$, $p < 0.05$), nitrate ($r = 0.6$, $p < 0.01$), cupper ($r=0.652$, $p < 0.01$).

Temperature: The variation of temperature of LLRB ranged between 16 C and 27.5°C; respectively (Table-2). During the present data, there was no great difference between the temperature of the rainy and wet season.

Temperature showed positive correlation with nitrate ($r = 0.54$ and $p < 0.05$), nitrite($r = 0.74$ and $p < 0.05$) that significant of the biodegradation that is increase by temperature, perhaps temperature showed negative correlation with Phosphate ($r = -0.47$and $p < 0.05$), Sulfate ($r = -0.58$ and $p < 0.01$), Potassium ($r =-0.65$ and $p < 0.05$), Chloride ($r = -0.58$ and $p < 0.01$), Cr ($r = -0.51$ and $p < 0.05$) negative correlation with other physico-chemical parameters which are given in Table 3.

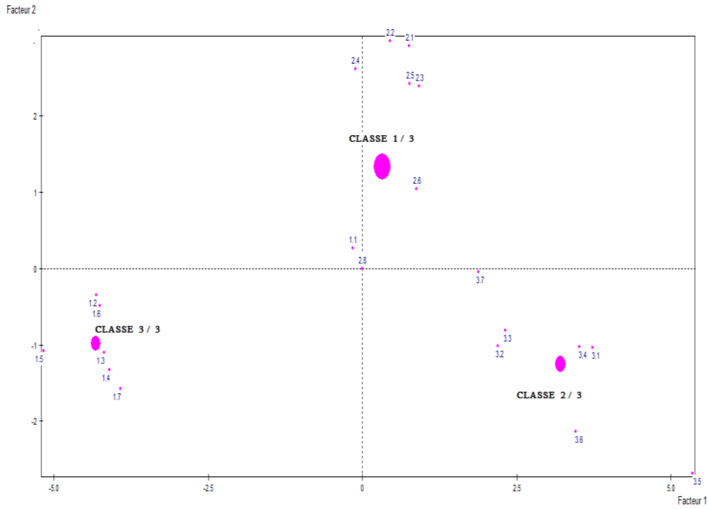

Fig. 5 - Factorial map C1 x C3

EC: is an excellent indicator of TDS, which is a measure of salinity that affects the taste of potable water (Razmkhah at all.2010).

The Electrical Conductivity of water sample of LLRB in rainy and Mid rainy and wet seasons was observed to be in the ranges of 467-599 and 495-719 and 415-857 µs/cm; respectively as shown in Table2. **EC** showed positive correlation, with Ammonium ($r = 0.49$ and $p<0.05$), TDS ($r = 0.75$ and $p<0.01$), with other physico-chemical parameters which are given in Table 4.

TDS: refer to any minerals, salts, metals, cations or anions dissolved in water. This includes any material presents in water other than the pure water (H_2O) molecule and suspended solids.

The correlation between TDS and all the chemical and heavy metals is high and significant with EC ($r =0.75$.$p<0.01$), NO_3^- ($r =0.64$, $p<0.05$),NO_2^- ($r =0,74$.$p<0.05$), which is due to the high concentration of ion and this suggests that the contamination is higher in summer because the water volume is not enough to dilute the pollutants. TDS shows significant and moderate correlation with EC ($r = 0.469$ $p < 0.05$) pH ($r = 0.52$, $p < 0.05$), and negative correlation with K ($r =-0.52$, $p < 0.05$), SO_4 ($r =-0.53$, $p<0.05$).

Chemicals parameters

Nitrite:

In general, the increase in pollution inputs downstream gives a sufficient indication of the quality deteriorating of water due to entry of wastewater into the river. The concentration of nitrite in the LLRB in rainy and mid rainy was found to be in a range of 0.06-0.15 and 0.2-0.4 and in the wet season is between 0-0.3 ppm which is high according to Libnor (max 0.1ppm).

Nitrite showed positive correlation with nitrate ($r = 0.64$ and $p < 0.05$), phosphate ($r = 0.53$ and $p < 0.05$) due to the sewage and domestic wastewater discharges, and showed a negative correlation with Sulfate (r = -0.81 and p <0.01), potassium (r =-0.83 and p <0.01), Chloride (r = -0.82, p < 0.01 negative correlation with other physico-chemical parameters which are given in Table 4.

Nitrate: nitrate/ammonium correlation can indicate the inputs of sewage and municipal solid wastes (Chettri et al. 1995), as well as fertilizers and other agricultural sources. Nitrate showed positive correlation with ammonium (r=0.56, p <0.05 **),** nitrite (r =0.64 and p < 0.05), Fe (r = 0.79 and p < 0.01), Copper (r =0.52 and p < 0.05) and showed negative correlation with phosphate (r = -0.53and p <0.05), Sulfate (r = -0.79 and p <0.01), potassium (r =-0.77 and p<0.01), Chloride (r = -0.70,p<0.01), Chromium (r = -0.60,p<0.01). The high concentration of nitrate >35ppm appears in mid rainy and dry season and this might be related to the use of fertilizers in the neighboring fields.

$CaCO_3$ = Hardness

Calcium is an important micronutrient in an aquatic environment. Hardness of the river water is of considerable significance in connection with the discharge of the sewage and industrial effluents containing pollution, as indicated by variations in the concentration of the hardness of water (Rai.H, 1974).

$CaCO_3$ showed positive correlation with, Cr (r =0.17 and p <0.05) and showed negative correlation with Cu (r = -0.51 and p <0.05), Mg^{2+} (r = -0.73 and p < 0.01). The high alkalinity (200-400ppm) in the river is attributed to soils and dissolution of minerals (Chidya et al. 2011, May et al. 2007).

Sulfate:

Sulfate is widely distributed in nature and may be present in natural waters. The main source of sulfur is the rocks present near the water-bodies and biochemical action of anaerobic bacteria. Sulfate showed positive correlation with Chromium (r =0.85 and p < 0.01) and showed negative correlation with Fe (r = -0.52 and p < 0.01). The sulfate contents found in river waters are probably a consequence of the morphology of soils irrigated by the river, which are formed mainly by limestone and marl. The sulfate/potassium association (r = 0.9, p < 0.01) can indicate inputs of sewage and municipal solid wastes as well as fertilizers. In addition, the correlation of Copper and iron (r = 0.39, p < 0.05), Chromium and Sulfate (r = 0.83, p < 0.01) can be explained by industrial discharges from dying and tanning, minerals processing and electroplating

Chloride:

Main sources of chloride in river waters are sediments, sewages and trade and industrial effluents (Houri et al. 2007). Also, one source can be due to the sewage derived with urine, which is rich in chloride content i.e. 4500-5000 ppm chloride 45/. The WHO suggested the standard of chloride is 250 ppm as a normal level. The concentration of chloride in LLRB samples in three seasons was found to be in the range of 200-800 mg/L and as shown in Table1,

Chloride showed positive correlation with sulfate (r = 0.88, p < 0.01), Chromium (r = 0.48, p <0.05). This is due to the sewage and domestic wastewater discharges in the region. It also showed negative correlation with iron (r =-0.52, p <0.01),

Principal component analysis

Principal component analysis, as a technique for variable reduction ,dispense with non homogeneity in sampling data, missing value and periodic trends in data and identifies temporal variation in water physic-chemicals characteristics and effective factors factor on it. It also extracts the most important parameter in polluted sites **(**kunwar et al. 2004, Singh C 2006, Razmkhah et al. 2010).

In this way diagonal of the correlation matrix transforms the original P correlated variables into P uncorrelated variables (orthogonal) variables called principal's components (PCs), which are weighted as linear combinations of the original variables.

Projection of the original variables on the sub space of the PCs are called loading and coincides with the correlation coefficients between PCs and variables (Reid et al. 2009, Viallee et al. 2011). Loading, Eigenvalues, percent of cumulative and percent of variance of five retained PCs are presented in Table 4.

PC1 (F1) explains **45.54** % and is contributed by must variables pH, T, TDS, NO_2^-, NO_3^-, K^+, Cl^-, Fe and NH_4^+. PC2 (F2) explains 13.88 % of variance and include pH, NH_4^+, Na^+, $CaCO_3$, Cu. PC3 (10.23%) is negatively contributed to EC. PC4 (7.10% of variance) is only contributed by BOD5 and finally PC5, which explains 6.08% of the variance is not contributed by any element. Because most of the variables are highly contributed by PC1, and PC2, PC3 and PC4 are contributed to by anthropogenic and mineral pollution; therefore PC1, PC2 and PC3 explained 69.59% of the total data and for that we take it in consideration during this study.

Factorials axes C1, C2, and C3

This circle shows (fig.3) that C1 which explains 45.54%, of total variance has strong positive correlation with T, TDS, NO_3^-, Fe, NO_2^-, and NH_4^+ and moderate positive correlation with pH, EC, and this axis is negatively correlated to K^+, Cl^-, PO_4^{3-}, SO_4^{2-}, and Cr. The higher concentrations of TDS observed in C1 is related to Ca and conductivity, which is an indication of anthropogenic pollution due to domestic wastes. The first principal component C1 is associated with a combination of various hydro geochemical processes which can be interpreted as a minerals component of the river water.

However, the variables that contribute in a major way the constitution of the C2 axis which explain **13.83** are the Na^+, $CaCO_3$ of positive side towards negative Cu. the presence of Na^+ ion suggests ion exchange on the clay materials. The process of dissolution of Na^+ and Cl^- ions indicates a higher rate of weathering in the area.

This circle shows that pH, COD and BDO5 were strongly associated due to the effect of bacterial activity.

The correlation between Chloride, Phosphate, Sulfate and potassium is due to the addition of fertilizers to these cultivated sites.

This circle shows that F3 which explained 10.23% has negative correlations with Ec, CaCO3 and Na. the correlations between COD, Ammonium was due to the reject of wastewater without treatment in the river.

In conclusion we deduce that among 18 variables and only 11 variables were participate in the formation of axes C1, C2 and C3

Analysis of factorial designs C1 X C2

Analysis of the factorial map C1xC2 (figure 4) allows to distinguish three groups of identified. The first class (1/3) has found in positive side of the axis C2, and was done during the winter season and was characterized by the presence of ammonium and nitrite in opposite situation, the third class (3/3) was negative correlated to C1and C2 and characterized by high concentration of potassium, sulfate, phosphate and Chloride due to the excessive use of fertilizers. The second class (2/3) has found in negatives side in the axis of C1 corresponding to the spring samples and characterizes by the presence of high values of COD, BOD5, Cu which indicates the anthropogenic pollution due to the reject of domestic water.

Table 1 - Coordinates and description of different sites

Sites		Coordinate			Sites description
		Latitude	Longitude	Altitude	
Qelia	S1	33°26′ 21″ N	35°38′ 55″ E	510m	Quarry site and Touristic zones pumping stations.
Khardali	S2	33°20′ 34″N	33°32′ 34″ E	257m	Agriculture and touristic zone.
Kakaeyat Eljisr	S3	33°18′ 31″N	35°26′18″ E	159m	Touristic and agriculture zone.
Tair Flsaiy	S4	33°19′10″N	35°20′ 27″ E	172m	Touristic zone.
Abou Abdellah	S5	33°19′ 26″ N	35°15′ 50″ E	15m	Vegetated sites.
Qasmieh	S6	33°20′ 22″N	35°15′ 04″E	3m	Urban, irrigation canal and agricultural zone.

Table 2 - Physico-chemical characteristics of water in LLRB

Libnor (1999)	WHO (2006)	Average values (range)			Parameter
		Dry season	Mid rainy season	Rainy season	
6.5-8.5	6.5-8.5	9-8.5	8-7.7	8.4-7	PH
15.57-21.10	15.57-21.10	27.5-19	23.3-17.4	17.8-16	T
Max 1500μs/cm	Max 1500μs/cm	857-415	719-495	599-467	EC
<500 mg/L	<500 mg/L	502-273	352-248	300-233	TDS
<500 mg/L	Max 0.5 ppm	8-2	11.2-0	0.028-0.002	NH_4^+
45 ppm	Max 50 ppm	39-21	22.1-8.7	0.15-0.06	NO_3^-
0.05 ppm	Max 0.1ppm	0.3-0	0.4-0.2	0.15-0.06	NO_2^-
1 ppm	Max 1 ppm	0	0	0.77-0	PO_4^{3-}
12 ppm	Max 12 ppm	8-1	4.3-2.7	55.46-25.91	K^+
200 ppm	Max 250 ppm	31-12	32-0.5	800-200	Cl^-
250 ppm	Max 250 ppm	0.07-0.03	0.03-0	29.9-19.6	SO_4^{2-}
200 ppm	Max 200 ppm	400-200	385-330	400-300	$CaCO_3$
150 ppm	Max 150 ppm	6-1	9.6-0	9-0	Na^+
0.05 ppm	0.05 ppm	0.05	0.02-0	0.54-0.07	Cr
1 ppm	1 ppm	0.1-0.08	0.05	0.05	Cu
0.3 ppm	0.3 ppm	9-3	7.1-0.8	7.1-0.8	Fe
50 ppm	50 ppm	3-1	1.5-0.7	1.5-0.7	Mg
25 ppm	25 ppm	5	5	5	BOD_5
25 ppm	25 ppm	53-20	20	20	COD
5 ppm	5 ppm	ND	ND	ND	Zn
0.01 ppm	0.01 ppm	ND	ND	ND	Pb
0.2 ppm	0.2 ppm	ND	ND	ND	Al
0.5 ppm	0.5 ppm	ND	ND	ND	Ba
0.02 ppm	0.02 ppm	ND	ND	ND	Ni
0.05 ppm	0.05 ppm	ND	ND	ND	Mn
0.005 ppm	0.005 ppm	ND	ND	ND	Cd
		2.426	8.179	5.23	Discharge Mm3/s

ND: Not detected

Table 3 - Coefficient values of physical and chemical parameters of water samples of LLBR

Correlation matrix	PH	T	TDS	EC	NH_4^+	NO_3^-	NO_2^-	PO_4^{3-}	K^+	Cl^-	SO_4^{2-}	$CaCO_3$	Na^+	Cr	Cu	Fe	Mg^{2+}	BOD5	COD
PH	1.00		0.52																
T	0.40	1.00																	
TDS	0.52	0.44	1.00	0.75															
EC	0.00	0.09	0.75	1.00	0.49														
NH_4^+	0.18	0.18	0.45	0.49	1.00	0.56													
NO_3^-	0.60	0.54	0.64	0.23	0.56	1.00													
NO_2^-	0.43	0.74	0.47	0.14	0.27	0.64	1.00												
PO_4^{3-}	-0.10	-0.47	-0.39	-0.24	-0.40	-0.53	-0.53	1.00											
K^+	-0.27	-0.65	-0.52	-0.30	-0.58	-0.77	-0.83	0.65	1.00										
Cl^-	-0.52	-0.58	-0.43	-0.21	-0.55	-0.70	-0.82	0.48	0.82	1.00									
SO_4^{2-}	-0.42	-0.66	-0.53	-0.28	-0.62	-0.79	-0.81	0.59	0.90	0.88	1.00								
$CaCO_3$	-0.60	-0.49	-0.45	0.07	-0.15	-0.51	-0.37	0.30	0.28	0.36	0.34	1.00							
Na^+	-0.28	-0.31	-0.27	0.00	0.34	-0.06	-0.21	0.00	0.00	0.01	0.00	0.43	1.00						
Cr	-0.21	-0.51	-0.41	-0.26	-0.50	-0.62	-0.61	0.22	0.71	0.64	0.85	0.17	-0.03	1.00					
Cu	0.63	0.29	0.59	0.11	0.04	0.52	0.17	-0.18	-0.10	0.01	-0.08	-0.51	-0.38	0.03	1.00				
Fe	0.38	0.45	0.51	0.31	0.79	0.75	0.44	-0.46	-0.57	-0.52	-0.67	-0.41	0.02	-0.59	0.42	1.00			
Mg^{2+}	0.43	0.48	0.40	-0.08	0.13	0.56	0.36	-0.19	-0.30	-0.23	-0.37	-0.73	-0.17	-0.33	0.53	0.43	1.00		
BOD5	0.36	0.48	0.22	0.10	0.21	0.31	0.24	-0.16	-0.19	-0.19	-0.24	-0.03	-0.15	-0.17	0.35	0.42	-0.11	1.00	
COD	0.38	0.5	0.55	0.45	0.32	0.35	0.26	-0.18	-0.19	-0.21	-0.26	-0.25	0.21-	0.19-	0.45	0.52	0.10	0.8	1.00

Table 4 - Factor loadings of elements data in the water samples

F5	F4	F3	F2		F1	Variables
-0.35	-0.15	0.22	-0.48		0.59	PH
0.17	0.37	0.27	-0.12		0.75	T
0.29	-0.36	-0.32	-0.26		0.74	TDS
0.47	-0.23	-0.71	0.06		0.39	EC
-0.30	-0.15	-0.50	0.35		0.63	Ammonium
-0.23	-0.18	0.05	-0.01		0.89	Nitrate
0.16	0.15	0.34	0.18		0.80	Nitrite
-0.24	0.07	-0.06	-0.18		-0.61	Phosphate
-0.06	-0.02	-0.10	-0.41		-0.85	Potassium
0.06	-0.03	-0.22	-0.33		-0.82	Chloride
0.00	-0.05	-0.12	-0.36		-0.90	Sulfate
0.07	0.36	-0.41	0.42		-0.54	$CaCO_3$
-0.51	-0.03	-0.38	0.47		-0.31	sodium
-0.03	-0.12	-0.03	-0.37		-0.68	Chromium
-0.13	-0.26	-0.05	-0.77		0.39	Copper
-0.32	-0.05	-0.24	0.03		0.83	Iron
-0.16	0.69	- 0.28	-0.42		0.43	BOD5
0.06	0.39	-0.46	-0.52		0.54	COD
1	1.27	1.84	2.49		8.20	Eigenvalues
6.08	7.10	10.23	13.83		45.54	%Variance
82.77	76.70	69.59	59.37		45.54	% cumulative

The effect of the factor "Season" is not being blocked. Similarly, if one considers the significance of the physicochemical axis C1 we deduce that the statements of the class 2/3 and 3/3 are characterized by high concentration in Fe and nitrite because of the presence of cultivated land and wastes water and low concentration of nitrate and potassium.

Furthermore, the significance of the C2 axis permits to note the existence of identified with high concentrations of $CaCO_3$ and moderate concentration of sulfate and chloride. And high conductivity of the site 3, 4.

Conclusion

Evaluation of surface water quality was determined for the Lower Litani River Basin (LLRB) to evaluate its combined physicochemical data for the samples collected over the three period of time in 2011.

The present study suggests that the principal component analysis determines the assemblages of water quality, which are an indication of genetic processes and the origin of pollutants with respect to domestic, agricultural sectors and small industrials activities.

Analysis is useful for sustainable development through planning and for implementing remedial measures within time to mitigate the adverse effects of the poor quality of water on human health.

This study provides an informative data and helps to understand the physicochemical proprieties and their pollution and the influences the ecology of (LBL).

The major sources of pollutants are local anthropogenic activities, agricultural runoff due to a high level of NO_2^-, Fe and $CaCO_3$.

Univariate descriptive statistics for the observed variables were conducted for each sampling event. An effort was made to extract more information from the datasets through the use of the multivariate analysis techniques PCA and CA revealed some specific features of the data structure. Three principal components were identified.

The first PC shows high loadings of NO_2^-, NO_3^-, K^+, Cl^- and Fe. Either these elements have a common ground of variance or they are inter-correlated. The concentration of NO_2^- in the water is also anthropogenic.

The high loadings of Fe, K^+ are attributed to the fact that they exist in the main soil forming such components. The oxides and hydroxides of Fe are one of the main soil parameters governing processes of absorption and desorption of trace elements. Results reveal the presence of NO_2^- in domestic water and NO_3^- and K^+ due to the excessive use of fertilizers.

However, no critical pollution has been reported in this part of the river; except the high concentration of Fe and NO_2^- in all investigated sites.

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References

Abd EL-Al I (1953) Statics and dynamics of water in the Syro-Lebanese limestone massif. Ankara symposium on arid zone hydrology, Ankara, Turkey, UNESCO, 60-76.

Amery H (1993) The Litani River of Lebanon. Geographical Review, Jul93, Vol. 83 Issue 3, p229, 238

Beydoun, Z (1972) A new evaluation of the petroleum prospects of Lebanon with special reference to the Pre-Jurassic. 18th Arab Pet. Cong., Algeria, 80(B-3).

Beydoun, Z (1988) The Middle East: Regional Geology and Petroleum Resources. Scientific Press Ltd., London, 296p.

Bou Kheir, R, Cerdan O, Abdallah C (2006) Regional Soil Erosion Risk Mapping in Lebanon, Geomorphology, pp. 347-351

Chettri M, Smith G (1995) Nitrate pollution in ground water in selected districts of Nepal, Hydrogeol. J. 371–76.

Chidya R., Sajidu.M.I , Mwatseteza J, Masamba,W.R.L(2011) Evaluation and assessment of water quality in Likangala River and its catchment area Physics and Chemistry of the Earth 865–871

DoummarJ, Massoud M.A, Khoury R, Khawlie M (2008) optimal resource management :case of lower litani river,Lebanon,water resource management 2343-2360

FAO (1994) Irrigation rehabilitation and modernization project: preparation report. FAO Investment Centre/World Bank Cooperative Programme Report No. 5/94 CP-LEB 8, Rome

Jurdi M ,Korfali S I,KarahagopianY ,Davies B (2001) evaluation of water quality of the qaraoun reservoir,Lebanon:suitability for multipurpose usage ?.

Haddad N (2001), Surveillance de la qualité de l’eau de la rivière Litani Lebanese Science Journal, P81-87.

Hao et al., (2008), Irrigation performance measures: efficiency and uniformity”. J. Irrig. Drain. Eng., ASCE, 123: 423-442.

Hajar L, Haidar-Bustani M, Khater C,Chedadi R (2009)« Environmental changes in Lebanon during the Holocene: Man vs. Climate Impacts », Journal of Arid Environments.1-10.

Hamed A, Mark S (2008) Assessing Water Quality Management Options in the Upper Litani Basin, Lebanon, Using an Integrated GIS-Based Decision Support System, Environmental Modeling and Software 1327-1337

Houri A, El-Jeblawie S (2007) Water quality assessment of Lebanese coastal rivers during dry season and pollution load into the Mediterranean Sea, Journal of Water and Health. 615-620.

Khoury R. Doummar J. Khawlie M. Doumit A. Chaaban A. Abdalah C (2006) Using the Water Resources Model (WRM) for Optimization : the Lebanon Lower Litani River Case Study, WatMed3, Tripoli, Liban, November, pp. 6.

Karaa K. Karam,F. Tarabey N (2001) Attempts to determine some performance indicators in the Qasmieh Ras –El-An irrigation schema (Lebanon) series B n^0 52

Koukal B, Dominik J, Vignati D, Arpagausa P,Santiag S, Ouddane B, Benaabidate L (2004) Assessment of water quality and toxicity of polluted Rivers Fez and Sebou in the region of Fez (Morocco) Environmental Pollution 166-170

Kunwar P.Singh M, Amrita M, Dinesh M, Sarita S (2004) Multivariate statistical techniques for the evaluation of spatial and temporal variations in water qualityof Gomti River (India)—a case study, Water Research 3982-3990

Lebanese Norm for Drinking Water (1999) , n ° 161, ICS 13.060.20.

May A, Massoud M, Mark D, John N (2006) Factors influencing development of management strategies for the Abou Ali River in Lebanon II: Seasonal and annual variation Science of the Total Environment 31– 41.

Nimah M.N. J. , Haddad dandan M.(1999), Modélisation de la qualité de l'eau de la rivière Litani ; dans l'espace et le temps, Thesis.

Office National du Litani(ONL) 2012, *www.litani.gov.lb*..

Raad D (2004) Analyse évolutive des facteurs agro et socio-économiques du périmètre irrigué de Qasmieh-Ras-el-Aïn au Liban-Sud , Thèse doctorat d’agronomie et socio-économiques, Bordeaux, Université de Michel de Montaigne Bordeaux III, pp. 361.

Razmkhah H, Abrishamchi A, Torkian A (2010) Evaluation of spatial and temporal variation in water quality by pattern recognition techniques: A case study on Jajrood River (Tehran, Iran) Journal of Environmental Management, 852–860

Reid M, Spencer K (2009) Use of principal components analysis (PCA) on estuarine sediment datasets: The effect of data pre-treatment, Environmental Pollution, 350-370

Rai H (1974), Limnological observation on the different rivers and lakes in the Ivory Coast, Hydrobiologia **,** 301-317.

Singh C (2006), Pattern characteristics of Indian monsoon rainfall using principal component analysis (PCA) Atmospheric Research 317–326.

USAIDS (2004-2005), Gestion de l’eau de litani, Liban litani water quality management, Water Projects program , Litani river authority.

Vialle C, Sablayrolles C , Lovera M., Jacob S, Huau, M, Montrejaud-Vignoles, M. (2011) Monitoring of water quality from roof runoff: Interpretation using multivariate analysis water research 7 6 5 - 7 7 5

Ministry of Environment and the Lebanese Environment and Development Observatory. ECODIT, Beirut, Lebanon (2001) SOER (State of the Environment Report) p 240. http:// www.moe.gov.lb.

World Health Organization (WHO) (2006) A Proposal for Updating Lebanese Norm of Drinking Water (1999) based on WHO Guidelines.