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Macrophytic communities of Ghouzaiel, a Mediterranean river of Bekaa plain (Lebanon) with anthropic disturbances

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Abstract—**Although several rivers in Lebanon have been studied for hydrological, chemical, faunistic and epithilic parameters, little attention has been paid so far to the macrophytes. The present study assesses aquatic plants growth in Ghouzaiel River in the Bekaa region (Lebanon). Investigations of this river showed that Ghouzaiel, in different sites, was affected by anthropic disturbances. Eleven sampling campaigns were carried out from April 2009 to April 2010 at four stations on Ghouzaiel River from its source to its confluency with Litani River. In the first place, the abiotic characteristics were measured. The inventory of the species belonging to the macrophyte communities were drawn up, and the spatio-temporal variations in their patterns of distribution were analysed and compared. The successive species and the rates of cover of macrophyte population depend on seasonal climatic changes and anthropic disturbances. A native species, Nuphar lutea, considered as an extinct species in Lebanon was detected for the first time since 25 years. An exotic species, Ceratophyllum demersum potentially invasive was detected on the Ghouzaiel.**

Keywords-Mediterranean rivers; Lebanon; Bekaa plain; community dynamics; biodiversity; macrophytes; disturbances; invasive species

I. INTRODUCTION

Macrophytes show a longitudinal pattern of zonation in rivers (Haury & Muller 1991), provide useful biotypological tools (Haury 1988) and can indicate the quality of river environments (Bernez 1999, Abou-Hamdan et al. 2005). They are often used for monitoring heavy metals and other pollutants present in the water and submerged sediments (Sawidis et al. 1995). The macrophytic communities affect and depend on several processes such as the sedimentation, the hydrological and underwater light regimes (Khedr et al. 1997, Daniel & Haury 1996). Crowder and Painter (1991) indicate that the lack of macrophytes in a system where they are expected to grow may suggest a reduced population of living beings and waterfowl.

In Lebanese freshwater environments, as far as we know, besides the study of the macrophytic communitie of Litani rivers (Ismaïl et al., 2009) no other study on macrophyte has been done so far and to our knowledge only a few rather fragmentary data are available concerning the inventory of aquatic plant (Tohmé et al. 2001, 2002 , 2004, 2005, 2006, 2007, 2014) . It is therefore necessary to attempt to fill this gap by carrying out biological and ecological studies on the aquatic plants growing in this type of environment.

So, the aim of the present study is:

to draw up a first inventory of the macrophyte species living in the Ghouzaiel River;

to study the changes in the spatial patterns of distribution of the plant communities during a seasonal cycle;

to study the effects of human disturbances on the aquatic plant communities, and the description of any local specificity will be assessed.

II. MATERIALS and METHODS

A. *Sites of study*

River Ghouzaiel has its source at the bottom of western side of “Anti-Liban” at an altitude of 884 m. After a course of 18 km, it flows into Litani River at an altitude of 862 m. In this river the slope is gentle and the substratum is generally fine. From the source to the confluence with Litani river 5 stations have been studied (G1, G2, G3, and G4) (Figure 1).

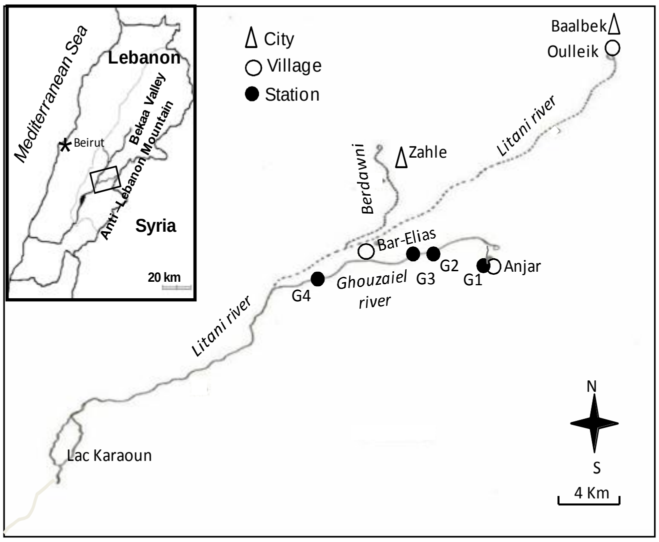

Figure 1 Map of the studied area in Bekaa region (Lebanon), showing the location of Ghouzaiel river and study sites

G1 is located at Anjar source (primary source of Ghouzaiel river) at an altitude of 884 at 2 km from Anjar village. This station is present as a basin of 30 m width and the depth varie from 20 to 115 cm. The water is limpid. However we signal, in water, the presence of some plastic bags which come aparently from tourist activities which reign in the area especially during summer. The ripisylve is very reduced on this site what supports, with the nature of substratum (fine) and the low velocity, the development of macrophyte. We signal the presence of touristic activities in this sector.

G2 is located at 3 km from Anjar source, at an altitude of 880 m, on the level of a restaurant very attended during summer. The average width of the river bed at this point is 10 m. The depth varies from 20 to 200 cm. In this area the river is dammed at the left bank. The ripisylve is reduced. This sector is subjected to repeat scraping in summer period.

G3 is located at 4 km from Anjar source, at an altitude of 875 m. The average width of the river bed at this point is 35 m. The depth varies from 30 to 100 cm. Bordered, on two banks, by agricultural lands. The water is limpid. We note the presence of several pipes which pump the water directly from the river. The ripisylve is absent. Macrophyte are very developed in this sector.

G4 is located at 16 Km from Anjar source, at an altitude of 870 m. In this sector the river is dammed. The average width of the river bed at this point is 8 m. The depth varies from 20 to 250 cm. This sector is bordered by an agricultural land on the side of its left bank and by a small farm on the side of its right bank. The ripisylve is absent. Macrophyte are very developed in this sector.

B. *Sampling and Parameters*

A standard sampling unit with an area of 100 m2 was used to study the macrophytic communities (Abou Hamdan et al. 2005, AFNOR 2003). To evaluate the percentage rate of cover of macrophyte, each station was divided into plots of 4 m2. A detailed inventory of the flora was drawn in each plot and the percentage rate of cover of each macrophyte taxon was assessed visually. For this purpose, each plot was divided into 16 sub-plots 2500 cm2 in size. A value of 2% was applied to all the species having a cover less than 5%. To make sure that no floristic information was lost, surveys were carried out over a distance of 100 m following (Ismaïl et al. 2009, Abou-Hamdan et al. 2005, Abou-Hamdan. 2004).

The following physical characteristics of the habitat were determined in situ in each station: depth, granulometry of the substrate (fine = lime, silt, sands; coarse = gravels, pebbles and boulders) and the current velocity (FLO-MATE, portable Model 2000).

In addition, 14 abiotics parameters of the water were analyzed either on the field (temperature, depth, dissolved oxygen, pH, conductivity and Total Dissolved Solids: multisonde WTW analyzer) or at the laboratory (NO2-, NO3-, NH4+, PO43-, DBO5, M.E.S.mn, M.E.S.org), using the SEQ-Eau protocol recommended by the French Water Agency (SEQ-Eau 1999).

In order to synthetize the information a multivariate analysis (PCA and FCA) was applied to the physico-chemical and macrophytic data respectively (ADE 4 program by Thioulouse et al. 1997).

Eleven sampling campaigns were carried out at each station from April 2009 to April 2010, at monthly intervals, from April to October, and every two months from the end of November to February.

III. RESULTS

A. Non-biotic variables

The average and extreme values of the physical and chemical parameters analyses of the four stations G1, G2, G3 and G4 of Ghouzaiel are presented in Tables 1 (a & b).

TABLE 1 (A & B). MEAN (AVG), STANDARD DEVIATIONS (SD), N = 11 SAMPLES, MINIMUM AND MAXIMUM OF 15 PHYSICOCHEMICAL VARIABLES ANALYZED ON THE 4 STATIONS OF GHOUZAIEL RIVER.

(a)	**G1**				**G2**			
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
T (°C)	17.0	0.3	16.5	17.5	17.1	1.6	14.6	19.3
Cond.(µs.cm^{-1})	459.5	6.0	450.0	469.0	480.4	18.3	450.0	510.0
TDS (mg.l^{-1})	359.5	12.3	340.0	375.0	380.0	13.1	368.0	405.0
O2 (mg.l^{-1})	7.9	0.5	7.2	8.7	9.6	2.1	7.1	13.8
NO2 (mg.l^{-1})	0.0	0.0	0.0	0.0	0.4	0.3	0.1	0.7
NO3 (mg.l^{-1})	8.5	1.9	5.7	11.5	15.9	3.8	10.7	19.6
NH4 (mg.l^{-1})	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.1
PO4 (mg.l^{-1})	3.2	2.1	1.0	6.0	5.1	1.6	3.0	7.0
SO4 (mg.l^{-1})	13.6	1.0	12.0	15.0	15.8	2.0	12.0	18.0
DBO5 (mg.l^{-1})	0.8	0.4	0.1	1.5	1.1	0.9	0.1	2.7
MESmn (mg.l^{-1})	40.3	8.5	31.0	55.0	21.0	6.6	14.5	30.5
MESorg (mg.l^{-1})	1.9	0.5	1.5	2.8	19.7	3.9	15.4	25.5
pH	8.3	0.4	7.8	8.9	7.9	0.4	7.3	8.9
V (m.s-^{1})	0.0	0.0	0.0	0.0	0.5	0.2	0.2	0.8
Prof cm	69.5	10.1	60.0	90.0	98.2	19.4	70.0	120.0

(b)	**G3**				**G4**			
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
T (°C)	17.1	1.5	14.8	19.0	17.9	2.6	14.0	22.0
Cond.(µs.cm^{-1})	484.8	18.4	455.0	520.0	505.2	31.9	472.0	580.0
TDS (mg.l^{-1})	388.4	12.5	375.0	410.0	398.3	56.7	330.0	500.0
O2 (mg.l^{-1})	9.7	2.0	7.4	13.6	6.4	1.2	5.0	8.0
NO2 (mg.l^{-1})	0.3	0.2	0.1	0.6	0.6	0.2	0.3	0.9
NO3 (mg.l^{-1})	15.1	3.3	10.3	18.0	20.0	1.5	18.0	22.0
NH4 (mg.l^{-1})	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1
PO4 (mg.l^{-1})	3.9	1.6	2.0	6.0	6.2	2.3	3.0	9.0
SO4 (mg.l^{-1})	16.0	2.0	12.5	18.2	17.9	2.1	14.0	20.0
DBO5 (mg.l^{-1})	1.7	0.9	0.6	3.2	5.6	1.2	4.0	7.0
MESmn (mg.l^{-1})	22.1	6.7	14.0	32.0	42.1	3.0	38.0	48.0
MESorg (mg.l^{-1})	19.7	3.9	15.4	25.5	51.8	4.2	44.0	56.0
pH	7.9	0.4	7.4	8.8	7.8	0.2	7.5	8.0
V (m.s-^{1})	0.6	0.2	0.3	0.9	0.3	0.1	0.2	0.5
Prof cm	59.9	10.1	49.0	70.0	70.0	16.8	50.0	90.0

In all stations, water is slightly basic. This is directly related to the water-rock interaction in the river bed. The rocks are primarily limestone and dolomite; so the river water has rather elevated pH values. Temperature, depth and current velocity vary according to months (Figure 2) and from a station to another. The depth is higher in G2 because of the sharp slope of river bed and the channelization work carried out in this region. The current velocity varies according to stations and months with a great values in January and April and lower values in August and September. The total suspense matter concentration are very high in G4 whereas it's concentrations are low in other stations (Tables 1 a & b, Figure2).

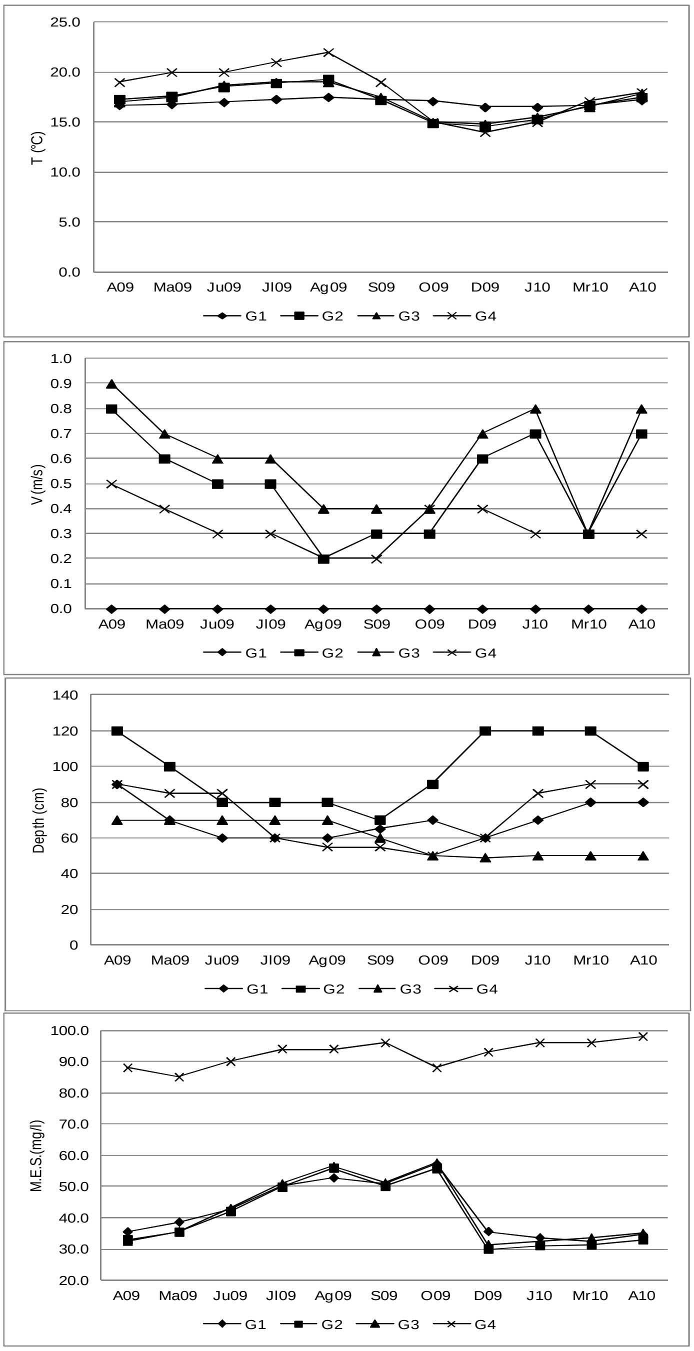

Figure 2 Temperature, Velocity, Depth and M.E.S. in the different stations (G1, G2, G3 & G4) at each sampling month.

Moderate values for conductivity and TDS for all studied stations show that the water is slightly mineralized. In addition the concentration of TDS and conductivity evolve in the same way showing a light increase from G1 to G4. Nitrate concentrations are below the permissible limit in drinking water (Nisbet & Vernaux, 1970 – EU requirements) with a higher value in G4 (20 mg/l). The other measured anions including phosphate, sulphate and nitrite and the BOD increased from G1 to G4 while the oxygen concentration decreases showing the lowest value at G4. The direct discharge of farm wastes and the proximity of the main road contribute to anthropogenic inputs elevating the measured physical and chemical parameters in G4 (Tables 1 a & b).

The substrate granulometry was finer at G4 (fine = 96%, coarse = 4%) than G2 (fine = 87 %, coarse = 13 %), G3 (fine = 84 %, coarse = 16%) and G1 (fine = 75 %, coarse = 25%) which, together with the high level of physical and chemical variables favoured the proliferation of plants, such as macroalgae and phanerogams.

To release the physicochemical differences between the different stations at Ghouzaiel River, a PCA analysis taking into account 14 quantitative abiotic parameters was realized (Figure 3). This PCA support the results presented above. It highlighted the ecological features of stations with respect to some abiotic parameters: Axis 1(inertia = 67.8%), which describe a gradient of eutrophication, opposes G1 (crenon) to G4 (potamon) characterized by a strong mineralisation. Whereas axis 2 (24.7%) individualizes G2 and G3 (rithron) characterized by their current velocity and oxygen concentration.

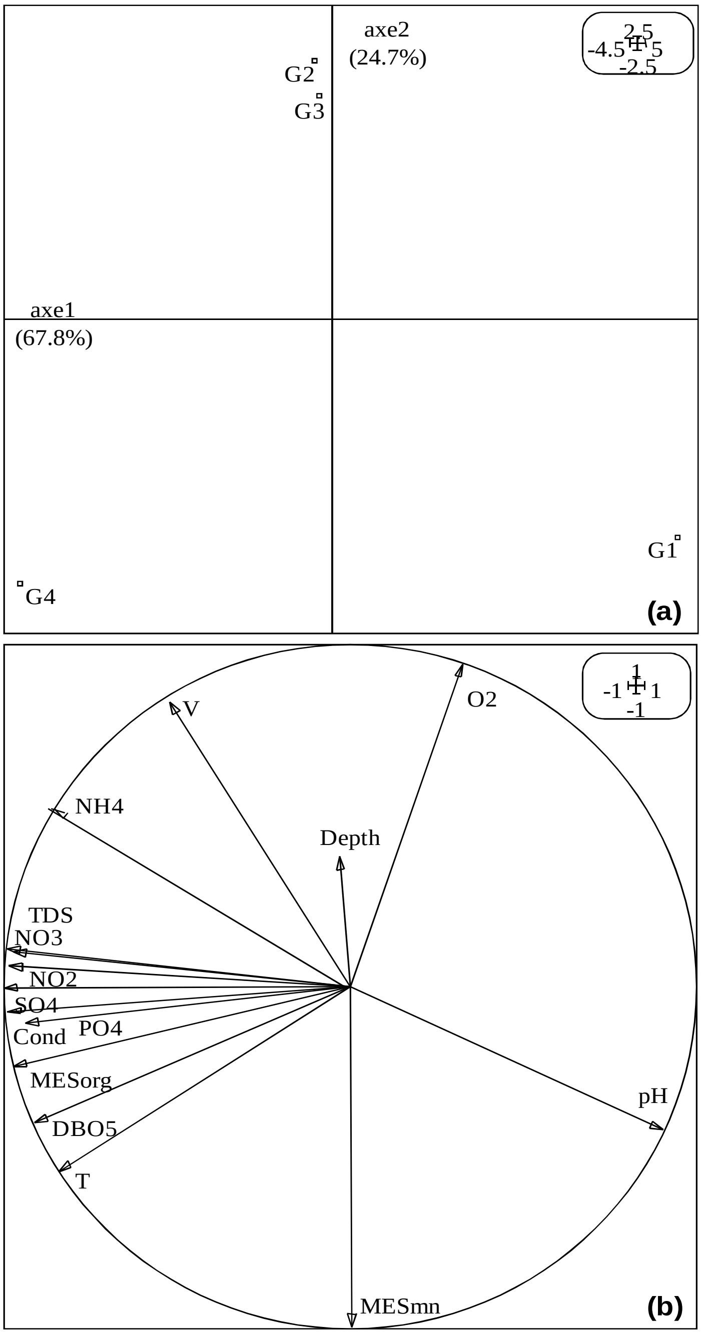

Figure 3 PCA applied on the 15 abiotic variable (average for the quantitative statement) in G1, G2, G3, G4. Projections of the stations points (a) and abiotic variable points (b).

B. *Biotic variables*

a. Macrophytic richness

Forty-three taxa including hydrophytes, helophytes and terrestrial species were observed at the four stations (Table 2). The taxonomic richness differed among the stations: 26 taxa at G1 5 taxa at G2, 25 taxa at G3 and 13 taxa at G4.

The hydrophyte species were more numerous at G1 (11 taxa) and G4 (8 taxa) than G2 and G3 (5 and 6 taxa respectively) whereas the helophytes dominate at G3 (13 taxa) and the terrestrial species at G1 and G3 (6 taxa for each one). In addition, there are no common taxa among all stations, however, some taxa were found to be specific for each station like the group of bryophytes and the phanerogam Ranunculus trichophollyus (Chaix) at G1, Nuphar luteum (Sibth. & Smith) and Ranunculus sphaerospermus (Boiss. & Bl.) at G2, Chara sp2, Sparganium erectum subsp. neglectum (Beeby) and six other helophytes between them, the rare helophytic species Myosystis caespitosa (Schul.) at G3, and trophic taxa like the two algae Cladophora sp., Vaucheria sp., the hydrophytic phanerogam Lemna gibba L. and the helophytic phanerogam Butomus umbellatus (L.) at G4 (Table 2).

Table 2 List of the macrophytes growing at the four sites studied: A = algae, B = Bryophyte, Ph = phanerogams.

Species	Codes of sepcies	G1	G2	G3	G4
Hydrophytes					
A *Cladophora* sp.	Clad	-	-	-	+
A *Chara* sp1	Char1	+	-	+	-
A *Chara* sp2	Char2	-	-	+	-
A *Ulotrix* sp.	Ulo	+	-	+	-
A *Vaucheria* sp.	Vau	-	-	-	+
B *Amblystegium* riparium (Hedw.)B., S.& G.	Amb	+	-	-	-
B *Cinclidotus* sp.	Cinc	+	-	-	-
B *Fissidens crassipes* Wils. ex B., S. &G.	FisC	+	-	-	-
B *Fissidens* sp.	Fiss	+	-	-	-
B *Rhynchostegium riparoides* (Hedw.) Card.	RhyR	+	-	-	-
Ph *Lemna gibba* L.	LemG	-	-	-	+
Ph *Ceratophyllum demersum* L.	CerD	+	+	+	-
Ph *Myriophyllium spicatum* L.	MyrS	+	+	-	+
Ph *Nuphar luteum* (Sibth. & Smith)	NupL	-	+	-	-
Ph *Potamogeton crispus* L.	PotC	+	+	-	+
Ph *Potamogeton lucens* L.	*PotL*	-	-	-	+
Ph *Potamogeton pectinatus* L.	*PotP*	-	-	-	+
Ph *Ranunculus sphaerospermus* Boiss. & Bl.	*RanS*	-	+	+	-
Ph *Ranunculus trichophollyus* Chaix	*RanT*	+	-	-	-
Ph *Sparganium erectum subsp. neglectum* (Beeby)	SpaE	-	-	+	+
Total (20)		11	5	6	8
Helophytes					
Ph *Apium nodiflorum* L.	ApiN	+	-	+	+
Ph *Polygonum persicaria*	PolP	+	-	+	-
Ph *Butomus umbellatus* L.	ButU	-	-	-	+
Ph *Cyperus eragrostis* L.	CypE	+	-	-	+
Ph *Juncus inflexus* L.	JunI	+	-	-	-
Ph *Lycopus europaeus* L.	LycE	-	-	+	-
Ph *Lythrum salicaria* L.	LytS	+	-	+	-
Ph *Mentha aquatica* L.	MenA	-	-	+	-
Ph *Mentha sylvestris* L.	MenS	-	-	+	-
Ph *Myosystis caespitosa* (Schul.)	MyoS	-	-	+	-
Ph *Nasturtium officinale* R.Br.	NasO	+	-	+	-
Ph *Phalaris arundinacea* L.	PhaA	+	-	+	-
Ph *Phragmites australis* (Cav.) Trin ex Steudel	PhrA	-	-	+	+
Ph *Veronica-anagalis-aquatica* L.	VerA	+	-	+	-
Ph *Juncus effusus* L.	JunE	+	-	+	-
Ph *Solanum dulcamara* L.	SolD	-	-	+	-
Total (16)		9	0	13	4
Terrestrial species					
B *Bryum* sp.	Bryu	+	-	+	-
Ph *Cyperus fuscus* L.	CypF	+	-	-	-
Ph *Galium aparine* L.	GalA	+	-	+	+
Ph *Galium prusens* Koch.	GaAp	-	-	+	-
Ph *Ecballium elaterium* (L) Rich	EcbE	+	-	+	-

Ph *Plantago major* L.	PlaM	+	-	+	-
Ph *Plantago lanceolata* L.	PlaL	+	-	+	-
Total (7)		6	0	6	1
Total species (43)		**26**	**5**	**25**	**13**

In 2009, except for winter (total disappearance of hydrophyte in G2 and G4) the number of taxa in each group is stable at all stations according to seasons. The comparisons of spring (2009 and 2010) show a variation of taxonomic richness with higher number in spring 2010 (Figure 4). In addition, we mention the disappearance of hydrophyte in winter at G4 whereas the station G2 show a special communitiy of macrophytes characterized by the presence of only hydrophyte species and the stability of their number during seasons (except winter). The terrestrial species were stable and more numerous in all seasons of 2009 at G1 (Figure 4).

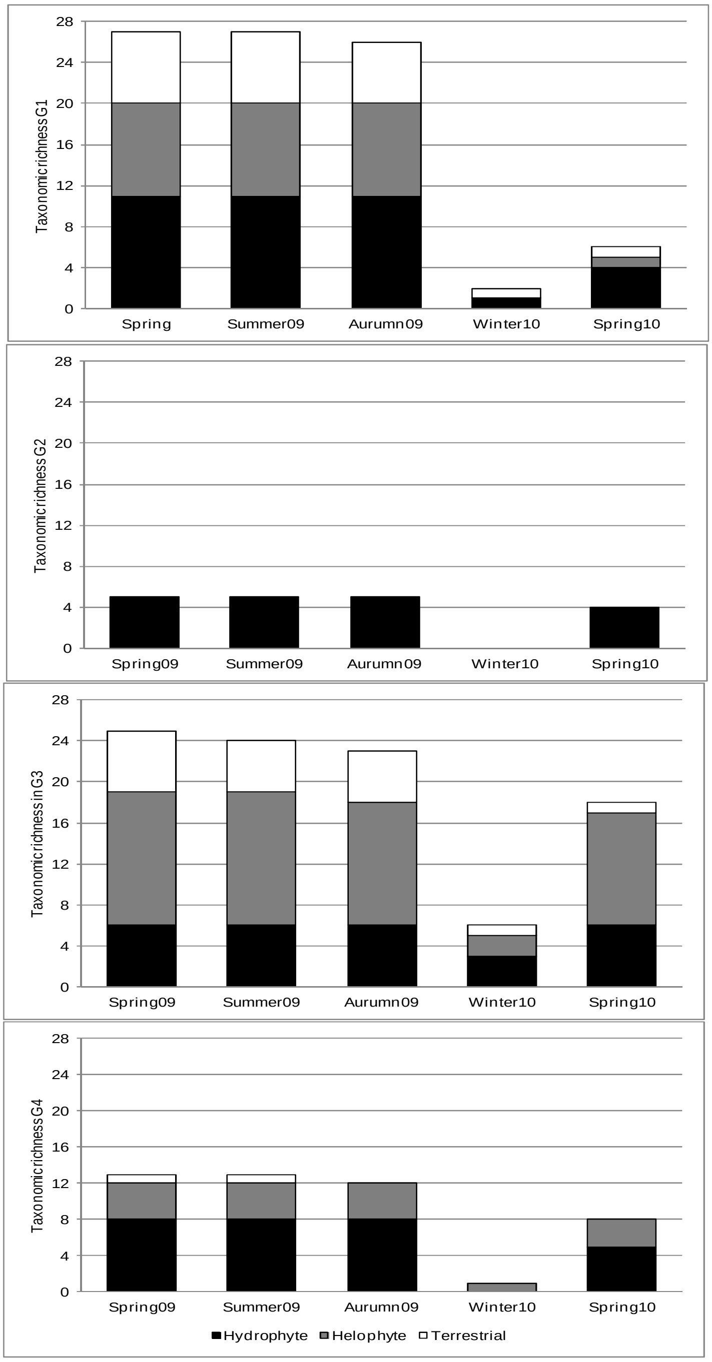

Figure 4 Seasonal variations in the taxonomic richness in the stations according to different groups (the values are the sum of species for each macrophyte type of each season). Spring= April, May, June. Summer = July, August, September. Autumn= October, December, Winter= January, March.

A factorial Correspondence Analysis (AFC), taking into account the totality of taxa detected at the 4 stations and treating the presence or absence of taxa individualizes several floristic units at different stations, was applied. Two units (U1 and U2) of taxa represented by bryophytes, Characea (algae, muskgrasses) and a group of helophyte located on both sides of the negative part of axis 1 (inertia 43.4%) characterize G1 and G3 stations respectively are opposed to a unit of algae and aquatic phanerogams (U3) characteristic of eutrophic sector characterizing the G4 station. Whereas a unit represented by a single hydrophyte phanerogams (Nuphar luetum) (U4) individualize G2 station. A fifth unit (U5), not characteristic, represents the different common taxa to all station specially G1 and G3. In addition, the distribution of all stations along axis 1 shows an upstream-downstream gradient characterized by a crenon station (G1) with bryophyte and a potamon station (G4) with eutrophic phanerogams. Between them we can identify a ritron stations (G2 and G3).

b. Macrophytic cover

The average percentage of macrophytic cover and the composition of communities differed among all stations (60% at G1, 42% at G2, 72% at G3 and 55% at G4). The 42% of macrophytic cover at G2 correspond only to the hydrophyte cover. Whereas, Hydrophyte dominated at G1 (56%) and G4 (49%), helophyte were more abundant at G4 (24%) and G1 (18%) (Figure 5).

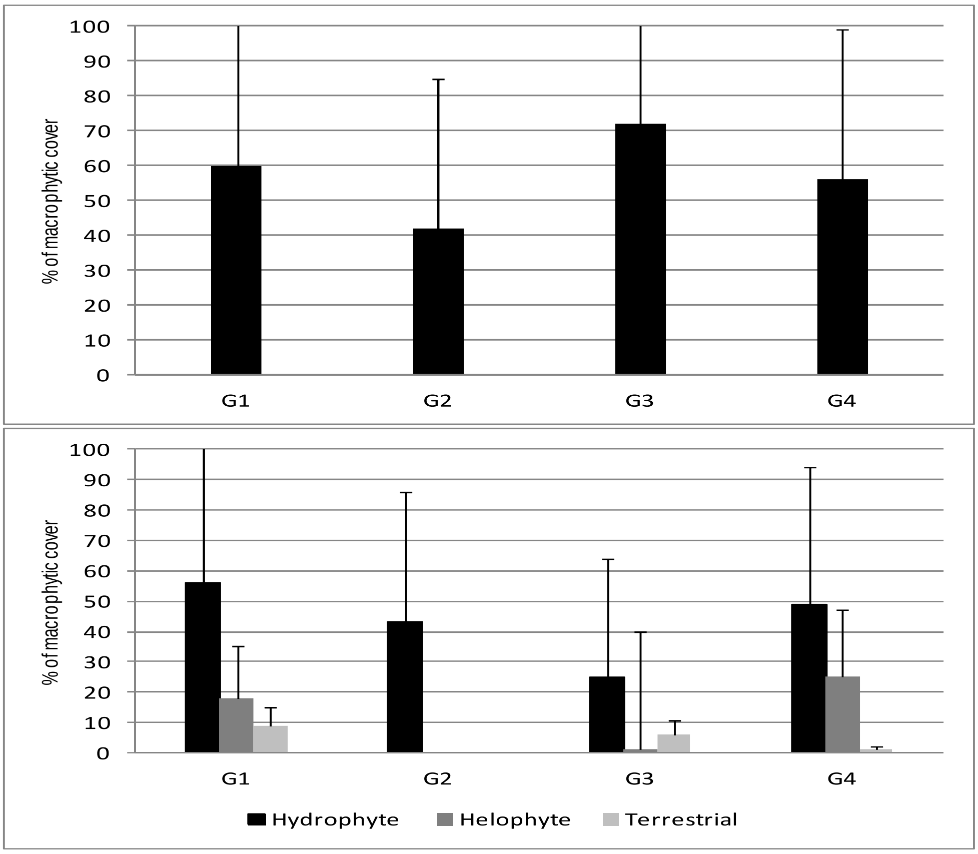

Figure 5 Average percentage of macrophytic cover (average + SD) among the different stations (L1, L2, L3 & L4). (a) all taxa, (b) for each type of macrophytes categories at the four stations.

Seasonal changes were observed in all stations (Figure 6). The overall cover was greater in summer for all stations with a maximum of hydrophytes (100% for each station). Helophytes present a maximum in G3 (100%) followed-up by G4 (58%) and G1 (40%) whereas the cover of terrestrial species was dominated at G1 and G3 (14%). In winter the cover of hydrophytes become below 5% in G1 and G3 and it disappears in G2 and G4 whereas the cover of helophytes become below 5% in G3 and G4 and disappears totally at G1 and G2. By comparison of macrophytic cover for spring 2009 and spring 2010 we can see a difference according to years with higher cover for spring 2009 at all stations. Because of absence of helophytes and terrestrial species at G2 there is no plant at all in winter at this station (Figure 6).

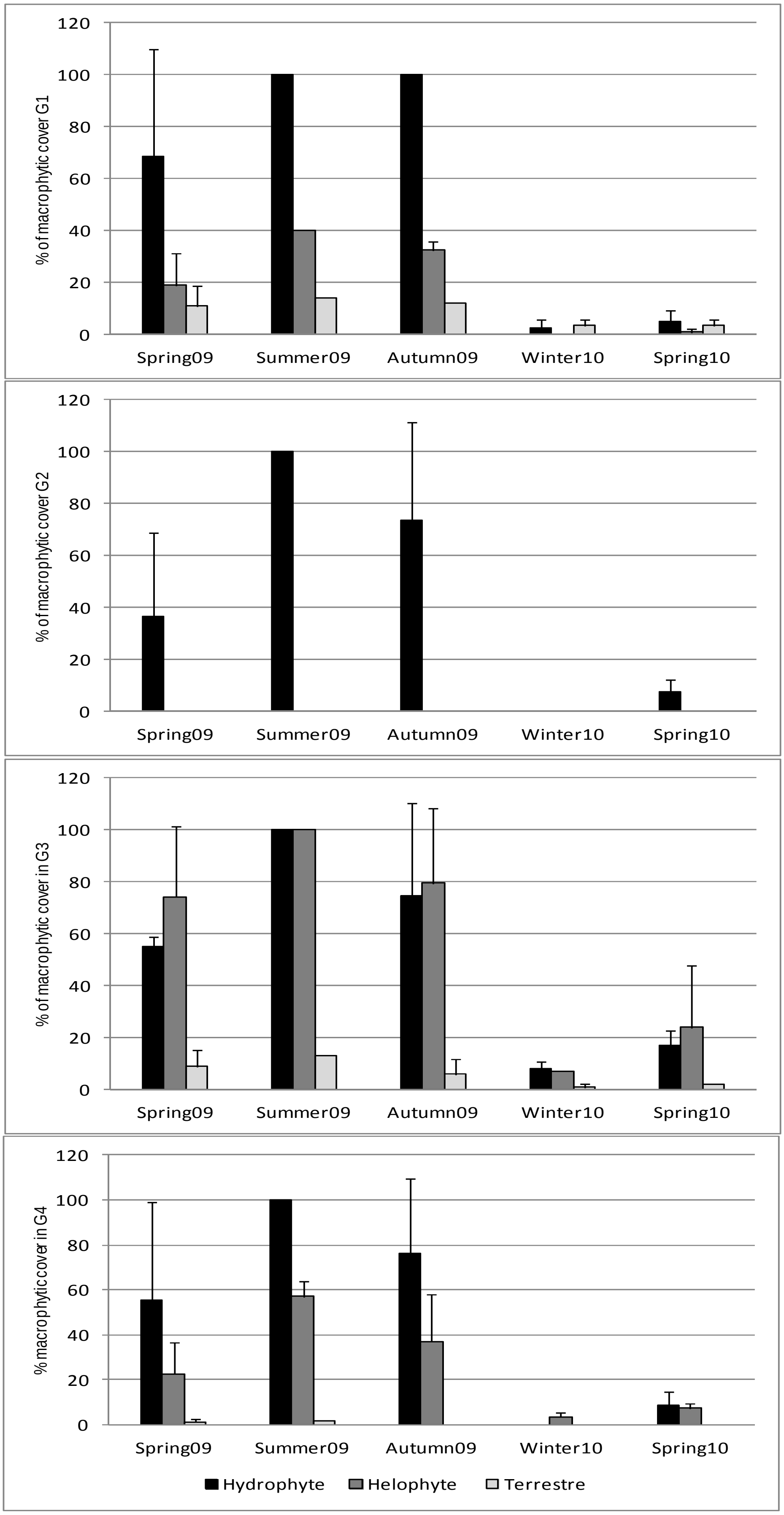

Figure 6 Variations in macrophytic cover (average + SD) in the stations according to seasons and groups.

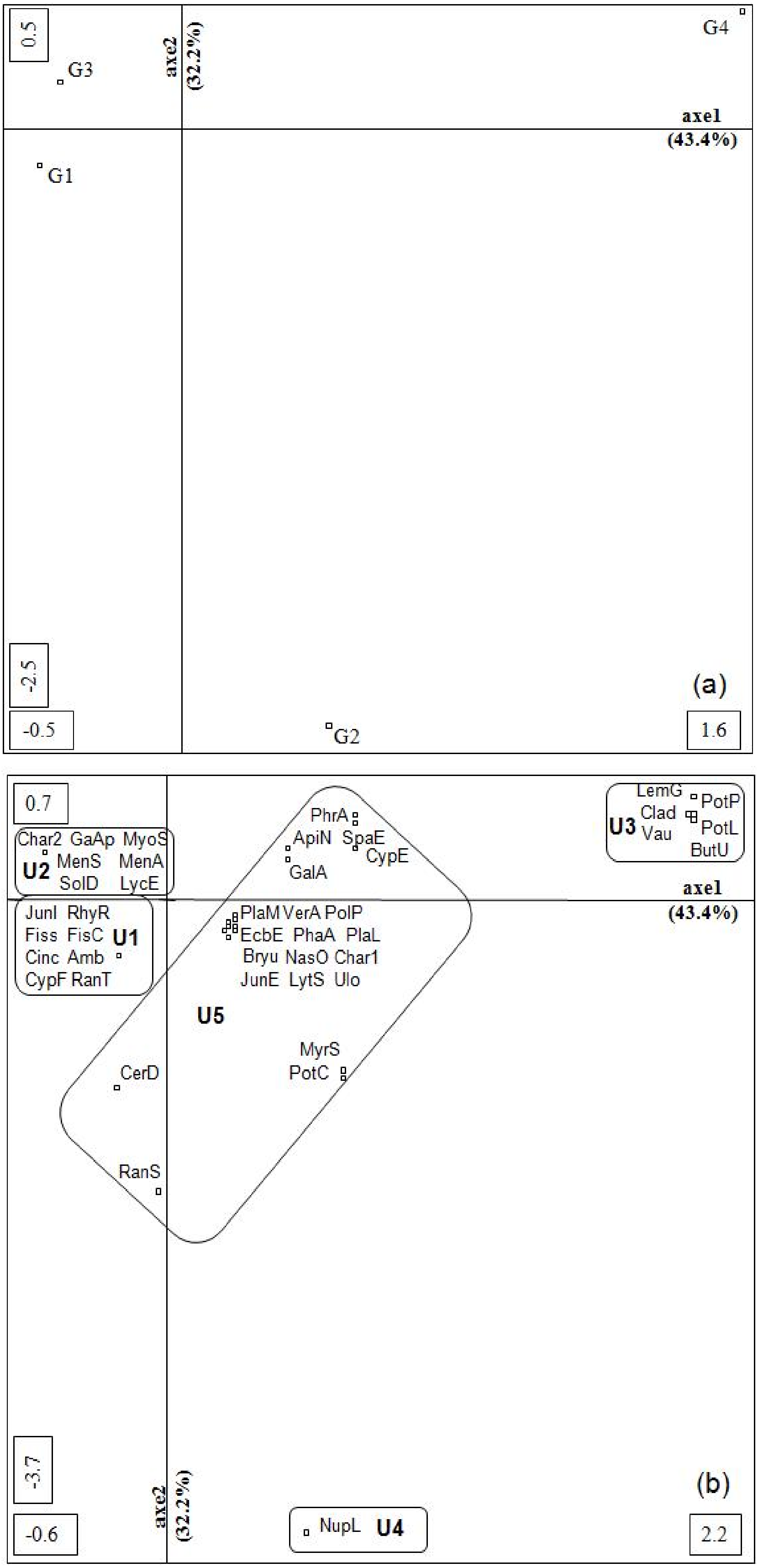

Figure 7 FCA applied on the 43 biotic variables (presence -absence for the qualitative statements) in G1, G2, G3 and G4. Projection of stations points (a) and biotic variable points (b). Hydrophyte: Amb, CerD, Cinc, Clad, Char1, Chara2, Fiss, FissC, LemF, MyrS, NupL, PotC, PotL, PotP, RanF, RanT, RhyR, SpaD, Ulo, Vau. Helophyte: ApiN,ButU, CypE, JunE, JunI, LytS, MenA, Mens, MyoS, NasO, LycR SolD, PhaA, PhrA, PolP, VerA. Terrestrial: Bryu, GaAp, GalA, CypF, EcbE, PlanL, PlaM.

IV. DISCUSSION

According to non-biotic variables, temperature, depth and current velocity vary according to seasons. This is due to the precipitation, management and the regulation operations especially used for agriculture activity (Ismaïl et al., 2009). In contrast to result found at Litani River (Ismaïl et al., 2009) conductivity for all studied stations show that the water is slightly mineralized (Nisbet & Vernaux, 1970 – EU requirements).

In term of zonation, contrary to what was found on Litani river (Ismaïl et al., 2009) the evolution of physicochemical characteristics confirm the results indicated by Ismaïl H. (2008) on Ghouzaiel river and show an eutrophication according to upstream downsteam gradient (Illies & Botosaneanu, 1963).

Considering macrophyte communities, the floristic groups represented in the studied sectors are primarily macro-algae, phanerogams (monocotyls and dicotyls) with some bryophytes on the crenal (G1). The absence of bryophytes and pteridophytes on rithral (G2, G3) and potamal (G4) stations reflected a granulometric and thermal assessment unfavorable in different stations and an absence of ripisylve which supports the sunshine, thus the competition with higher plants is exerted to the detriment of bryophytes and pteridophytes. In the same way, the absence of hygrophytes and terrestrial phanerogams on G2 is dependent on the total absence of trues banks and a strong tourist pressure which represent strong disturbances and act by reducing specific diversity on this station confirming thus the work of Bernez et al. (2000) and Abou-Hamdan (2004) which showed that sectors of rivers with moderate disturbance present a phytocenosis more diversified than the low or strongly disturbed sectors. These results seem to answer the “intermediate Disturbance Hypothesis” (IDH) (Connel, 1978) what can explain the fact that the taxonomic richness is more important in G1 and G3 (sector less disturbed than G2 and G4).

By comparison with floristic list of upper Litani river (Ismaïl et al., 2009; Ismaïl, 2008), the floristic list drawn up on Ghouzaiel river testifies to a taxonomic richness rather important in spite of the length of Ghouzaiel river (18 Km) relatively much shorter than that of upper Litani river (80 Km).

The taxonomic richness and plant covering of Ghouzaiel macrophytic vary in space and time. The distribution and the characteristics of macrophyte populations, at the short and long term, depend directly on chemical factor such as the concentration of organic and mineral nutritive matters (Robach, 1996; Abou-Hamdan, 2004; Abou-Hamdan et al., 2005; Tracy et al., 2003; Ismaïl et al., 2009). It is the same for the physical factors such as width, depth, flow, velocity, granulometry and sunlight (Thiébaut & Muller, 1999; Abou-Hamdan, 2004; Breugnot, 2007). Thus, Lemna gibba, Vaucheria sp. and Cladophora sp. (favoured by the high nitrate phosphate and sulfate concentrations) were well represented at G4. Ranunculus sphaerospermus was developped in rapid water (station G2, G3) and Ranunculus trichophyllus in still water (station G1). These results confirm information in flora literature (Bonnier 1990, Fare et al. 2001). In addition, G1, which presents a limnocrene source, lodges a very specific flora characterized by the colonization of hydrophytes species dominated by pionneers species such as Chara sp. (Fayolle, 1998; Ismaïl et al., 2009). The rithral stations (G2, G3) are marked by flora rich in hydrophytes phanerogams as the sector is broader (Ismaïl, 2008) (G3 is Border and less disturbed than G2).

Concerning Nuphar luteum it presence in G2 and disappearance in G3 and G4 may be related to the variation of water level and pollution degree. Research on its maintenance either with seeds or vegetative fragments should be undertaken especially that this species was not mentioned before in literature in Lebanon. It was added to the flora of Lebanon (Thome et.al., 2014) after we detect it in Ghouzaiel in 2010.

The presence of Ceratphyllum demersum (L.) native in North-American and regarded as invasive species (Hyldgard & Brix, 2012; Dewitton et al., 2009) which can be found in ponds, lakes, ditches, and quiet streams with moderate to high nutrient levels (El Ghanem, 2010; Keskinkan et al. 2004; 2007) require a follow-up and a surveillance of proch considering the danger it caused to other ecosystems such as some lake in New Zeland (Champion and Clyton 2001, 2002) and which can potentially cause on Ghouzaiel river and other Lebanese rivers.

V. CONCLUSION

Abiotic and biotic factors revealed some anthropic disturbance and some pollution from the source of Ghouzaiel and all the way along the river. All the species and the cover rates of the macrophyte seemed to depend on the following combined two main factors: seasonal and annual climatic variations, which lead to drastic changes in the hydrological conditions (flooding), and anthropogenic disturbances such as organic and domestic pollution, water management and regulation operations related to agriculture and touristic activities.

The detection for the first time in Lebanon since 2000 of Nuphar luteum in Ghouzaiel river reveal the potential of this river and require an ecological follow-up which will protect the functioning and biodiversity of such type of ecosystems. In addition, the presence of Ceratophyllum demersum requires further montoring. This species considered as invasive in literature can prolifere in Ghouzaiel and may destroy the ecosystem and reduce the biodiversity of this river already weakened by disturbances of various origins. However further researches are needed on other rivers especially in upper Litani basin in order to obtain more data for better understanding the functioning of Litani River and its effluents.

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