PROJECT TITLE:

Strengthening the scientific foundation of water quality programs

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ACTION 3: RIVER BASIN FUNCTIONS AND VALUES ANALYSIS AND WATER QUALITY CRITERIA DETERMINATION

DELIVERABLE 2: STATUS OF THE ECOSYSTEM REPORT

Final Report

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Contents

1. INTRODUCTION

Temporary salt lakes

The cyclical nature of many temporary waters creates habitats that are quite distinct from those found in permanent waters (Williams, 2005). The former support biotas containing many elements that either is not found in other habitat types, or have their highest population in temporary waters (Williams, 2002). In terms of contributing to the Cyprus's overall aquatic biodiversity, brackish temporary waters are of considerable importance. Macrophytes are aquatic plants, growing in or near water, that are emergent, submerged or floating. They are beneficial to lake because they provide food and settler for fish and aquatic invertebrates (Vardanyan & Ingole, 2006), they produce oxygen, which helps in overall lake functioning, and provide food for some fish and other wildlife (Vardanyan & Ingole, 2006). Aquatic macrophytes are unchangeable biological filters and they carry out purification of the water bodies by accumulating dissolved metals and toxins in their tissue (Vardanyan & Ingole, 2006).

Biotas Function Analysis

The brick red unicellular algae *Dunaniella salina* (Teodoresco) is located at the base of the lake food chain since it belongs to the main primary producers of the ecosystem. Along with *Dunaniella salina,* the filamentous algae *Chaetomorpha linum*, the charophyte *Lamprothamnium papulosum*, the pteridophyte *Riella helicophylla* (Manolaki and Giannouris, 2011) and the angiosperms *Ruppia maritima var. brevirostris* and *Althemia filiformis* also support the primary productivity of the lake (Verhoeven, 1979).

The primary producers support the fairy shrimp *Branchianella spinosa* and the brine shrimp *Artemia salina* and consist the primary consumers of the food chain (Mura, 1993).

In addition invertebrates and insects laid their eggs in the secure microhabitat created by the aquatic macrophytes growing on the substrate and halophytes.

The invertebrates and insects develop colonies that attract the avifauna of the site with more than 100 bird species, like *Himantopus himantopus* L. and *Charadrius alexandrinus* L. (Birds of Greece, Cyprus and Europe, 2007). Many of them are migrating birds that stopover in order to feed and rest (http://www.birdlifecyprus.org). Furthermore, on average about 1,000-2,000 Flamingo overwinter here each year. In peak years, such as 1995 and 2005, there may be as many as 7,000 (Hadjichristophorou, 2004; Demetropoulos, 2006).

The secondary consumers level is consisted of some preying insects like *Sphodromantis viridis* and *Blepharopsis mendica*. These insects usually feed on other insects or any other dead birds, mammals or reptiles. (Battiston *et al.*, 2010; Battiston *et al.*, 2008). These producers in combination with primary consumers constitute the main food of the side avifauna. Tertiary consumers level forms the top of trophic chain and it consisted of birds, residents or migrants, feeding on insects' colonies and shrimp populations.

Terrestrial Important Functions

Other areas around the Larnaca Salt Lakes, such as the extensive salt flats, found mainly in the east and south of the lakes, with their halophytic communities are also ecologically important habitats. Many halophytes (salt loving plants) such as *Salicornia* spp (glassworts), *Suaeda fruticosa* etc. are characteristic of these salt flats which stretch down to the sea (NATURA 2000 Network).

In the small forest on the western shore of the main Salt Lake, near the Tekke, but also in other areas around the lakes, many species of orchids can be found. *Orchis italica*, *Orchis coriophora*, *Spiranthes spiralis*, *Serapias* spp, as well as several Bee orchids, such as *Ophrys umbilicata*, *O. flavomarginata*, *O. apifera*, *O. lutea*, *O. fusca* and others can be found here, some of them in profusion (Hadjichristophorou, 2008).

In the Tekke area, but also elsewhere, there is a large diversity of other plants. Various butterflies and other insects depend on these plants for their survival. Two small species of butterfly, *Zizeria knysa karsandra* and *Chilades galba* can be found here in large numbers, from spring until late in autumn. Many dragonflies and damselflies also abound near the Tekke and in the halophytic communities around the lakes. (http://www.moa.gov.cy)

Effects of environment changes on ecosystem functionality

The shallow and temporary water bodies are more exposed and sensitive to environment changes (Williams, 2002). That makes the ecosystem vulnerable as small environmental changes can disturb ecosystems' functionality and performance (Williams, 2002). According to John (2002) salt lakes have a water temperature very close to the atmospheric temperature with high diurnal and seasonal variation.

Generally, salt lakes are well oxygenated due to fact that the wind is mixing the air oxygen with the water in the interface (John, 2002) and the low depth of the salt lakes facilitates this. Also, the water temperature has an important effect on Dissolved Oxygen (Anzecc/Armacanz, 2000). In addition the rising water temperatures further decreases the D.O saturation (Boulton & Brock, 1999).

The temporary salt lake display a range of pH values depending on the stage of the filling/drying cycle, the organic matter present and the chemical composition of the sediment. The low macrophytic photosynthesis also leads to a lower pH (McComb & Qiu, 1998) and the most common pH ranges in salt lakes is 7-9.5 (John, 2002).

The water nutrient concentrations are very important in temporary wetlands and often are varying according to the stage of the hydrocycle (Smith *et al.*, 2004). The existing biota in and around the lake plays an important role in the uptake or release of nutrients.

It is well established that phosphorus concentration in sediment-water system is determined essentially by interactions between phosphorus and iron and aluminum hydroxides. These interactions can be strongly affected by several key factors, including redox, pH and temperature (McComb & Qiu, 1998). Also, uptake and release of phosphorus by biological material, mineralization of organic matter and generation of phosphate by microorganisms may create anoxic conditions at the sediment-water interface, under which phosphorus release can be greatly accelerated (McComb & Qiu, 1998).

2.1 ASSESSMENT OF SALT LAKES ECOLOGICAL CONDITION

2.1.1. Methodology

According to the results from the two years monitoring on Larnaca's salt lake complex and in order to immunize the ecosystem's functionality the following ecosystem functions should be monitored:

a) Water quality assessment

For the assessment of water quality, it is essential to take into consideration the desirable quality standards for the living organisms of the current waterbody. Some species are more tolerant to physicochemical changes in their habitat than other species (Williams, 2002, Orhanides *et al.*, 2001, 2003). If species that tend to be sensitive to pollution are present in a wetland, then that wetland seems to have a good water quality ecological status (Enderlein, 1996).

Based on this ecological information we applied several indices which use either nutrient concentration or biological communities for habitat quality assessment.

b) Biological community structure (present and abundance)

Temporary salt lakes are dominated by species with salt preferences and some other with salt tolerance (Williams, 2002). We examined the plant species composition and abundance, the presence of temporary salt lake key species, the tolerance of each species to the salinity fluctuation and the interactions between aquatic species and the surrounding habitat.

Locally, salt lakes may be more abundant than freshwater, in which case they often dominate this landscape and provide critical habitat for endemic species, and breeding and migratory birds (Jellison *et al.*, 2004).

c) The protection status of species found in the studied area.

The vertebrate fauna of the site with more than 100 bird species (Ramsar area) and 19 species of amphibians and reptiles gives a unique value to the ecosystem. Furthermore the invertebrate fauna of the area includes 63 important insects (35 endemic), like *Libelloides acaronius*, an important (Koomen & Van Helsdinger, 1996) threatened taxon listed on the European Red List of Globally Threatened Animals and Plants and on the IUCN Red List of Threatened Animals (1988) and the existence of 8 endemic land snails is an additional reason to include Larnaca Salt Lakes in Natura 2000 Network.
In addition, the small populations of Ophrys kotchyi (accepted new addition to Annex II 92/43/EEC) and the first record for the island of Cyprus of *Riella helicophylla* (Bory & Mont.), has given an additional protection status for Larnaca Salt lake complex. *Riella helicophylla is* a liverwort species included in the Red Data Book of Bryophytes as an European endangered species.

d) The status of microhabitats that influence species survival-the extent of the littoral zone and the occupied area by the halophytic vegetation.

The extensive salt flats, found mainly in the east and south of the lakes, with their halophytic communities are ecologically important habitats. Many halophytes (salt loving plants) such as *Salicornia* spp (glassworts) and *Suaeda fruticosa* are characteristic of these salt flats which stretch down to the sea (NATURA 2000 Network). A lot of invertebrates and insects laid their eggs in the secure microhabitat created by the aquatic macrophytes growing on the substrate and halophytes.

Furthermore, at many types of temporary waters, the formation of algal mats and especially those formed from the drying and felted remains of filamentous species can be crucial to the survival of other organisms that may take refuge under them during drought. (Reynolds, 1983; Williams, 2005). The preservation of the habitats and the food network is crucial for the sustainability of the ecosystem.

2.1.2 Results

1) Water quality assessment

The nutrient and trophic status were worldwide used to assess the impact of human activities on inland waterbodies (U.N.E.P, 2006). The following analyses provide information pertaining to temporal and spatial variability of water physicochemical parameters, water quality, trophic state and habitat evaluation based on biological communities. All those information are going to be used to the proposal of water quality standards for salt lake ecosystem.

i) Physicochemical variables between stations

In order to perform any statistical test of the physicochemical data the One-Sample Kolmogorov-Smirnov test normality was applied to the whole dataset. The physicochemical parameters were first log-transformed for multivariate analysis (log x + 1) to approximate normal distribution. The results showed that from the 12 physicochemical variables tested during the present study five [*Temperature, Conductivity, pH, Ammonium nitrogen* (NH_4*-N)* and *Dissolved Inorganic Nitrogen (DIN)]* followed normal distribution (Table 1). On the other hand *Dissolved Oxygen* (D.O), %O2, *Salinity*, *Nitrate nitrogen* (NO_3-N), *Nitrite nitrogen* (NO_2-N), *Soluble Reactive Phosphorus* (SRP) and *Total Phosphorus* (TP) were not normal distributed (Table 1).

Table 1: Results of the **One-Sample Kolmogorov-Smirnov** test of normality applied on water physicochemical variables.(# indicates normal distribution)

Test of Normality	Kolmogorov-Smirnov(a)		
	Statistic	df	Sig.
# Temperature (^oC)	**0,080**	**55**	**0,200**
# Conductivity (mS/cm)	**0,114**	**55**	**0,070**
DO (mg/l)	0,268	55	0,000
% O_2	0,257	55	0,000
Salinity ($^0/_{00}$)	0,156	55	0,000
# pH	**0,070**	**55**	**0,200**
NO_3-N (mg/l)	0,221	55	0,000
NO_2-N (mg/l)	0,249	55	0,000
# NH_4-N (mg/l)	**0,099**	**55**	**0,200**
# DIN (mg/l)	**0,105**	**55**	**0,200**
SRP (mg/l)	0,346	55	0,000
TP (mg/l)	0,185	55	0,000
* This is a lower bound of the true significance.			
[a] Lilliefors Significance Correction			
# Normal distributed variables			

In order to investigate the temporal (between seasons and years) and spatial (between sampling stations) variability of the physicochemical dataset, one Way ANOVA (Table 2) was applied to the normal distributed variables (Temperature, Conductivity, pH, NH_4-N, DIN) while Kruskall-Wallis non parametric test was applied to non normal distributed variables (D.O, % O_2, Salinity, NO_3-N, NO_2-N, SRP, TP).

Table 2: Results of One-Way ANOVA among sampling stations for the normal distributed variables

Variables	***F***	**Sig.**
Temperature (^oC)	0,170	0,990
Conductivity (mS/cm)	1,097	0,384
pH	1,667	0,145
NH_4-N (mg/l)	0,719	0,656
DIN (mg/l)	0,517	0,817

The application of One Way ANOVA test showed the absence of significant spatial variability between the 8 sampling sites of Larnaca salt lake complex. None of the 5 variables that follow the normal distribution appeared to have statistically significant differences ($p<0.05$) among the sampling stations (Table 2). On the other hand the temporal variability of the normal distributed variables showed that water temperature is very important variable on salt lake ecosystems and showed statistically significant differences both between seasons (dry/wet) and years (2010/2011) (Tables 3 and 4).

Also, Dissolved Inorganic Nitrogen (DIN) appeared to have statistically significant differences between seasons (Table 3) and pH between years (Table 4).

Table 3: One-Way ANOVA between wet/dry periods for the normal distributed variables

Variables	*F*	Sig.
Temperature (°C)	**34,945**	**0,000**
Conductivity (mS/cm)	1,585	0,214
pH	3,681	0,061
NH_4-N (mg/l)	0,003	0,954
DIN (mg/l)	**8,711**	**0,005**

Table 4: One-Way ANOVA between 2010/2011 years for the normal distributed variables

Variables	*F*	Sig.
Temperature (°C)	**31,365**	**0,00**
Conductivity (mS/cm)	0,015	0,90
pH	**7,899**	**0,01**
NH_4-N (mg/l)	0,480	0,49
DIN (mg/l)	**23,210**	**0,00**

The investigation of the temporal and spatial variability of the non normal distributed variables showed that some pattern as with normal variables. The application of Kruskall-Wallis test showed the absence of significant spatial variability between the 8 sampling sites of Larnaca salt lake complex. None of the 7 variables appeared to have statistically significant differences ($p<0.05$) among the sampling stations (Table 5).

Table 5: Kruskall-Wallis test among sampling stations for the non-normal distributed variables

	Chi-Square	Asymp. Sig.	Monte Carlo Sig.	99% Confidence Interval	
				Lower Bound	Upper Bound
D.O (mg/l)	3,265	0,859	0,874	0,865	0,882
% O_2	2,791	0,904	0,912	0,905	0,919
Salinity ($^0/_{00}$)	6,547	0,478	0,493	0,480	0,506
NO_3-N (mg/l)	2,547	0,923	0,932	0,925	0,938
NO_2-N (mg/l)	6,410	0,493	0,514	0,501	0,526
SRP (mg/l)	5,343	0,618	0,639	0,626	0,651
TP (mg/l)	4,790	0,686	0,706	0,694	0,717

One the other hand according to the results of the Kruskall Wallis test, Dissolved Oxygen (D.O), %O_2, Nitrate nitrogen (NO_3-N), Soluble reactive Phosphorus (SRP) and Total Phosphorus (TP) appeared to have statistically significant differences ($p<0.05$) both among seasons (dry/wet) (Table 6) as well as among years (2010/2011) (Table 7).

Table 6: Kruskall-Wallis test between wet/dry periods for the non-normal distributed variables

	Chi-Square	Asymp. Sig.	Monte Carlo Sig.	99% Confidence Interval	
				Lower Bound	Upper Bound
DO (mg/l)	**15,65**	**0,00**	**0,00**	**0,00**	**0,00**
% O_2	**17,95**	**0,00**	**0,00**	**0,00**	**0,00**
Salinity ($^0/_{00}$)	1,65	0,20	0,20	0,19	0,21
NO_3-N (mg/l)	**15,67**	**0,00**	**0,00**	**0,00**	**0,00**

NO_2-N (mg/l)	3,29	0,07	0,07	0,06	0,08
SRP (mg/l)	**8,40**	**0,00**	**0,00**	**0,00**	**0,01**
TP (mg/l)	**12,08**	**0,00**	**0,00**	**0,00**	**0,00**

Table 7: Kruskall-Wallis test between 2010/2011 years for the non-normal distributed variables.

	Chi-Square	Asymp. Sig.	Monte Carlo Sig.	99% Confidence Interval	
				Lower Bound	Upper Bound
DO (mg/l)	**8,94**	**0,00**	**0,00**	**0,00**	**0,00**
% O_2	**16,67**	**0,00**	**0,00**	**0,00**	**0,00**
Salinity ($^0/_{00}$)	0,01	0,93	0,94	0,93	0,94
NO_3-N (mg/l)	**38,65**	**0,00**	**0,00**	**0,00**	**0,00**
NO_2-N (mg/l)	0,47	0,49	0,49	0,48	0,51
SRP (mg/l)	**6,92**	**0,01**	**0,01**	**0,00**	**0,01**
TP (mg/l)	**1,99**	**0,16**	**0,16**	**0,15**	**0,17**

ii) Trophic Indices

OECD classification

Despite the fact that Salt lakes are geographically widespread, numerous and a significant part of the world's inland aquatic ecosystems, limnologists and other groups interested in inland waters have largely ignored salt lakes until recently (Williams, 2002). Especially in Mediterranean region attention was given to brackish (lagoon) (e.g Specchiulli *et al*., 2008; Borja *et al*., 2007; Coehlo *et al*., 2007, Sfriso *et al*., 2007; Chrystia *et al*., 2007; Menendez *et al*., 2002; Comin *et al*., 2004) and lake ecosystems (e.g Boros *et al*., 2011; Stefanidis *et al*., 2010; Kagalou *et al*., 2009, Papastergiadou *et al*., 2009; Stefanidis *et al*., 2007; Karl, 2003; Andrian *et. al*., 1995, Van Liere *et al*., 1992).

Only few studies were published considering salt lakes and for Cyprus salt lake complex only Tziortzis (2008) and Chrystia *et al* (2011) published the flora of the ecosystems.

As a consequence, there is a significant lack of basic information considering the thresholds of the nutrient concentration in order to evaluate the water quality of the ecosystem. One of the first trophic classification schemes for lakes was developed by Carlson (1977) who used chlorophyll *a* and transparency (secchi disc depth) as measures of trophic status. Also, the most widely recognised classification in terms of chlorophyll *a* (and transparency) that developed during the OECD programme on eutrophication (OECD, 1982). This developed quantitative regression models relating chlorophyll *a* concentrations to total phosphorus concentrations (Table 8).

Table 8: OECD classification scheme for lake trophic status

	Annual mean TP (μg/l)	Annual mean chlorophyll a (μg/l)	Annual maximum chlorophyll a (μg/l)	Annual mean secchi depth (m)
Ultra-oligotrophic	<4	<1	<2.5	>12
Oligotrophic	<10	<2.5	<8	>6
Mesotrophic	10-35	2.5-8	8-25	3-6
Eutrophic	35-100	8-25	25-75	1.5-3
Hypertrophic	>100	>25	>75	<1.5

Due to the lack of classification scheme for salt lake ecosystems, in order to characterize the trophic level of Larnaca salt lake complex we used the OECD eutrophication criteria (Table 8).

According to the OECD classification Larnaka Salt Lake ecosystem is characterized "*Eutrophic or Hypertrophic*" (Table 9). Taking in consideration the concentrations of annual *mean chlorophyll-a* and annual *max chlorophyll-a*, Larnaka Salt Lake is classified as a *Eutrophic* ecosystem. On the other hand TP mean annual concentration is much higher than the upper limit about Eutrophic lakes. As long as phosphorus is the limiting factor of ecosystem's productivity, according to OECD classification the ecosystem should be included in "*Hypertrophic*" class.

Table 9: Results from OECD classification scheme for Larnaca salt Lake Ecosystem.

	Annual mean TP (μg/l)	**Annual mean chlorophyll a (μg/l)**	**Annual maximum chlorophyll a (μg/l)**
Eutrophic or Hypertrophic	546.66	11.39	25.26

The criteria for the annual mean depth was considered as unsuitable for temporary ecosystems since the maximum depth of the lake during wet period is about 2m and the index might underestimate the ecological status of the ecosystem.

TRIX Trophic Index

In order to be closer to the salinity values of the salt lake we additionally applied the TRIX trophic index. TRIX proposed by Vollenweider *et al*. (1998) provides useful metric for the assessment of the trophic status of coastal waters. According to Giovanardi & Vollenweider (2004) and Penna *et al.* (2004), TRIX values ranging from 0 to 4 correspond to high quality, 4-5 to good, 5-6 to moderate and 6-10 to degraded conditions.

The calculation of the trophic index (TRIX) integrates Chl-*a*, oxygen saturation, dissolved inorganic nitrogen and dissolved inorganic phosphorus and is scaled from 0 to 10, covering a range of four trophic states (*high*, *good*, *moderate,* and *degraded*). The equitation used to calculate the TRIX index is the following:

$$TRIX = [Log_{10} (Chl\text{-}a * aD\%O * DIN * TP)-(k)]/m,$$

Where: Chl-*a* is expressed as μg/l, Oxygen as absolute (%) deviation from saturation [abs |100-%O|= a D%O, DIN (NO_3-N+NO_2-N+NH_4-N) as μg/l, Total Phosphorus (TP) as μg/l and k= -1.5 while m=1.2.

Figure 1 indicates that the eutrophication status in Larnaca's salt lake varied from 5.2 on July 2011 (*moderate* quality) to 8.2 on February 2010, thus indicating a "*degraded*" condition. Along the monitoring period, the majority of the sampling sites (62.5%) had a *degraded* water quality (TRIX: 6-10) typical from high productive ecosystems. The 37.5% of the samples had a *moderate* (TRIX: 5-6) conditions, typical from moderately productive ecosystems with mean trophic level. High and good trophic conditions did not observed during the monitoring period (Table 10).

Table 10: TRIX Index values measured in Larnaca's salt lake ecosystem during the monitoring period 2010-2011.

	TRIX Index
Feb 10	8,2
Mar 10	7,6
Apr 10	5,4
Dec 10	7,2
Jan 11	7,1
Mar 11	6,5
Apr 11	5,6
Jul 11	5,2

In relation to the indicators of trophic level, it is concluded that the eutrophication status of Larnaca's salt lake according to TRIX index is characterized by *moderate* to *degraded* water quality showing the highest values during the wet period (Figure 1). During that period the precipitation values and the agricultural runoff enhances the amount of nutrients in Larnaca's saline lake. The high values of TP and Chl-*a* concentrations measured during the monitoring period affect the TRIX Index scores. The implementation of trophic indices has to be discussed on the framework of European Environment Agency (EEA) activities if the limits proposed and used by Vollenweider *et al.* (1998) are an acceptable assumption for monitoring and assessing the trophic state of all European coastal and marine waters (EEA, 2001), as the index was developed for the northern Adriatic waters. Despite these restrictions, it was used to assess the trophic status of a European coastal lagoon also (Coehlo *et al*. 200; Salas *et al*. 2008).

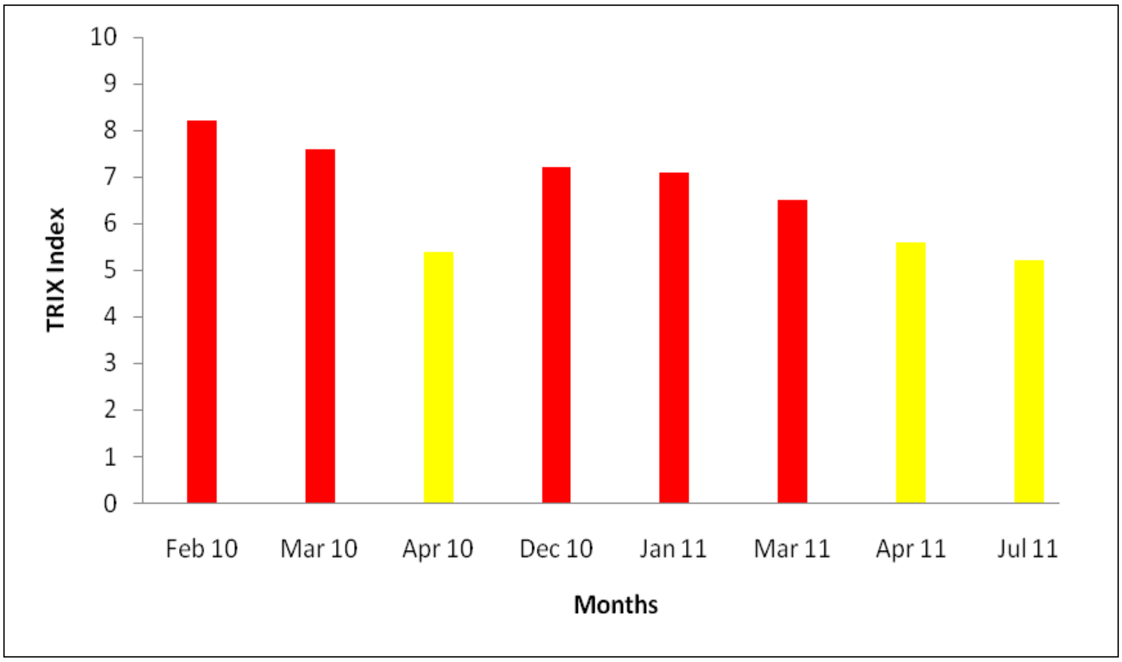

Figure 1: TRIX Index values measured in Larnaca's salt lake during the monitoring period 2010-2011.

As it was noted before, there is lack of threshold criteria for water nutrients in the case of salt lake ecosystems, especially for temporary. So we applied OECD classification and Trix Index in order to have a general overview of trophic status of the lake. However, the high salinity values might be constraint to OECD index reliability. Furthermore the criteria for the annual mean depth was considered as unsuitable for temporary ecosystems since the maximum depth of the lake during wet period is about 2m and the OECD index might underestimate the ecological status of the ecosystem.

In addition, the inefficient implementation of TRIX Index and the low scores of the ecosystem strengthen the need of developing an Ecological Index applicable for salt lakes as well.

b. Biological community structure

According to Williams (2002), eutrophication is less concern in salt lakes, however those ecosystems are threatened or impacted by other human activities less important for freshwater lakes (Williams, 1993).

Human activities that pose a heightened or significant threat to salt lakes are: *surface inflow diversions*, *salinization* and other catchment activities, *biological disturbances, mining*, *pollution*, and anthropogenically-induced climatic and atmospheric changes (Williams, 2002). Their relative importance varies according to the type of lake involved and time.

For the evaluation and management of salt lake ecosystems it is critical to identify the key biological signals (*impacts*) that indicate the intensity of anthropogenic stress or ecological status.

Orphanidis *et al* (2001) was pointed one critical issue for the assessment of the ecological status of coastal ecosystems, which was the spatial and temporal variability in community features as a result of changes in physical and chemical conditions. They also suggested that one possibility for overcoming this complexity is to study communities from a functional point of view (groups of functionally similar species) (Table 11). At a functional level, communities appear to be much more temporally stable and predictable than when examined at the species level (Steneck & Dethier, 1994;. Steneck & Walting, 1982) For example, anthropogenic stress shifts the community structure towards dominance of opportunistic species (Borowitzka, 1972; Regier & Cowell, 1972).

Ecological Evaluation Index (EEI)

Based on this theory, we tried to apply the concept of Ecological State Groups proposed by Orphanidis *et al* (2001) to the sampling stations of Larnaca salt lake complex.

Table 11: A list of the marine benthic macrophytes that included to EEI species list along with their functional characteristics and growth strategies. (Reproduced from Orphanidis **et al**., 2001).

Ecological State Group	Function Form Group	External Morphology	Internal Anatomy	Productivity	Longevity (Succession)	Growth Strategies	Genera
II	A. Sheet-Group	Thin tubular and sheet like (foliose)	Uncorticated, one-several cells thick	High	Annuals (Opportunistic)	Ruderal	Ulva, Enteromorpha, Scytosophon (erect phase), Dictyota
II	B. Filamentous - Group	Delicately branched (filamentous)	Uniseriate, multiseriate or lightly corticated	High	Annuals (Opportunistic)	Ruderal	Cyanophyceae, Chaetomorpha, Cladophora, Polysiphonia, Ceramium, Spyridia
II	C. Coarsely branched upright	Coarsely branched upright	Corticated	Species specific	Annuals (Mid-Succesional)	Stress-tolerant-Ruderal or Stress-tolerant-Competitors	Acanthophora, Caulerpa, Chordaria, Gracilaria, Laurencia, Liagora
I	D. Thick Leathery-Group	Thick blades and branches	Differentiated, heavily corticated thick walled	Low	Perennials (late-succesional)	Competitors	Cystoseira, Chondrus, Fucus, Laminaria, Padina, Sargassum, Udotea
I	E. Jointed Calcareous-Group	Articulated, calcareous, upright	Calcified genicula, flexible intergenicula	Low	Perennials (late-succesional)	Competitors	Amphiroa, Corralina, Galaxaura, Halimeda, Jania
I	F. Crustose-Group	Epilithic, prostrate, encrusting	Calcified or uncalcified parallel cell rows	Low	Perennials (late-succesional)	Competitors	Hydrolithon, Lithothamnion, Peyssonnelia, Porolithon
I	G. Seagrasses	Highly differentiated from foliose to cylindrical (Leafs, rhizomes, roots, flowers, fruits)	Highly differentiated (epidermis, mesophyll, vascular system	Low	Perennials (Pioneers to late-succesional)	Stress-tolerant	Cymodocea, Posidonia, Ruppia

The concept behind the index is based on the ecological observation that an anthropogenic stressed ecosystem is dominated by opportunistic species (Table 11) (Orphanidis *et al.,* 2001, 2003).

Specifically, in coastal ecosystems, species according to their functional characteristics and their growth strategies could be classified into 2 different Ecological State Groups (**ESG**). The first group (**ESG I)** includes the late successional species while group **ESG II** referred to the opportunistic plant species (Table 11) (Orphanidis *et al*., 2001, 2003).

The ***Ecological Evaluation Index*** (**EEI**) ranges from 2 to 10 (Figure 2) and is evaluate the overall ecological status of transitional and coastal waters. EEI is determined by estimate in each releve of the non overlapping polygons (PP) the absolute abundance (%) of each ESG, the average abundance (%) of ESG I and II, the surface area of each PP is multiplied by their ecological status value and then divided by the sum of surface areas of PPs (Figure 2). The area- or length-weighted values are then summed to obtain EEI and the ecological status category of the ecosystem (Orphanidis *et al.,* 2001, 2003).

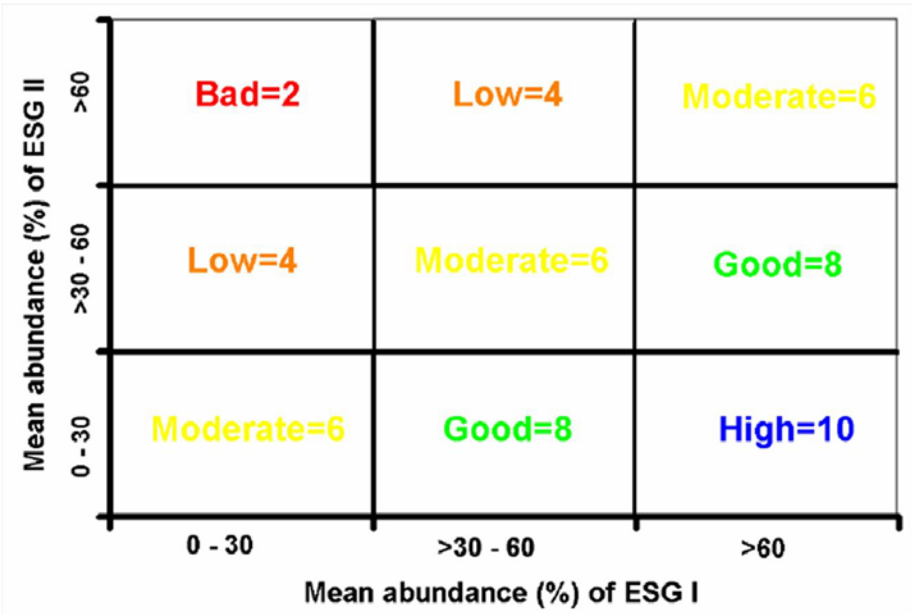

Figure 2: A matrix based on the mean abundance (%) of ESGs to determine the ecological status of transitional and coastal waters (Reproduction from Orfanidis S., 2007).

Table 12: A numerical scoring system for the evaluation of ecological status of transitional and coastal waters.

Numerical value of ecological categories	Ecological Evaluation Index (EEI)
High = 10	[≤10 - >8] = High
Good = 8	[≤8 - >6] = Good
Moderate = 6	[≤6 - >4] = Moderate
Low = 4	[≤4 - >2] = Low
Bad = 2	[2] = Bad

Pilot application of EEI in Larnaca Salt Lake

EEI index was pilot applied in 2 sampling stations of Larnaca salt lake. The selected sampling sites were sampling station 3 and sampling station 5 (see for details Deliverable I, page 16). Index was applied seasonally (wet and dry period) both for 2010 and 2011 years. In total, 8 indices were estimated; four for each sampling site (wet periods of 2010 and 2011 and dry periods of 2010 and 2011).

As it was proposed by Orphanidis *et al* (2003), in each selected station a cell of dimensions 10m X 10m was chosen and subsamples were taken from each cell (Orphanidis *et al*., 2003). We tried to cover the proposed number of 3 samples per season per cell (Orphanidis *et al.,* 2003). But in some cases, especially in dry periods, this was unfeasible because the previously selected samples were dried out.

The results for ***Ecological Evaluation Index*** (**EEI**) pilot application are presented in Table 13. Sampling station 3 according to EEI could be characterized as *High* and *Good* habitat quality. The number and the cover of the late successional species in sampling station 3 were indicated that the environmental condition of the site is not suffered by opportunist species like filamentous algae (Table 13).

Table 13: Classification of Stations 3 & 5 according to *EEI*

STATION	EEI	SEASON	YEAR	Classification
3	8.8	WET	2010	High
5	6	WET	2010	Moderate
3	8.6	DRY	2010	High
5	4	DRY	2010	Low
3	8	WET	2011	Good
5	6	WET	2011	Moderate
3	8	DRY	2011	Good
5	7	DRY	2011	Good

It also important to mention that inter-seasonal (dry/wet) fluctuations of EEI values of Sampling site 3 did not show significant differences (Table 13). On the other hand the habitat quality of sampling site 3 during 2010 was classified as *High* and during 2011 was classifies as *Good* (Table 13).

The degradation of sampling site 3 habitat quality (High → Good) during 2011, may be due to the late start of wet period (first rainfall 15/12/2010) which was characterized by intense rainfall incidents. The increase of nutrient salts concentrations result may be occurring as a result of nutrients from the drainage water loadings (Shakweer, 2006). The unexpected and intense rainfall incidents cause rapid and massive inflows in Salt Lakes that can cause big changes to ecosystems status because of salinity drop and nutrients salts.

The ecological quality of Sampling site 5 was varied from *Low* to *Good* (Table 13). The lowest EEI value was estimated during the dry period of 2010 and the highest value during dry period of 2011 (Table 13). It is also important to notice that during 2010 the habitat quality of the main course of the salt lake was dominated by the filamentous algae *Chaetomorpha linum* and we considered this fact the reason of the low quality status during this year.

When the water nutrient loads are high (especially nitrogen rather than phosphorus), species composition shifts from the dominance of angiosperms to blooms of opportunistic and nitrophilous macroalgae (Orfanidis *et al.*, 2008; Viaroli *et al.*, 2008; Sfriso, 1987; Sfriso *et al.*, 1987;), due to their more efficient nutrient assimilation (Thompson & Valiela, 1999) and lower light level demand (Congdon & McComb 1979; Luning 1990).

The smaller water body where station 3 is located (see also Figure 4, Deliverable I) was less affected by the predominance of *Chaetomorpha linum*. Although it presence was recorded however it abundance was limited.

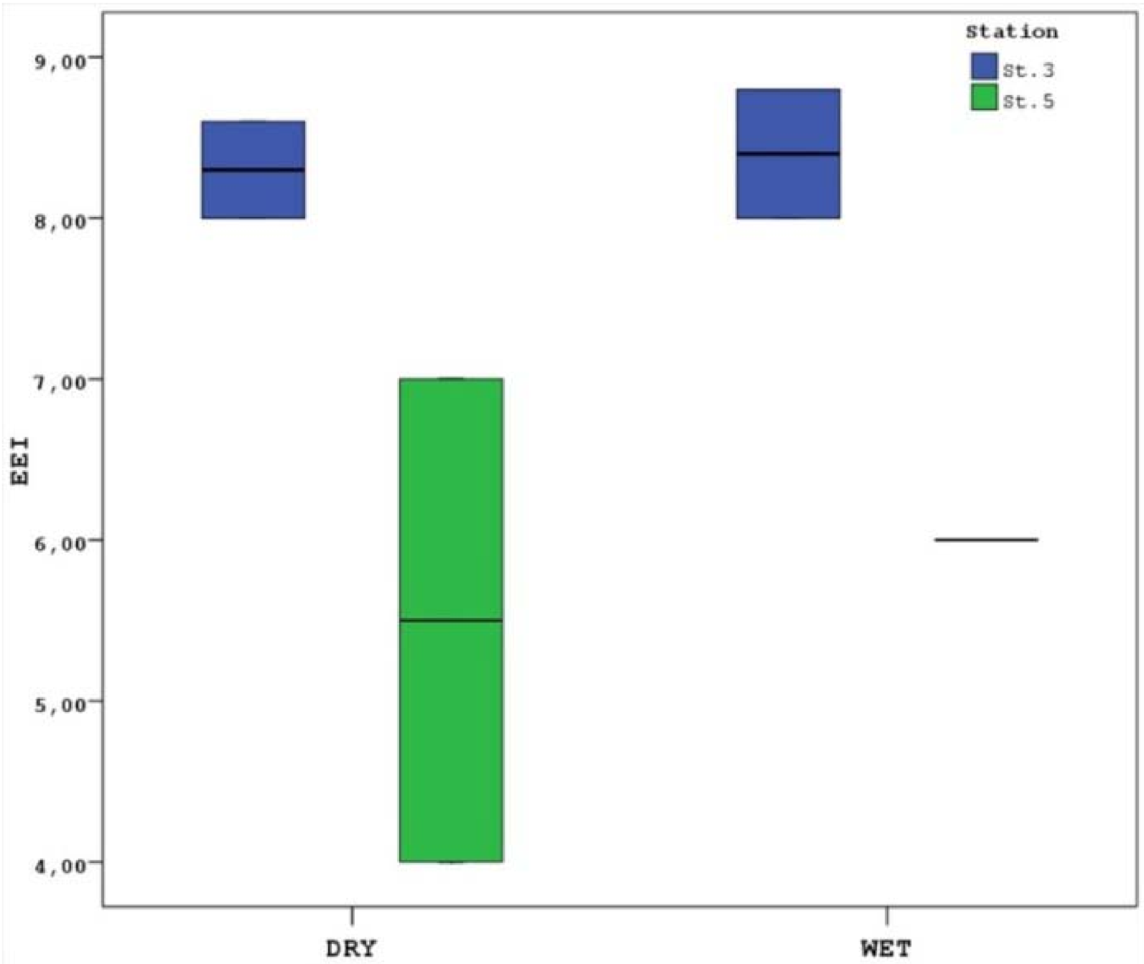

Figure 3: EEI values of sampling stations 3 and 5 for the two hydrological periods (wet/dry)

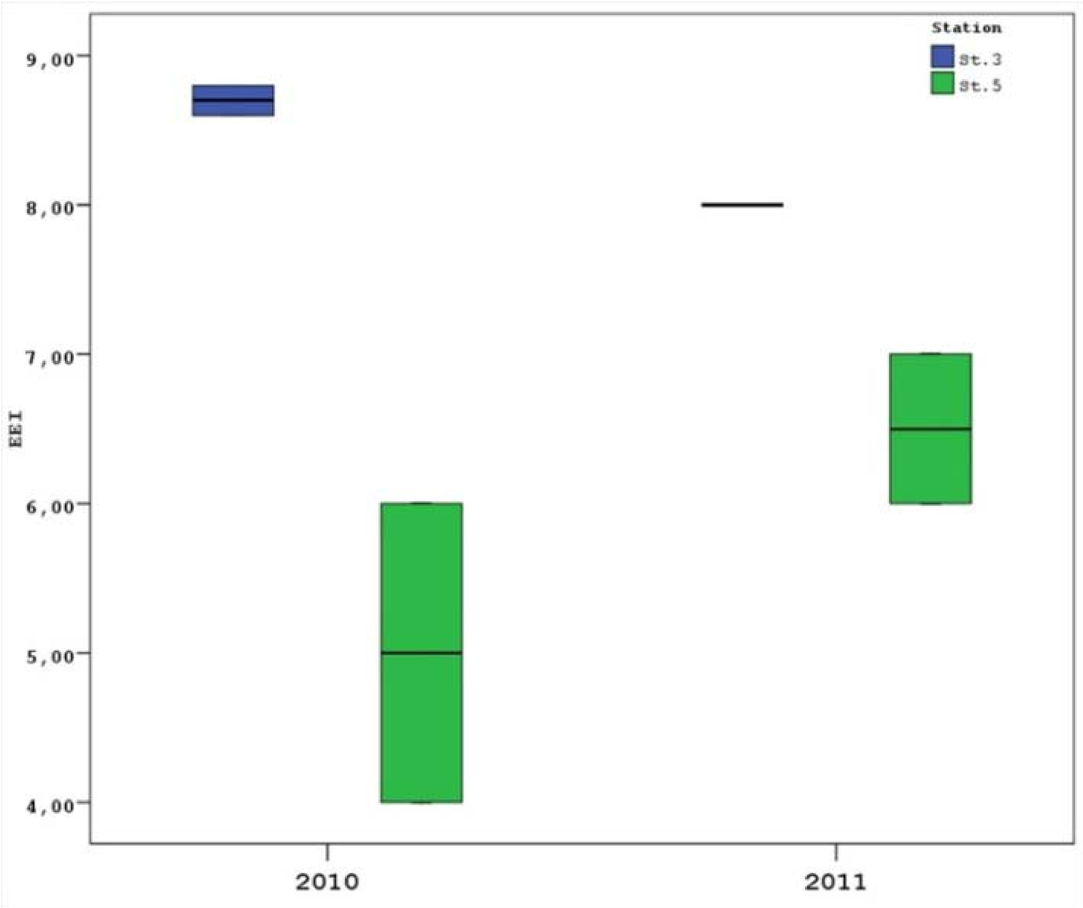

Figure 4: EEI values of sampling stations 3 and 5 for the two years of samplings (2010/2011)

c. *The protection status of species found in the studied area*

Larnaca Salt Lake complex is one of the most important wetlands of Cyprus, in terms of biodiversity. The area is one of the few locations in Cyprus where avifauna and specially migrating birds can stop over in order to feed and rest. Most common is *Phoenicopterus ruber* (flamingo) that visits Cyprus in big populations and stays here from November till the end of March.

The rest vertebrate fauna of the site consists of more than 100 bird species, 31 of them listed on Annex I 79/409/EEC (Ramsar area) or new additions to the Annex, and 19 species of amphibians and reptiles. Furthermore the invertebrate fauna of the area includes 63 important insects (35 endemic), and 8 endemic land snails (Natura 2000 Network).

The small population of *Ophrys kotchyi* (accepted new addition to Annex II 92/43/EEC) and the appearance of *Libelloides acaronius* which is an important (Koomen & van Helsdinger, 1996) threatened taxon listed on the European Red List of Globally Threatened Animals and Plants and on the IUCN Red List of Threatened Animals (1988), has given an additional reason for protecting the Study Area.

A liverwort species, *Riella helicophylla* (Bory & Mont.) Mont was found and collected from Larnaca's salt lake, making this the first record of this species for the island of Cyprus (Manolaki & Giannouris, 2011). It is included in the Red Data Book of Bryophytes as a European endangered species. The presence of *Riella* in the brakish aquatic ecosystems of Cyprus is considered crucial, since only a few species manage to develop in this harsh environment. *Riella helicophylla* as a demanding macrophyte sets really high standards for water quality and conditions in comparison with the other aquatic macrophytes appearing at the study area (Manolaki et al., Unpublished data).

d. *The status of microhabitats that influence species survival –extent of the littoral zone occupied by halophytic vegetation*

The extensive salt flats, found mainly in the east and south of the lakes, with their halophytic communities are ecologically important habitats. Many halophytes (salt loving plants) such as *Salicornia spp* (glassworts), *Suaeda fruticosa* etc are characteristic of these salt flats which stretch down to the sea (NATURA 2000 Network). A lot of invertebrates and insects laid their eggs in the secure microhabitat created by the aquatic macrophytes growing on the substrate and halophytes.

Furthermore, at many types of temporary waters, the formation of algal mats and especially those formed from the drying and felted remains of filamentous species can be crucial to the survival of other organisms that may take refuge under them during drought. (Williams, 2005).

In addition the key habitats and the vegetation species recorded by Natura 2000 Network ("*CY6000002 Alykes Larnaca*s") are increasing higher the ecological interest for the wetland. The preservation of the habitats and the food network is crucial for the sustainability of the ecosystem.

2.2. ASSESSMENT OF STREAM ECOLOGICAL CONDITION

a) Water Quality

i) Physicochemical variables

After testing the normal distribution (Table 14) of the water physicochemical data, the One-Way ANOVA test was applied to the normal distributed variables (Tables 15 and 16) while the non parametric Kruskall-Wallis test was applied to the non normal distributed variables.

Table 14: Normality test for variables of streams

	Kolmogorov-Smirnov(a)		
	Statistic	df	Sig.
Temperature (°C)	**.202**	**7**	**.200(*)**
Conductivity (mS/cm)	**.265**	**7**	**.147**
log (DO) (mg/l)	**.184**	**7**	**.200(*)**
log (%O_2)	**.166**	**7**	**.200(*)**
Salinity (‰)	**.225**	**7**	**.200(*)**
pH	**.246**	**7**	**.200(*)**
NO_3-N (mg/l)	.378	7	.003
NO_2-N (mg/l)	**.265**	**7**	**.148**
NH_4-N (mg/l)	.338	7	.015
log(DIN) (mg/l)	**.237**	**7**	**.200(*)**
SRP (mg/l)	.306	7	.046
TP (mg/l)	**.221**	**7**	**.200(*)**
* This is a lower bound of the true significance.			
a Lilliefors Significance Correction			

Tables 15-16 illustrate the results from One-Way ANOVA between the normal distributed variables in order to test the inter-annual and the seasonal (wet/dry) differences between the water physicochemical variables collected from both stream sites. The results showed that only Total Phosphorus had statistically significant differences between years (Table 15); while water temperature and Total Phosphorus are statistically significant different between seasons (Table 16).

The results from the non-normal distributed variables among years and seasons showed that the tested physicochemical parameters (NO_3-N, NH_4-N and SRP) had no statistically significant differences.

Table 15: One-Way ANOVA between 2010/2011 years for the normal distributed variables.

	F	***Sig.***
Temperature (^oC)	1.800	0.237
Conductivity (mS/cm)	0.224	0.656
log (DO) **(mg/l)**	0.030	0.870
log (%O_2)	0.001	0.971
Salinity ($^0/_{00}$)	0.085	0.782
pH	0.479	0.520
NO_2-N (mg/l)	0.005	0.944
log(DIN) (mg/l)	2.198	0.189
TP (mg/l)	**12.977**	**0.011**

Table 16: One-Way ANOVA between wet/dry periods for the normal distributed variables

	F	***Sig.***
Temperature (^oC)	**6.625**	**0.050**
Conductivity (mS/cm)	0.173	0.695
log (DO) **(mg/l)**	0.778	0.418
log (%O_2)	0.415	0.548
Salinity ($^0/_{00}$)	0.286	0.616
pH	0.567	0.485
NO_2-N (mg/l)	0.148	0.714
log(DIN) (mg/l)	0.146	0.716
TP (mg/l)	**17.789**	**0.006**

ii) Water Quality Assessment

Water nutrient levels are one of the most important parameters that influenced the overall aquatic ecosystems quality. The evaluation of water quality in developing countries has become a critical issue in recent years (Ongley, 1998), especially due to the concern that fresh water will be a scarce resource in the future. In order to classify the water quality in the five quality classes proposed by Water Framework Directive 2000/60EE, we followed the classification boundaries from European countries (Table 17).

The samples from each site were pre-classified according to the time of the hydrocycle (dry or wet period).

Table 17: Levels of nutrients in the five quality classes according to different methods.

Nutrients classification for French Rivers (Brunel et al., 1997)					
	High	**Good**	**Moderate**	**Insufficient**	**Bad**
N-NO_3^- (mg/l)	<0.45	2.3	5.6-11.3	11.3-18	>18
N-NH_4^+ (mg/l)	<0.07	0.07-0.39	0.39-1.55	1.55-6.22	>6.22
P-PO_4^{3-} (µg/l)	<65	65-163	163-196	196-653	>653
TP (µg/l)	<100	100-300	300-600	600-1000	>1000
Nutrients classification for Italian Rivers (Decreto Legislativo, 1999)					
N-NO_3^- (mg/l)	<0.07	<0.34	<1.13	<2.26	>2.26
N-NH_4^+ (mg/l)	<0.023	<0.077	<0.39	<1.17	>1.17
TP (µg/l)	<100	100-300	300-600	600-1000	>1000
Nutrients classification for Rivers (Cardoso et al., 2001)					
N-NO_3^- (mg/l)	0.24	0.29	0.93	1.64	2.03
N-NH_4^+ (mg/l)	0.022	0.054	0.072	0.376	0.697
N-NO_2^- (µg/l)	3.0	4.87	11.80	48.90	89.40
P-PO_4^{3-} (µg/l)	77.4	92.7	120.0	212.1	467.0
TP (µg/l)	115.4	137.8	194.4	247.3	566.3

iii) Results of Nutrient classification systems

As it can be observed from Tables 18 and 19 the water physicochemical quality of the studied streams ranges from "*High*" to "*Bad*" ecological status, depending on the time of the hydrocycle and according to the type of nutrients.

Sampling station 9

Specifically, according to the concentration of nitrate nitrogen during the wet period the water quality of sampling station 9 was classified to as "*Good*" following the criteria values of French system while according to Italian system and the values proposed from Cardoso *et al* (2001) was classified as "*Moderate*" quality status (Table 18). During the dry period the ecological quality has been fallen an ecological class considering the nitrate nitrogen concentrations. According to the French system from "*Good*' status turn into Moderate and according to Italian system and the values proposed from Cardoso *et al* (2001) from "*Moderate*' turn to "*Bad*" ecological class (Table 18).

Table 18: Stream site 1-Station 9

STATION 9						
Variable	Period	Mean	Std. Error	French Rivers	Italian Rivers	Cardoso et al (2001)
NO_3-N (mg/l)	WET	0,62	0,12	Good	Moderate	Moderate
	DRY	3,33	3,07	Moderate	Bad	Bad
NO_2-N (mg/l)	WET	0,04	0,00			Moderate
	DRY	0,03	0,02			Moderate
NH_4-N (mg/l)	WET	4,95	3,85	Bad	Bad	Bad
	DRY	0,60	0,41	Moderate	Insufficient	Bad
TP (mg/l)	WET	0,06	0,00	High	High	High
	DRY	1,44	0,57	Bad	Bad	Bad

Considering the nitrite nitrogen concentrations, the ecological quality of sampling station 9 was classified as "*Moderate*" for both wet and dry period, according to Cardoso *et al* (2001) evaluation system. Ammonium concentration showed deterioration in water quality since during the wet period all evaluation systems were classified the water quality as "*Bad*". The unexpected and intense rainfall incidents can cause rapid and massive inflows in Salt Lakes that can cause big changes to ecosystems status because of salinity drop and a nutrient salts (Shakweer, 2006). On the other hand the water quality according to ammonium concentration during dry period was classified as "*Moderate*", "*Insufficient*" and "*Bad*" according to the three European evaluation systems. Finally, according to the Total Phosphorus concentration during the wet period the water quality was classified to "*High*" ecological status, while during the dry period all evaluation systems was classified the stream site as "*Bad*".

Sampling station 10

Considering the water quality of the sampling station 10 the ecological status seems to be more impaired condition than the station 9. The nitrate nitrogen concentration was classified the water quality as "*Good*" during both dry and wet period according to the French evaluation system (Table 19). On the other hand during the wet period the water quality was classified as "*Moderate*" considering the Italian and Cardoso *et al* (2001), while during the dry period the water quality was drop to "*Insufficient*" and "*Bad*' quality classes respectively (Table 19).

On the other hand the water quality according to the nitrite nitrogen concentration was classified as "Insufficient" for both wet and dry periods. Furthermore, the water quality using the evaluation criteria of ammonium values was classified as "*Insufficient*" and "*Bad*" during the wet period, while during the dry period the water quality was drop to "*Moderate*" and "*Bad*" status. Finally, Total Phosphorus concentrations was classified the water quality as "*Good*" during the wet period and "*Bad*" during the dry period (Table 19).

Table 19: **Stream site 2-Station 10**

STATION 10						
Variable	Period	Mean	Std. Error	French Rivers	Italian Rivers	Cardoso Rivers
NO_3-N (mg/l)	WET	0,53	0,42	Good	Moderate	Moderate
	DRY	1,74	1,46	Good	Insufficient	Bad
NO_2-N (mg/l)	WET	0,07	0,05			Insufficient
	DRY	0,06	0,03			Insufficient
NH_4-N (mg/l)	WET	2,55	0,50	Insufficient	Bad	Bad
	DRY	1,42	0,83	Moderate	Bad	Bad
TP (mg/l)	WET	0,13	0,04	Good	Good	Good
	DRY	2,30	0,60	Bad	Bad	Bad

b. Habitat Quality

Qualitat del bosc de Ribera (QBR) Index (spanish)

In order to assess the ecological quality of the riparian zone of the two investigated streams the QBR index was applied. QBR index is a useful method to manage streams and rivers. By evaluating the riparian habitat quality turns into a useful tool into manager's hand. It can be applied in combination with other index of water quality and defining the ecological status of streams and rivers.

The QBR index consists an indicator of riparian quality that can be calculated in the field using identified and measurable features (Munne *et al.*, 2003). The index must be calculated in river or stream lengths of 50m or 100m. Both river banks should be considered together (e.g. for vegetation cover). For the index determination, the river is divided into two sections: the main channel and the riparian area. The survey area is subdivided into two: the area permanently covered with flowing water (which is not considered in the scoring process), and the channel zone between the permanently flowing reach and the bankfull. Helophytes are commonly found in the zone between the instream channel and the bankfull height, and are used in the index as an element to increase its ecological value because they provide habitat and refuge for many species. This index does not consider submerged macrophytes, because instream channel characteristics are not used (Munne *et al.*, 2003).

The QBR index ranges between 0 and 100 and it is the sum of 4 scores, based on four aspects of riparian quality. Each aspect is initially scored with one of four values: 0, 5, 10 or 25; intermediate values cannot be scored. If the final score is negative, it is recorded as 0. If the final score is above 25, it is recorded as 25. Negative values and values higher than 25 were excluded, in order to give the same importance to each of the four parts of the index (Munne *et al.*, 2003).

The four aspects of riparian quality of the QBR index:

1. Total vegetation cover: This is assessed both for the riparian and channel areas and includes any kind of tree, bush, shrub or helophyte. Grasses are excluded because they are annual plants and their cover may be very variable depending on the year and the hydrological conditions.

2. Vegetation cover structure: This criterion assesses the structural complexity of the riparian environment that may increase the biodiversity of the fluvial ecosystem, both for animals and plants. The initial score depends on the total percentage of cover due to trees and may be increased by the presence of shrubs and other low-lying vegetation below the trees and helophytes.

3. Cover quality: In order to fill in this criterion the definition of the geomorphological type should be preceded. Three stream types are defined according to the total geomorphological score which depends on the form and slope of the riparian environment. Both margins are surveyed and their values are added.

4. River channel alterations: During this assessment criterion the human made alterations are evaluated because they are one of the main disturbances to the riparian habitat. This includes structures such as embankments that are less penalized than rigid channels, because they may permit the presence of some plants growing between rocks and are more permeable to small animal species.

Classes of riparian quality

After completing the analysis, the sum of the four parts gives the final QBR index. The index varies between 0 and 100. There are five quality classes of riparian habitat (Table 20) which broadly correspond to those suggested in the Water Framework Directive (European Commission, 2000).

Table 20: Quality classes according to QBR index

Quality Classification	QBR	Colour code
Riparian habitat in natural condition	> ή =95	Blue
Some disturbance, good quality	75-90	Green
Disturbance important, fair quality	55-70	Yellow
Strong alteration, poor quality	30-50	Orange
Extreme degradation, bad quality	< ή =25	Red

RESULT OF *IMPLEMENTATION OF RIPARIAN INDEX QBR*

In order to assess the ecological quality of the riparian zone of the two investigated streams the QBR index was applied. QBR index is a useful method to manage streams and rivers. By evaluating the riparian habitat quality turns into a useful tool into manager's hand. It can be applied in combination with other index of water quality and defining the ecological status of streams and rivers.

As an index developed in Catalonia, NE Spain was to provide managers with a simple method to evaluate riparian habitat quality in Mediterranean Countries (Munne *et al*., 2003). In addition it can be used together with other indices of water quality to assess the ecological status of streams and rivers. QBR index is a useful tool for defining "high ecological status" under the EU Water Framework Directive and to compare sites with reference conditions. By taking in account and classifying the site depending on the geomorphology of the river from its headwaters to the lower reaches, is a reliable tool for evaluating different sides using the same method.

After the evaluation of two streams on the north part of the lake (Kamares and Phaneromeni Area), both were characterized of extreme degradation and bad quality (Table 21 and 22). The urban environment and the human interventions resulted low QBR score and degradation of flora at both sites (Figure 5).

Table 21: QBR score and indicating quality class per sampling station. Colours following the WFD codes

Side	QBR SCORE	Quality Class
Station 9 (Stream 1)	25	Extreme degradation, bad quality
Station 10 (Stream 2)	25	Extreme degradation, bad quality

Table 22: Score for each QBR section and total QBR score

Site	Total Riparian Cover	Cover Structure	Cover Quality	Channel Alternation	QBR SCORE
Station 9	15	10	0	0	25
Station 10	5	10	0	10	25

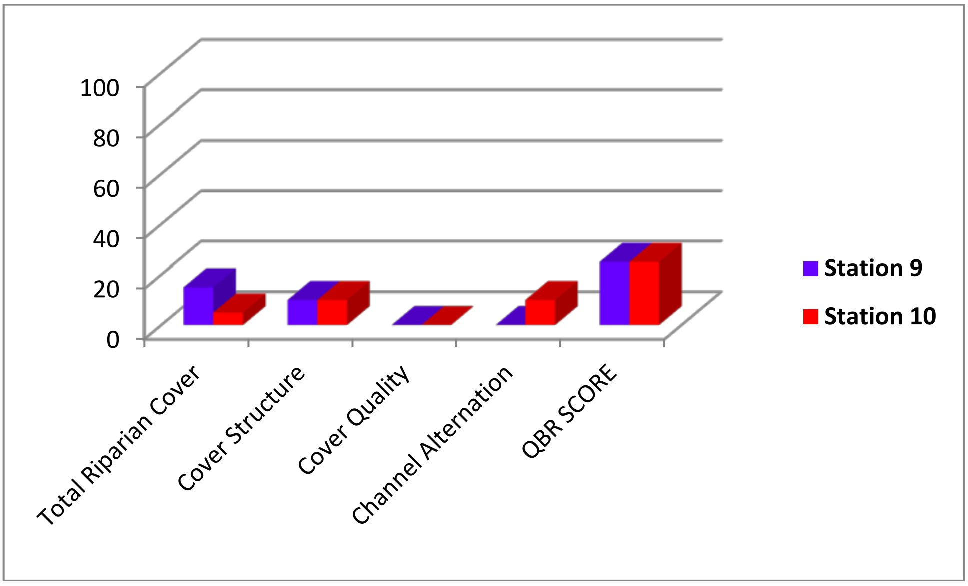

Figure 5: QBR section and total score for the two streams

3. Relationships between physicochemical variables and plant species

3.1. Methodology

The halophytic flora of the salt temporary lakes of Larnaca region includes the green algae *Ulva intestinalis*, *Enteromorpha olivascens*, and *Chaetomorpha linum*; the charophytes *Lamprothamnium papulosum* and *Chara sp* cf. *canescens*, the pteridophyte *Riella helicophylla* and the angiosperms *Althenia filiformis* and *Ruppia maritima.*

For the investigation of the relationships between the plant species and the water physicochemical variables we applied a Direct Gradient Analysis. The length of gradient was <<4 for all data, therefore Redundancy Analysis (RDA) was performed (Ter Braak & Smilauer, 2002). In RDA the *focus scaling* was chosen to be the *inter-species distances*. All variables with variance inflation factor (VIF) > 8 were omitted from the analysis to avoid collinearity. All variables were log-transformed and *down weighting of rare species.*

The parameter *Lambda-1* is a measure for the contribution of each variable if it was the unique variable to the model of the multiple regression analysis (*marginal effect*). While *Lambda-A* represent the contribution of each variable and shows the additional contribution of a variable in the regression when incorporated in the mode (conditional effect).

3.2. Ordination analysis Results

Ordination analysis of vegetation data (8) was undertaken, constraining first by water physicochemical variables and secondly by geomorphological attributes present at each site. Redundancy Analysis (RDA) of vegetation data was applied at 53 sampling plots (*samples*) with macrophytes, to explore the relationships between the 8 plant species as response variables and 9 non-collinear statistically significant physicochemical parameters (Table 22).

The main axis of RDA (AX1) explains the 72.8% and axis 2 the 17.9% of the total variance (Total inertia, 0.264) and the results of the analysis explain the 90.7 % of the total variance of the data (Table 22).

Table
22: Summary results of Redundancy Analysis (RDA) with physicochemical da ta of 9 non-collinear variables from 53 sample plots and macrophytes data (8).

Axes	1	2			Total Inertia
Eigenvalues:	0.192	0.047			
Species-environment correlations	72.8	90.7			
Sum of all canonical eigenvalues					0.264
	Marginal Effects	**Conditional Effects**			**Inflation Factor**
Variables	**Lambda1**	**LambdaA**	**P**	**F**	
T (^{0}C)	0.09	0.09	0.002	5.26	3.15
NO3 (mg/l)	0.01	0.09	0.002	5.38	1.63
TP (mg/l)	0.04	0.04	0.050	2.69	1.19
SRP (mg/l)	0.02	0.01	0.658	0.60	1.52
pH	0.02	0.01	0.696	0.54	1.84
Depth (m)	0.02	0.01	0.638	0.64	1.09
NH4 (mg/l)	0.01	0.01	0.926	0.23	1.75
D.O (mg/l)	0.05	0.00	0.932	0.21	2.14
Salinity ($^0/_{00}$)	0.03	0.00	0.910	0.24	1.90

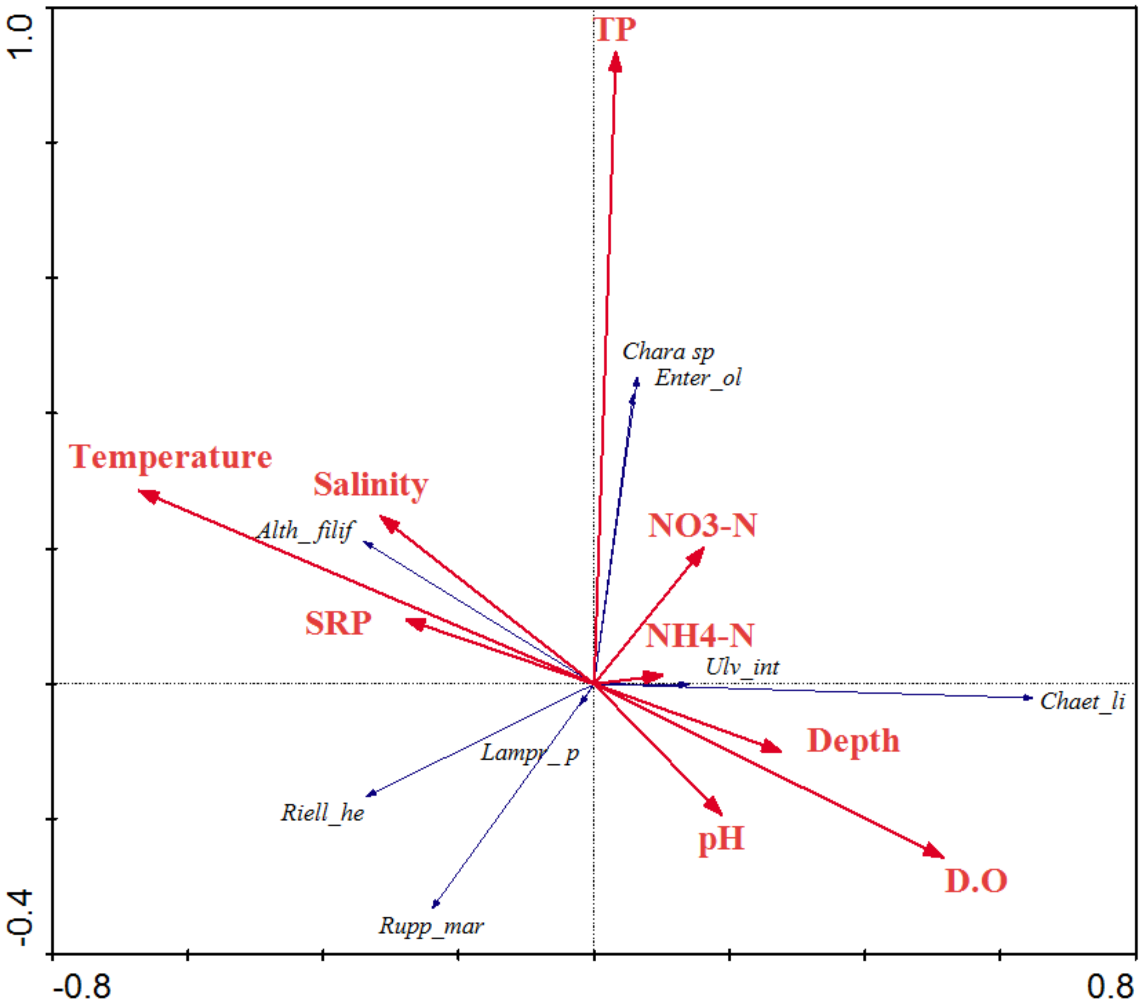

Figure 6: RDA biplot between the 9 non-collinear physicochemical parameters and the plant species (8 taxa) as response variables. The graph shows the plant species (*species*) in relation to physicochemical variables (*environmental variables*).

The graph in Figure 6 shows the location of the plant species on RDA plot in relation to their correlation with physicochemical variables. The first axis is positively correlated with *Dissolved oxygen* (D.O), *Nitrate nitrogen* (NO_3-N), and *mean water depth*, and negatively correlated with Salinity, Soluble reactive Phosphorus (SRP) and water Temperature The second axis reflects the trophic level phosphate (Total Phosphorus).

The species characteristic of rich nutrient enrichment has positive scores in the first axis whereas species of salt tolerant fluctuation have negative scores.

The first group of species includes only filamentous algae (*Ulva intestinalis*, and *Chaetomorpha linum*;) which are highly correlated with the positive part of the first axis. The present of green algae generally reflect water quality according to their relative abundance. According to Smith *et al* (2004) the predominance of filamentous green algae indicates nitrogen enriched trophic status. Our results are fully consistent with this pattern since both species are highly correlated with nitrate nitrogen and ammonium nitrogen concentration (Figure 6).

The second group of species which is located at the left part of the diagram is referred according to Hartog (1981) as a *eurysaline* group and consists of a number of aquatic plant species occurring in various fresh waters, mixo- and hyperhaline brackish waters, and in continental waters of very different chemical composition and concentration. These plants can tolerate considerable fluctuations in the salt content, and their salinity range of occurrence is very wide (Davis & Tomlinson, 1974; Bourn, 1935; St. John & Courtney, 1924). These plants are also in other respects very tolerant, particularly to high temperatures.

From a taxonomic point of view the eurysaline is very restricted since they belong only in two families, Ruppiacea and Zanichelliacea. The only other plants which form an integrated component of these communities are various species of Charophyta. This algal class has developed a number of species with eurysaline character, e.g. *Lamprothamnium papulosum* (Wallr.) J. Ag. The species *Lamprothamnium papulosum* is well adapted to environments with changing salinity, tolerating to sub-saline to hypersaline waters (Garcias & Chivas, 2004) the genus has a cosmopolitan distribution and is characteristic of coastal brackish waters and inland salt-water habitats.

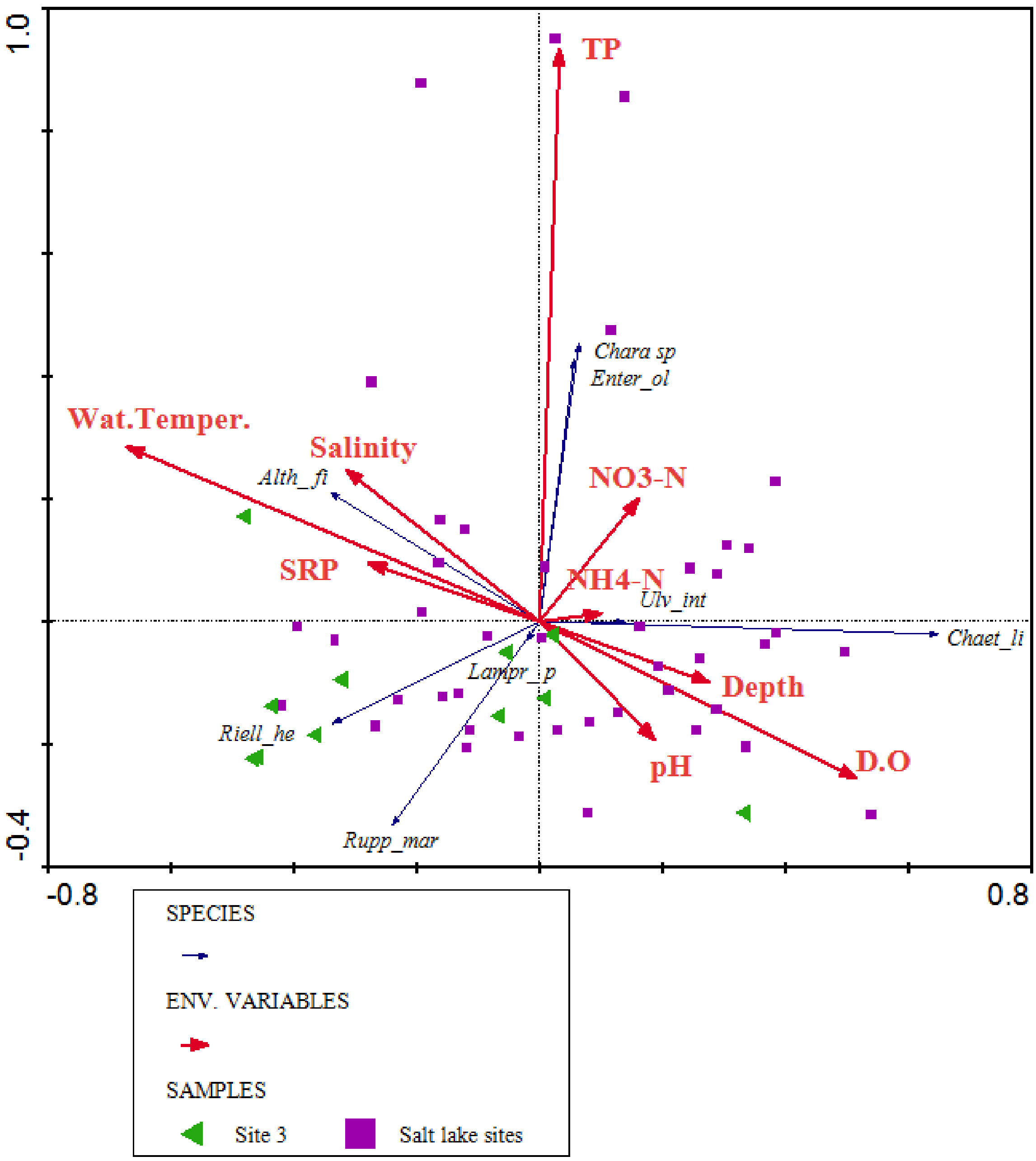

Figure 7: RDA triplot between the 9 non-collinear physicochemical parameters, the plant species (8 taxa) as response variables. The graph shows the plant species (*species*) in relation to physicochemical variables (*environmental variables*) showing the 53 sampling plots (*samples*).

Finally, last species of this group includes the bryophytic species of *Riella helicophylla*. The genus *Riella* comprises twelve species, all of which are halophytic and restricted to regions of arid climate (Allorge, 1947). Five of these species (*R. affinis*, *R. cossoniana*, *R. helicophylla*, *R. notarisii* and *R. parisii*) are of Mediterranean or peri-Mediterranean provenance (Duell, 1983). The distribution of *R.helicophylla* follows a Mediterraneo-Atlantic pattern (Casas *et al*., 1981). It has been recorded in Morocco, Portugal, Egypt and Jordan, with references recorded before 1962, and in Tunisia, France, Spain, Italy, Malta, Balearic Islands, and Algeria, based on collections during or after 1962 (ROS *et al*., 2007). *Riella helicophylla* is one of the few species that tolerates these unfriendly conditions prevailing in hypersaline temporary ecosystems. It has a remarkably disjunction distribution which correlates with desert or near-desert ephemeral standing water bodies.

The second axis separates the halophytic species to those with preference of high of Total Phosphorus concentration which are the algal species *Enteromorpha olivascens* and *Chara sp* cf. *canescens.* The latest species belong to the eurysaline group and the green filamentous algae *Enteromorpha olivascens* apart from the strong correlation with the nitrogen nutrients; in the study area it showed a positive correlation with the concentrations of total phosphorus.

The diagram in Figure 7 illustrates the species distribution and the correlation with the physicochemical variables with indicator shapes showing the salt lake sampling stations and the sampling station 3. As it is well distinguished from the results sampling station 3 is located at the left bottom of the diagram related *to Riella helicophylla* species (Figure 7).

4. CONCLUSIONS

All aquatic ecosystems are very important of ecological, economic and aesthetic point of view (De Leo and Levin, 1997).). Furthermore if those ecosystems are located in regions with intense drought events, they should be treated as ecological "*treasures*" and must be protected under the National legislation. However in order to be able to protect an ecosystem must first be able to understand their functions, the correlation between abiotic variables and biotic communities, the interactions with the surrounding area etc. Such knowledge derived after years of systematic monitoring of the ecosystem (Krause *et al* .2011).

The shallow and temporary water bodies are more exposed and sensitive to environment changes. That makes the ecosystem vulnerable as small environmental changes can disturb ecosystems' functionality and performance (Williams, 2002). Locally, salt lakes may be more abundant than freshwater, in which case they often dominate this landscape and provide critical habitat for endemic species, and breeding and migratory birds (Jellison et al., 2004).

According to the results of the current study, the main salt lake is dominated by very low number of aquatic plant species, and in many sampling sites we didn't find angiosperms but only filamentous algae (*Ulva intestinalis, Chaetomorpha linum*). The results indicated habitat degradation on the quality status which gives space for opportunistic taxa to invade (Orfanidis *et al.*, 2003). The result of the invasion and the change of aquatic flora could cause an interruption at food network, with indirect effects lowering the ecosystem's functionality (Williams, 2002).

Additionally the degradation of the streams flowing in the main salt lake is another important factor affecting the Salt Lake ecological status. The drainage water from the urban environment in combination with the bad ecological status and the apparent human interventions in both of the streams, contribute negatively on ecosystems conservation (McComb and Qiu, 1998).

However, our results indicated that the temporary salt lakes of Larnaca apparently support rather few vascular plants some of them are of conservation significance. The angiosperm species belong to the primary producers and they are very important for the food chain supporting the whole ecosystem. Despite the small number of species that are well adapted to temporary salt lake ecosystems, we found that sampling station 3 supports high productivity and high biodiversity values. The composition of aquatic flora of sampling station 3 is consisted of two species of angiosperm (*Ruppia maritima var brevirostris, Althenia filiformis*), one species of bryophytes (*Riella helycophylla*), one species of stonewort algae (*Lamprothamnium papulosum)* and one species of filamentous algae (*Chaetomorpha linum*) with very low abundance.

According to the results of the biotic index EEI as well as the presence of the European Endangered (E) species *Riella helycophylla* it seems to be an area with high quality status and it has to be protected (Hugonnot & Hebrard, 2004). This assumption is further supported by the very low abundance of only one species of filamentous algae, which are opportunistic species (Lobban & Harrison, 1994, Coelho *et al*., 2000, Orfanidis *et al*., 2001), during sampling periods such as *Ulva* and *Enteromorpha* Furthermore the abundance of angiosperms found in sampling station 3 and the creating microhabitats which support the ecosystems functionality (Loreau *et al*., 2001, Fridley, 2001) and the numerous avifaunal species that were recorded feeding and breeding during the sampling periods 2010-2011, (Hooper *et al.,* 2005) in combination to the good quality scores of EEI (Orfanidis *et al*., 2002) index gave an additional value on choosing Station 3 as the less disturbed site.

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