Original Research Article

The lowermost *Chara* locality in the world near Dead Sea, Israel

ABSTRACT

Aims: First study of the lowermost locality the Neot HaKikar with charophytes in the Dead Sea region of Israel has been implemented for revealing of algal diversity and ecological assessment of the water object environment.

Study design: We implement diverse bio-indication methods.

Place and Duration of Study: Institute of Evolution, University of Haifa, Israel, Central Siberian Botanical Garden of the Siberian Branch of the Russian Academy of Sciences, Russia, between January 2012 and December 2014.

Methodology: Material for this study comes from nine living and nine fixed algological samples, four samples of charophytes and four samples of water. We use bio-indication methods in purpose to characterize of the pool water quality and ecosystem sustainable. Index saprobity S and Index of aquatic ecosystem sustainable WESI was calculated.

Results: Altogether 54 species of algae including one of them macro-algae *Chara contraria* A.Braun ex Kützing (Charales, Charophyceae) were revealed in the Neot HaKikar pool. *Chara* was found in significant growth in the bottom and coastal part of studied pool. Bio-indication and chemical variables characterize the charophyte site environment as mesotrophic to eutrophic with prevailing of benthic type of organisms of autotrophic type of nutrition, which are mostly attached of substrate and preferred standing water, medium enriched by oxygen, with temperate temperature, medium salinity, low alkalinity, and low to middle organic pollution, Class III of water quality. Seasonality of algal community and water quality showed of organic and other contaminants pollution during winter period as a result of evaporation and atmospheric dust impact. Charophyte community is sharp limited in its development as a result of periodical anthropogenic desiccation of the pool. We found unique property of *Chara contraria* to renewing population after two years desiccation.

Conclusion: We can recommend the Neot HaKikar pool for monitoring of unique natural aquatic object in the Dead Sea area, and *Chara contraria* as climatic indicator of surviving under future climate warming.

Keywords: Charophytes, ecology, bio-indication, Dead Sea, Israel

1. INTRODUCTION

Diversity of algae in Israel has been studied sporadically during the last century, but from 2000 we continue regular work in the rivers and other water bodies [1]. As a result we studied known localities as well as find new localities not only for algal diversity update but especially for charophyte revealing [2,3] in present time we revealed 14 charophyte species (16 with ifraspecific variety) that known for Israel [4] from references and our studies.

The charophytes prefer alkaline water environment which forms on the carbonates that are very distributed in studied region. Therefore, the Eastern Mediterranean environment gives us more chance to find new, unstudied aquatic objects in which can be identified charophyte algae. The altitude gradient play the major role in historical species diversity forming process [5] especially it can be interesting in the Arava Valley, which placed in the lowermost area of the world. Biodiversity of the Arava Valley refers to the Sakharo-Arabian Realm with sharp arid climatic environment [6-8].

We assume that the diversity of this group of algae in Israel is still far from complete. Thus, the aim of our work was to find new habitats of charophytes and study their community and the environment especially in the lowest place in the world that that affected by shading of solar radiation of the dust layer more than 500 meters thick.

2. MATERIAL AND METHODS

2.1. Sampling and laboratory studies

Material for this study comes from nine living and nine fixed algological samples, four samples of charophytes and four samples of water that were collected during two field trips in January, 16 and June,12 of 2012 in the Neot HaKikar pool.

Algological samples were collected by scratching and scooping, placed in 15 ml plastic tubes, and partly fixed with 3% neutral formaldehyde solution, as well as partly not fixed and transported to the laboratory in the ice box.

Charophytes were treated with 2-3% HCl to remove calcium carbonate. After washing several times with distilled water the material was studied with Nikon stereomicroscope with distilled water the material was air-dried on cover glasses and mounted in Naphrax®. The structure elements were observed with Nikon with digital camera, DinoLight camera, and light microscopes (LM) in the Institute of Evolution, University of Haifa and the Central Siberian Botanical Garden with help of international handbooks [9,10]. Charophyte and microscopic algae abundance were assessed as abundance scores according 6-score scale [11].

Algae and cyanobacteria were studied with the SWIFT and OLYMPUS dissecting microscopes under magnifications 740x–1850x from three repetitions of each sample and were photographed with a DC (Inspector 1). The diatoms were prepared by the peroxide technique [12] modified for glass slides [13] and were placed in the Naphrax® resin from two repetitions of each sample.

Temperature was measured with a thermometer. Acidity (pH), conductivity (EC), and TDS were measured with HANNA HI 9813-0. This meter has a full-spectrum pH measurement range. The Electrical conductivity range goes to 4.00 mS cm-1. The TDS ranged from 0 to 1999 mg l^{-1}. Measurements were made by adding the probe into the water till the reading was stabilized. Chlorides and sodium percentage as measured with “Handheld Refractometers X-Series Sodium Chloride”. The concentration of N-NO3 was measured with HANNA HI 93728.

Index saprobity s was calculated according to [14]. Index of aquatic ecosystem sustainable was calculated according to [1, 11] as (1):

WESI = Rank S / Rank N-NO3.   (1)

Where: Rank S – rank of water quality on the Sladeček’s indices of saprobity; Rank N-NO3 – rank of water quality on the nitric-nitrogen concentration.

If WESI is equal to or larger than 1, the photosynthetic level is positively correlated with the level of nitrate concentration. If the WESI is less than 1, the photosynthesis is suppressed presumably according to toxic disturbance [11].

2.2. Description of study site

The Neot HaKikar pool placed south from the Dead Sea in 30.57.221 N and 35.21.450 E at altitude of 356 m below sea level (Fig. 1). Pool is permanent, about 10-12 m in diameter, about 0.5-0.7 m deep, and affiliated to the Israeli Mekorot Company as one of freshwater source in the Kibbuz Ein Tamar. The area has a desert climate. Throughout the year, there is virtually no rainfall in Neot HaKikar. The average annual temperature in is about 24.1 °C.

The average annual rainfall is 53 mm [15]. The driest month is August with 0 mm. Most precipitation falls in December, with an average of 12 mm but one time per 2-4 years. The warmest month of the year is August with an average air temperature of 31.4 °C. In January, the average temperature is 15.3 °C. It is the lowest average temperature of the whole year.

Periodical year round dust storms are attack the area when sunlight rather decreased (Fig. 2) even in the mid-day. The most impacted period is in the mid-day, when dust concentration in the Beer-Sheva area raised up to 2-5 mg m^{-3} in March-May, and up to 5 mg m^{-3} in January-February and May in dependency of the sand storm generation area [16]. Massive dust transportation covers an area of about 4,800 square kilometers in the Arava Valley [17]. As a result, the sunlight intensity decreased at the altitude about 300 m in Beer-Sheva to the Neot HaKikar at the altitude about 356 m below sea level for 20-25 percent [18] because the dust level thickness comprises for 356 m more than in the sea level.

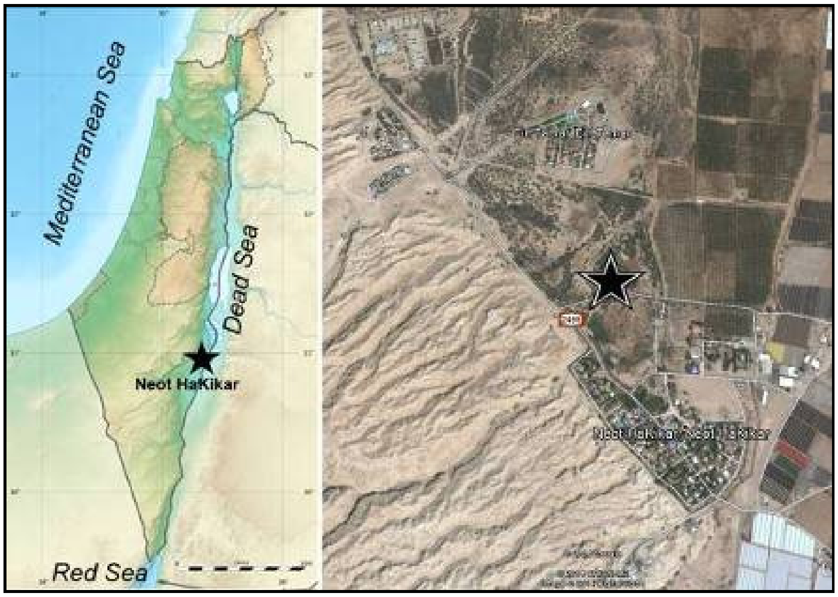

Fig. 1. Study site in the Neot HaKikar pool, Arava Valley, Israel

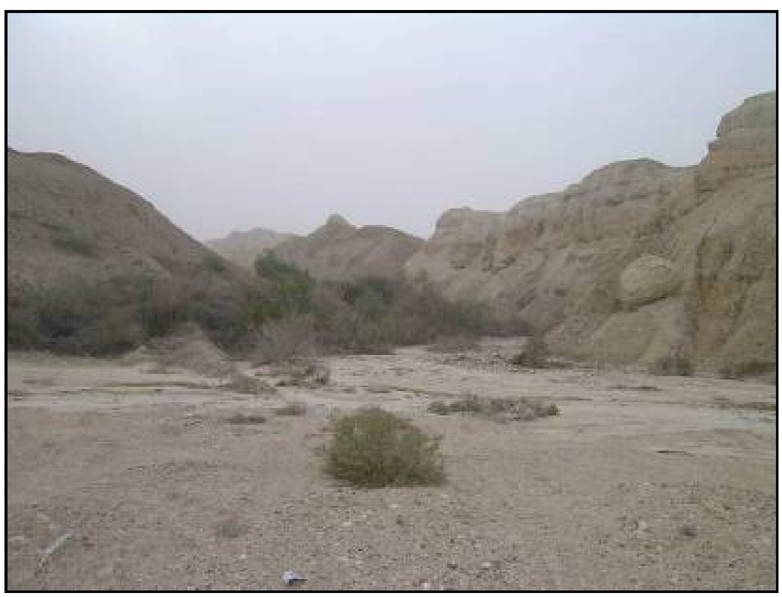

Fig. 2. The Neot HaKikar area during the sandstorm, midday, January, 2012

3. RESULTS AND DISCUSSION

3.1. Chemical composition of the pool water

Chemical variables were measured two times in winter and summer seasons (Tab. 1). Environment variables are fluctuated in small range and reflected fresh to brackish, low alkaline, temperate temperature, and low polluted waters [1, 11]. Index of saprobity S fluctuated in small range and reflects low level of organic pollution, Class III of water quality. Sodium and chlorides content rather fluctuated between winter and summer from 20% to 60% respectively. We can assume that sharp arid climate due impact to salinity which increased in summer as a result of evaporation.

Tab. 1. Chemical and biological variables in the Neot HaKikar pool in 2012.

Variables	Min	Max	Aver
Conductivity, mS cm^{-1}	5.51	6.29	5.93
$N\text{-}NO_3$, mg l^{-1}	0	1.30	0.58
pH	7.30	7.70	7.47
Total Dissolved Solids (TDS), mg l^{-1}	1084	1729	1442.3
Temperature	22.70	23.70	23.14
Cl%	0.20	0.60	0.38
Na%	0.20	0.60	0.38
No. of Species	23	25	24
Index saprobity S	1.53	2.04	1.79
Index WESI	1.00	1.33	1.00

3.2. Diversity and ecology of algae

We revealed 39 species of algae (Tab. 2) diversity of which is rather constant during the sampling dates. Earlier in this place, may be in the same pool has been found twenty species of diatom algae [19]. Only five species from historical list and our finding were overlapped. From other hand, we don't find fifteen species that represented in [19], but find 33 species of cyanobacteria, euglenoids, green algae and very abundant charophyte *Cosmarium* over the book of Ehrlich [19] data.

Tab. 2. Algal diversity with abundance scores and species ecological preferences (according to [11, 20]) in the Neot HaKikar pool in January (Jan) and June (Jun) 2012, and in reference [19] (Hist).

Taxa	Hist	Jan	Jun	S	Hab	T	Reo	pH	Sal	Sap	D	Aut-Het	Tro	pH range
Cyanobacteria														
Anabaena sp.	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Anabaenopsis sp.	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Chroococcus turgidus (Kützing) Nägeli	-	1	2	0.8	P-B,S	-	aer	alf	hl	o	-	-	-	-
Coelomoron pusillum (Van Goor) Komárek	-	1	-	1.8	P	-	-	-	-	b	-	-	me	-
Limnococcus limneticus (Lemmermann) Komárková, Jezberová, O.Komárek & Zapomelová	+	-	3	1.5	P	-	-	-	-	o-b	-	-	o-m	-
Microcoleus autumnalis (Gomont) Strunecky, Komárek & J.R.Johansen	-	-	1	2.3	B,S	-	st-str	-	-	b	-	-	-	-
Oscillatoria sancta Kützing ex Gomont	-	4	-	2.7	P-B, S	eterm	st-str, aer	-	i	b-a	-	-	me	-

Phormidium breve (Kützing ex Gomont) Anagnostidis & Komárek	-	-	3	3.1	P-B, S	-	st	-	-	b-p	-	-	-	-
Planktothrix agardhii (Gomont) Anagnostidis & Komárek	-	-	4	2.2	P-B	-	st	-	hl	b-o	-	-	-	-
Pseudanabaena raphidioides (Geitler) Anagnostidis & Komárek	-	-	3	-	-	-	-	-	-	-	-	-	-	-
Pseudanabaena redeckei (Goor) B.A.Whitton	-	3	6	2.1	P-B	H_2S	-	-	-	b-o	-	-	me	-
Romeria leopoliensis (Raciborski) Koczwara	-	-	2	1.5	P	-	st	-	-	o-b	-	-	e	-
Romeria minima (Lemmermann) Komárek	-	-	1	-	B	-	-	-	-	-	-	-	o	-
Ochrophyta														
Achnanthes thermalis (Rabenhorst) Schoenfeld	+	2	-	0.3	B	warm	st-str	ind	hl	o	-	-	-	-
Amphora pediculus (Kützing) Grunow ex A.Schmidt	-	-	3	1.7	B	temp	st	alf	i	o-a	sx	ate	e	8.0
Anomoeoneis sphaerophora E.Pfitzer	-	4	3	2.7	P-B	warm	st-str	alb	hl	x-b	-	ate	e	6.3-9.0
Brachysira vitrea (Grunow) R.Ross	+	-	-	0.5	B	-	-	ind	i	o-x	-	-	-	-
Caloneis amphisbaena (Bory de Saint Vincent) Cleve	-	2	-	2.3	B	-	st-str	alf	hl	o	-	ate	e	-
Caloneis macedonica Hustedt	+	-	-	-	B	-	st	alf	i	-	-	-	-	-
Cyclostephanos invisitatus (Hohn & Hellermann) Theriot, Stoermer & Håkasson	-	1	-	1.9	-	-	-	-	-	o-b	sx	-	-	-
Cyclotella meneghiniana Kützing	-	2	1	2.8	P-B	temp	st	alf	hl	o-a	sp	hne	e	5.5-9.0
Diploneis elliptica (Kützing) Cleve	+	-	-	0.6	B	temp	str	alf	i	o-a	sx	ats	m	-
Diploneis oblongella (Nägeli ex Kützing) Cleve-Euler	+	2	2	0.9	B	-	str	alf	i	o-a	sx	ats	-	-
Diploneis ovalis (Hilse) Cleve	-	1	-	0.9	B	-	str	alb	i	b	sp	ats	-	6.5-9.0
Gomphonema parvulum (Kützing) Kützing	+	-	-	2.3	B	temp	str	ind	i	x	es	hne	e	4.5

Halamphora acutiuscula (Kützing) Levkov	+	-	-	-	P-B	warm	-	alf	mh	-	sp	-	-	-
Halamphora subturgida (Hustedt) Levkov	+	-	-	-	B	-	-	alf	mh	-	-	-	-	-
Mastogloia aquilegiae Grunow	+	-	-	-	P	-	-	-	ph	-	-	-	-	-
Mastogloia braunii Grunow	-	3	6	-	P-B	-	-	alf	mh	-	-	-	-	-
Mastogloia lacustris (Grunow) Grunow	-	3	-	1.3	B	-	str	alf	hl	o	-	ats	e	-
Mastogloia smithii Thwaites ex W.Smith	-	2	-	1.3	B	-	-	alf	mh	b	sx	-	-	-
Navicula globulifera Hustedt	-	4	-	-	B	-	-	-	-	o	-	-	-	-
Navicula schroeteri Meister	+	-	-	-	B	-	str	alf	i	a-b	es	-	e	-
Navicula subrhynchocephala Hustedt	+	-	-	-	P-B	-	-	alf	i	-	sp	-	-	-
Navicymbula pusilla (Grunow) K.Krammer	+	-	4	-	B	-	-	alf	mh	-	es	-	-	-
Nitzschia amphibioides Hustedt	+	3	-	-	P-B	-	st-str	alf	i	-	-	-	-	-
Nitzschia elegantula Grunow	+	2	-	-	P-B	-	st	alf	hl	-	sx	-	-	-
Nitzschia fonticola (Grunow) Grunow	-	3	1	1.5	B	-	st-str	alf	oh	o-b	-	ate	me	7.7-7.95
Nitzschia microcephala Grunow	+	-	-	2.3	B	-	st-str	acf	hl	o-b	sx	hce	e	-
Nitzschia obtusa W.Smith	+	-	-	2.5	B	-	-	-	mh	b	es	-	-	-
Nitzschia palea (Kützing) W.Smith	-	-	3	2.8	P-B	temp	-	ind	i	o-x	sp	hce	he	7.0-9.0
Nitzschia scalpelliformis Grunow	+	-	-	-	B	-	-	-	hl	-	sp	-	-	-
Pinnularia ignobilis (Krasske) A.Cleve	-	-	4	-	-	-	-	-	-	-	-	-	-	-
Pinnularia kneuckeri Hustedt	+	-	-	-	B	-	-	-	-	-	-	-	-	-
Rhopalodia gibberula (Ehrenberg) Otto Müller	-	3	1	-	B	warm	str	ind	mh	-	es	-	-	4.8-9.0
Seminavis strigosa (Hustedt) Danieledis & Economou-Amilli	+	-	-	-	B	-	st	-	-	a-b	-	-	-	-
Surirella angustata	-	1	-	1.7	B	-	-	alf	i	b	-	-	-	-

Kützing														
Tryblionella hungarica (Grunow) Frenguelli	+	-	-	2.9	P-B	-	-	alf	mh	a-b	sp	ate	e	-
Euglenozoa														
Trachelomonas volvocina (Ehrenberg) Ehrenberg	-	1	-	2.0	B	eterm	st-str	ind	i	b	-	-	-	4.4-8.4
Chlorophyta														
Eudorina elegans Ehrenberg	-	-	2	2.3	P	-	st-str	-	i	b	-	-	-	-
Gemellicystis imperfecta (Korsh.) Lund	-	1	-	1.2	-	-	-	-	-	-	-	-	-	-
Scenedesmus apiculatus (West & G.S.West) Chodat	-	1	1	-	P	-	st-str	-	-	-	-	-	-	-
Charophyta														
Chara contraria A.Braun ex Kützing	-	3	2	1.1	B	-	st-str	alf	i	o-b	-	-	-	-
Cosmarium laeve Rabenhorst	-	6	6	1.9	B, P-B, aer	-	st-str	ind	i	o-a	-	-	me	5.4-9.4

Note: Ecological types (Hab): P, planktonic; B, benthic; P–B, planktonic-benthic, S, soil. Temperature (T): temp, temperate waters inhabitant; eterm, eurythermic inhabitant; warm, warm-water inhabitant; H_2S, anoxia indicators. Streaming and Oxygenation (Reo): str, streaming waters inhabitant; st-str, low streaming waters inhabitant; st, standing waters inhabitant; aer, aerophytic inhabitant. Acidity (pH): ind, indifferent; alf, alkaliphil; acf, acidophil; alb, alkalibiont. Halobity (Sal): i, oligohalobious-indifferent; hl, oligohalobious-halophilous; mh, mesohalobious; ph, polyhalobious. Saprobity (D): es, eurysaprob; sx, saproxen; sp, saprophil. Saprobity (Sap): o, oligosaprob; o-a, oligo-alpha-mesosaprob; x-o, xeno-oligosaprob; x-b, xeno-betamesosaprob; b, betamesosaprob; b-o, beta-oligosaprob; o-b, oligo-beta-mesosaprob; b-p, beta-meso-polysaprob a-b, alpha-beta-mesosaprob; b-a, beta-alpha-mesosaprob; x, xenosaprob. S: species-specific Index saprobity according [14]. Nitrogen uptake metabolism (Aut-Het) [20]: ats, nitrogen-autotrophic taxa, tolerating very small concentrations of organically bound nitrogen; ate, nitrogen-autotrophic taxa, tolerating elevated concentrations of organically bound nitrogen; hne, facultatively nitrogen-heterotrophic taxa, needing periodically elevated concentrations of organically bound nitrogen; hce, nitrogen-heterotrophic taxa, needing elevated concentrations of organically bound nitrogen. Trophic state (Tro) [20]: me, meso-eutraphentic; e, eutraphentic; m, mesotraphentic; ot, oligotraphentic; o-m, oligo-mesotraphentic; he, hypereutraphentic.

As a result, the Neot HaKikar algae list now included 54 species one of which is macrophyte alga *Chara contraria* (Fig. 3). Structural elements and thallus habitat show that our samples are in the typical diagnosis ranks. Species is also widely distributed in the Mediterranean countries and some climatic similar dry regions and is cosmopolitan [21]. Species distribution is known from the sea level up to 2000 m a.s.l. in Central Europe [22]. It seems that the lowermost altitude for charophytes had not been assessed at all. Previously, we have shown that the species of the genus *Chara* in Israel populations are well separated from one to another by AFLP analysis [23] and *Chara contraria* including. *Chara contraria* community was dominated by diatoms (Tab. 2) that attach of macro-alga as well as stones and plants in the pool bottom. It is very sorry that native peoples are periodically reconstructed area and dried the pool. During few field trips in 2002-2014 we don't recognized the pool, but it was periodically renewed. As a result of periodically desiccation, the charophyte plants are died, but can renewed after one-two years dry period. We assume that surviving of *Chara contraria* in this dry land site can be possible with oospores storage in the pool sediments. It is very important that studied population of *Chara* demonstrated high tolerance to desertification as bearing on ecological consequences of climate change [24] in region under desertification coming [25].

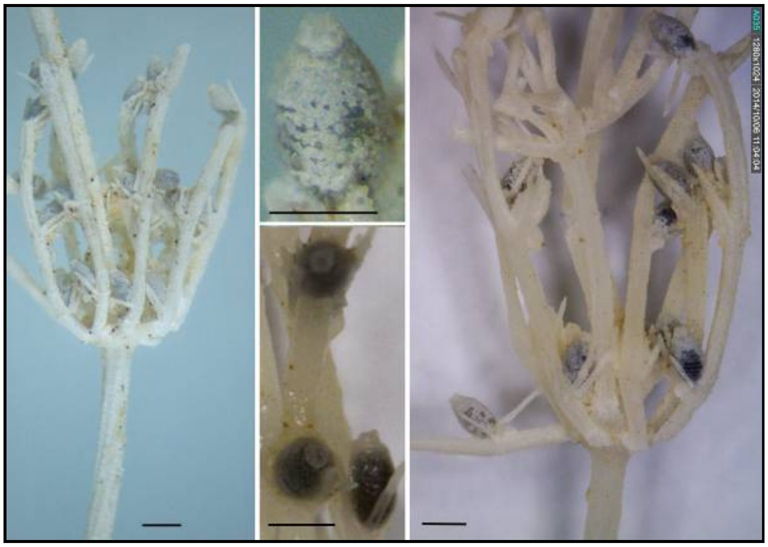

Fig. 3. *Chara contraria*: 1 – axis with stipulodes, base of whorl, axial cortex, and oogonia; 2, 3 – oogonia; 3 –axis with branchlets and oogonia. Scale bar 10 µm

3.3. Bio-indication of the studied pool environment

We use bio-indication methods in purpose to characterize of the pool water quality and ecosystem sustainable. We found that the identified species (Tab. 2) in the majority are the inhabitants of benthos (27), which corresponds to the small size of the pool. Temperature indicators are represents by not only temperate species (5) but also warm water inhabitants (4). One species of cyanobacteria is indicator of anoxia and sulfides which come from the bottom sediments as a result of organic matter degradation. As a whole, the pool community is containing more species that indicated of medium oxygen enrichments (11). Indicators of water pH represented by wide range of groups from acidophilic to alkalibionthic, and alkaliphilic species strongly prevailed (20). It is remarkable that spectrum of salinity indicators shift to the high salinity group such as mesohalobes (8) and even polyhalobes (1), but group of oligohalobious-indifferent species is prevail (17). This alignment of salinity indicator groups suggests long-term effects of salinity and increases in the long process of forming the diversity in the pond under excessive arid environment. As has been revealed [28] the natural streams water in the Arava Valley, and the Neot HaKikar in particular have permanent trend in decreasing under arid climate impact. Indicators of organic pollution in [14,26] system demonstrated wide ranks of species from eleven groups of saprobity from which indicators of Class II and III are prevail. Watanabe's system indicators (D) were represented by diatoms only and reflect medium organic enrichments. Indication of nutrition type [20] that preferred revealed algal species shows shift to the autotrophic groups that used photosynthetic way of proteins synthesis. As a result the trophic indicators [20] reflect that pool environment correspond to eutrophic ecosystem state.

As can be seen in Tab. 2, the water quality defined by bio-indication is the same that show by water chemistry (Tab. 1). In conclusion we can characterize studied pool as mesotrophic to eutrophic with prevailing of benthic type of organisms with autotrophic type of nutrition, which are mostly attached of substrate and preferred standing water with medium oxygen enrichment water, temperate temperature, middle salinity, low alkalinity, and low to middle organic pollution.

We use Tab. 2 with Index saprobity S value that we calculated on the base of species abundance scores and species-specific index s after Sládeček [14,26] model, and nitrate concentration (Tab. 1) data for ecosystem state index WESI calculation. Despite the Index Saprobity S value that show low organic matter concentration, the index WESI is fluctuated from 1.00 to 1.33, which can characterize studied site ecosystem as high capacity to self-purification. Few species of filamentous cyanobacteria and euglenoids (Tab. 2) can confirm that charophyte site is impacted by organic and other contaminants mostly in winter. This situation is similar to that of the Upper Jordan River previously examined by us [27] where the pollution coming from the catchment area pollute the water more in winter than in summer.

We can assume that it is few causes of the water quality impact in the Neot HaKikar pool and its algal community also. Because pool is under Mekorot company protection there is no strong pollution impact. But we can see that anthropogenic influence come from periodically reconstruction of the pool area, which we in particular explore during 2012-2013. Unfortunately the studied pool is under climatic impact also, which provoke increasing of salinity [28] and therefore algal species richness will decrease [29,30].

From other hand, this area is under sunlight decreasing during the sandstorms that periodically come from Sahara Desert, from Arabian Desert across the Negev Desert [16] with massive dust transportation that not only covered large deserted areas [17] such as the Arava Valley but also decreased sunlight intensity during the day, especially in the lowermost area near the Dead Sea in which light intensity decreased to 25% more [18] as a result of the dust layer thickness is more to 250 m. Algal species formed special compounds [31] as response to UV-radiation impact [32] from one hand, and negatively react on the sunlight inhibition. UV-radiation increasing effects include inhibition of photosynthesis, inhibition of growth, and DNA damage. As a result algae have been developed mechanism of avoidance as well as adaptation to the light intensity fluctuation during its evolutionary process. It is especially related with the charophyte species definition. Well known that *Chara vulgaris* L. and *C. contraria* are two cosmopolite species that sometimes difficult to define one from another [33]. More of them, these species often occupied the same habitat as we revealed in the Negev Desert stream Ein Avdat [23, 24]. Because each charophyte species evolved in the presence of UV a multitude of adaptive strategies have been developed, allowed to exist at sunlight exposition (*C. vulgaris*) or at less exposed places (*C. contraria*) [10], and the repair of DNA damage as a result of development the major mechanism of UV adaptation [32]. As we revealed in the Ein Avdat stream charophytes polymorphism with AFLP, comparative tree distinctly divided these two species into clusters that affiliated to shadow or sun lighted parts of stream that flow in the deep canyon in the Central Negev Desert. Therefore we can assume that environmental preferences of both morphologically similar species of *Chara* entrenched in the process of evolution as a result of repair injured DNA by ultraviolet radiation and subsequent consolidation features. As a result we are seeing the shade-tolerant *C. contraria* in the Arava valley inhabiting the lowest place in the world that is affected by shading of solar radiation of the dust layer more than 500 meters thick.

5. CONCLUSION

The new unique locality the Neot HaKikar pool in the Arava Valley is protected area near Dead Sea and the lowermost habitat of charophytes in the world that placed in the altitude about 350 m below sea level. Pool’s environment can be characterize as natural, brackish, low alkaline with low- to middle organic polluted waters that inhabit by fifty four algal species from which the charophyte *Chara contraria* and diatoms were rather dominated. The charophyte *C. contraria* which distributed over the world can renewing after one-two year’s periodical desiccation with helps of oospores buried in bottom sediments. This unique property of *C. contraria* can help charophytes to survive in the Eastern Mediterranean region that is under desertification process with periodical sandstorms impact, which decreased photosynthetic radiation intensity for about 25% as a result of high dust concentration and regional climate change. Therefore, the Neot HaKikar pool as unique charophyte habitat can be protected for anthropogenic reconstruction, as well as its water quality and algal communities can be studied and monitored for more detail characteristic of diversity that we here presented in the first time.

REFERENCES

1. Barinova S. Algal diversity dynamics, ecological assessment, and monitoring in the river ecosystems of the eastern Mediterranean. NY, USA: Nova Science Publishers; 2011a.
2. Barinova S, Romanov R. A new Chara locality in the protected area of the Galilee Mountains, Israel. Nat Res Conserv. 2014a; 2(5):80-85, DOI: 10.13189/nrc.2014.020502.
3. Barinova S, Romanov R. Unique locality with charophytes in the Mount Arbel National Park, Israel. Elixir Bio Diver. 2014b; 77:28932-28936.

4. Romanov RE, Barinova SS. The charophytes of Israel: historical and contemporary species richness, distribution, and ecology. Biodiv Res Conserv. 2012; 25:57–64.
5. Barinova S. The effect of altitude on distribution of freshwater algae in continental Israel. Current Topics in Plant Biol. 2011b;12:89–95.
6. Amiram DHK, Rosenan N, Kadmon N, Elster J, Gilead M, Paran U, eds. Atlas of Israel. Jerusalem: Ministry of Labour, and Amsterdam: Elsevier Publishing Co.; 1970.
7. Galun M. The lichens of Israel. Jerusalem: The Israel Academy of Science and Humanities; 1970.
8. Barinova S, Nevo E. Climatic and pollution impact on algal diversity of the freshwater ecosystems in Eurasia. In: Climate Change and Impacts. WY, USA: Academy Publish; 2012.
9. John DM, Whitton BA, Brook AJ, eds. The freshwater algal flora of the British Isles: an identification guide to freshwater and terrestrial algae. Cambridge: Cambridge University Press; 2011.
10. Krause W. Charales (Charophyceae). Süßwasserflora von Mitteleuropa, vol. 18. Stuttgart: Gustav Fischer Verlag; 1997.
11. Barinova SS, Medvedeva LA, Anissimova OV. Diversity of algal indicators in environmental assessment. Tel Aviv: Pilies Studio; 2006. Russian.
12. Swift E. Cleaning Diatom Frustules with Ultraviolet Radiation and Peroxide. Phycologia. 1967; 6(2-3): 161–163.
13. Barinova SS. Morphology of connective spines in diatom algae of the genus Aulacoseira Thwaites. Paleontological J. 1997; 31(2): 239–245.
14. Sládeček V. Diatoms as indicators of organic pollution, Acta Hydroch Hydrob. 1986; 14: 555–566.
15. Climate data for cities worldwide. Accessed 02 January 2015. Available: http://en.climate-data.org/location/201911/
16. Krasnov H, Katra I, Koutrakis P, Friger MD. Contribution of dust storms to PM10 levels in an urban arid environment. J Air Waste Manag Ass. 2014; 64(1): 89-94, DOI:10.1080/10962247.2013.841599.
17. Bruins HJ, Lithwick H. Solar Energy in Arid Frontiers: Designing a Photovoltaic Power Plant for Kibbutz Samar, Israel. The Arid Frontier: Interactive Management of Environment and Development. Netherlands; 1998. Google Books. Kluwer Academic Publishers.
18. Boykiw E. The effect of settling dust in the Arava Valley on the performance of solar photovoltaic panels. The Senior Thesis in Department of Environmental Science Allegheny College Meadville, Pennsylvania, USA, April, 2011, 36 pp.
19. Ehrlich A. Atlas of the inland-water diatom flora of Israel. Jerusalem: Israel Academy of Science and Humanities; 1995.
20. Van Dam H, Martens A, Sinkeldam J. A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. Netherlands J. Aquatic Ecol. 1994; 28: 117–133.
21. Corillion R. Les Charophycées de France et d'Europe Occidentale. Trav Lab Fac Sc Angers. 1957; 11–12: 7–499.
22. Haas JN. First identification key for charophyte oospores from central Europe. Eur J Phycol, 1994; 29(4): 227–235.
23. Yehuda G, Barinova SS, Krugman T, Pavlicek T, Nov Y, Nevo E. Microscale adaptive response of charophytes of the Negev Desert, Israel: species divergences by AFLP. Nat Res Conserv. 2013; 1(3): 55-64. DOI: 10.13189/nrc.2013.010301.
24. Barinova SS, Yehuda G, Nevo E. Comparative analysis of algal communities of northern and southern Israel as bearing on ecological consequences of climate change. J Arid Env. 2010; 74: 765-776. doi:10.1016/j.jaridenv.2009.03.001
25. Perry AS, Perry RY. Effects in arid regions. In: Ecotoxicology and Climate. SCOPE: Published by John Wiley and Sons Ltd.; 1989.
26. Sládeček V. System of water quality from the biological point of view. Ergeb Limnol. 1973; 7: 1–128.
27. Barinova SS, Nevo E. The Upper Jordan River algal communities are evidence of long-term climatic and anthropogenic impacts. J Wat Res Prot. 2010; 2: 507–526.
28. Bruins HJ, Sherzer Z, Ginat H, Batarseh S. Degradation of springs in the Arava Valley: anthropogenic and climatic factors. Land Degrad Develop. 2012; 23: 365–383, DOI: 10.1002/ldr.2149
29. Dor I, Ehrlich A. The effect of salinity and temperature gradients on the distribution of littoral microalgae in experimental solar ponds, Dead Sea Area, Israel. Mar Ecol. 1987; 8: 193-205.
30. Barinova SS, Tsarenko PM, Nevo E. Algae of experimental pools on the Dead Sea coast, Israel. Isr J Plant Sci. 2004; 52(3): 265-275

31. Karsten U, Garcia-Pichel F. Carotenoids and mycosporine-like amino acid compounds in members of the genus Microcoleus (cyanobacteria): a chemosystematic study. Syst Appl Microbiol. 1996; 19(3): 285–294.
32. Klish M, Sinha RP, Hader D-P. UV-absorbing compounds in algae. Curr Topics Plant Biol. 2002; 3: 113-120.
33. Grant MC, Proctor VW. Chara vulgaris and C. contraria: patterns of reproductive isolation for two cosmopolitan species complexes. Evolution. 1972; 26(2): 267–281.