REGIONAL INFLUENCES ON ALGAL BIODIVERSITY IN TWO POLLUTED RIVERS OF EURASIA (RUDNAYA RIVER, RUSSIA, AND QISHON RIVER, ISRAEL) BY BIOINDICATION AND CANONICAL CORRESPONDENCE ANALYSIS

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Abstract. In our study we investigated two polluted rivers of Eurasia from silicate and carbonate regions. We revealed an algal diversity consisting of 184 algal species and cyanoprokaryotes in the Rudnaya River, and 175 in the Qishon River. The distributions of species over the 7 higher taxa were very similar for both rivers with diatom prevealing. Bioindicational analysis in respect salinity, acidification, oxygenation, and organic pollution show that the water is cleaner and the diversity is higher in the Rudnaya River than in the Qishon River. The indices of saprobity S ranged similar. The impact of pollution on Rudnaya River increases downstream. In tha case of Qishon River, the impact of pollution decreases downstream.As a result of CCA, we revealed biosensors group sensitive to borates and fluorides in the case of Rudnaya River and these were: *Ankistrodesmus acicularis*, *A. angustus*, *Scenedesmus acuminatus*, *Lyngbya kuetzingii, Neidium ampliatum,* and *Sellaphora rectangularis.* In the case of Qishon River, *Audouinella pygmaea, Characium ornithocephalum*, and *Chamaesiphon amethystinus* were found as biosensor species. We found that algal biodiversity is more sensitive to technogenic pollution in the silicate province being more tolerant to the same organic pollutants in the carbonate province. Therefore, the combination of bioindicational methods and statistics are effective for determination of the main factors influencing algal diversity, indicators or biosensing species for the most important environmental variables.
Keywords: *CCA, algal biodiversity, ecology, Russia, Israel.*

Introduction

According to our research, algal diversity is significantly influenced by changes in the environmental parameters. We can use this contiguity in bioindication methodology. However, the major parameters used in bioindication are individual for each species, while the reaction of the entire community is left unseen.

To change this situation, in this research we reveal the reaction of the entire algal community present in two rivers in Eurasia, the Rudnaya River and the Qishon River (Figure 1) as a result of the changes in water parameters under anthropogenic pollution and regional climatic influence.

The main characteristic of the Israeli climate is a short rainy season,which lasts from December to March. The cliamte of the Far-East is mainly characterized by a summer-humidity season which lasts from April to October.

Therefore, we have assumed that water quality during the rainy season can represent the sum of all climatic influences and anthropogenic impacts in both regions. The bioindicational analysis is able to define the major influencing factors. Oridnation as a statistical method can also be used if bioindicational analysis fails to give the desired results. This method can be used to show, for example, the unique light and temperature responses of cyanobacterial species from two differens habitats on Antarctic and Arizona (Banerjee, Sharma 2004).

Study sites description

Rudnaya River

The Russian Far East is basically a basaltic volcanic area (Meybeck & Helmer 1989). The Rudnaya River starting at the eastern slope of Sikhote-Alin Range and it empties into the Rudnaya bay of the Sea of japan. The river is 73 km long, its basin occupies 1140 square kilometre. The water flow varies over the year: 96 percent during the warm season, from April to November, and only 4 percent during the cold period, from December to March (Berezneva 2006).

The Rudnaya River Basin is ecologically the most polluted area in the Primorye Region. Ore mines, enrichment factories and other industries contribute to the pollution in the river valley.

Both surface and underground waters are heavily polluted and lost their utility as a water source over the river flow from Krasnorechensk to Rudnaya Pristan'. The Rudnaya River had lost its significance as fishing water (Kuznetsova 2005).

About 20,000 tons of various technogenic substances are discharged to the river per anuum. The concentration of Mn, Zn, Cd and Pb in the polluting substances is more than ten times higher than their natural level. The residents suffer from serious lead poisoning caused by the old smelters and the insecure transporation of the lead concentrate from the local mining site.

The sources of water pollution can be grouped according to their origin and their impact. However, an objective information on the pollution sources is lacking. The tentative assessments given below are lesser than real. The discharges, in t/year are the following: Cu-0.13; Zn-4.66; Fe-1.12; Pb-0.49 (Kuznetsova 2005).

According to the most recent study, lead concentrations in the residential gardens (476-4310 mg/kg) and in roadside soils (2020-22900 mg/kg) exceed USEPA regulations by orders of magnitude. These data suggest that drinking water, dust in the air, and garden plants also likely contain dangerous levels of lead. Water discharged from the smelter 2900 m^3 as a daily average with concentrations up to 100 kg of lead and 20 kg of arsenic (Von Braun et al. 2002; Kachur et al. 2003; Sharov 2005; Shilov 1997).

Qishon River

The Qishon River is the second largest river among the coastal rivers of Israel, and also regarded as the most polluted river system in Israel (Herut et al., 2000; Herut & Kress 1997). In general, pH is relatively constant fluctuating between 9.1 and 7.5 down the river channel corresponding to the regional norm for carbonate provinces (Meybeck & Helmer 1989). The river drains an area of approximately 1100 km^2 and flows through agricultural, domestic, and industrial districts before joining the Mediterranean Sea near

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the city of Haifa. The Qishon's water is contaminated by agricultural runoff, various types of industrial effluents, and domestic sewage (Herut & Kress 1997); by heavy metals and a mixture of organic materials (Richter et al. 2003; Herut et al. 1994; Krumgalz 1993) including polycyclic aromatic hydrocarbons (PAHs), alkylated benzenes, halogenated alkanes, and chlorinated aromatic organic compounds; and some radionucleotides. As a result, the lower part of the Qishon River has been denuded for years of its multicellular life forms (Richter et al. 2003). Moreover, tissue analyses of fishes, crustaceans, and mollusks from the shallow waters of Haifa Bay at the mouth of Qishon River revealed high levels of heavy metals and deviations in oxidizing enzyme activities (Kress et al. 1999; Herut et al. 1999). Herut et al. (2003) reported medium degree of pollution in the Qishon estuary by heavy metals (mercury, copper, zinc, cadmium, nickel) and high degree of pollution upstream by international environmental criteria. Not surprisingly, the Qishon River has been identified as the main source of mercury, cadmium and other heavy metals pollution in the Haifa ports. High concentrations of Tributyltin (TBT) (> 100 µg/Kg), probably originating from anti-fouling paints, were found in the sediments at both, the Haifa port, and Qishon river. Probably, as the consequences of the TBT pollution the entire female population of the snail *Murex forskoehli* collected in the vicinity of Haifa Port (~ 800 specimens) exhibited male sexual characteristics. The sediments at the Ports of Haifa, and Qishon river are also significantly contaminated by PCB's and by polycyclic aromatic pollutants (PAH's) not to speak about high levels (recorded from 1990 to 2002) of dissolved inorganic nutrients (nitrogen and phosphorous), representing a high degree of pollution by international environmental criteria (Herut et al. 2003). The Qishon River has also elicited major public concern for its potential long-term cancer risks to fisherman working in its vicinity and to navy soldiers who used to dive in the river (Richter et al. 2003).

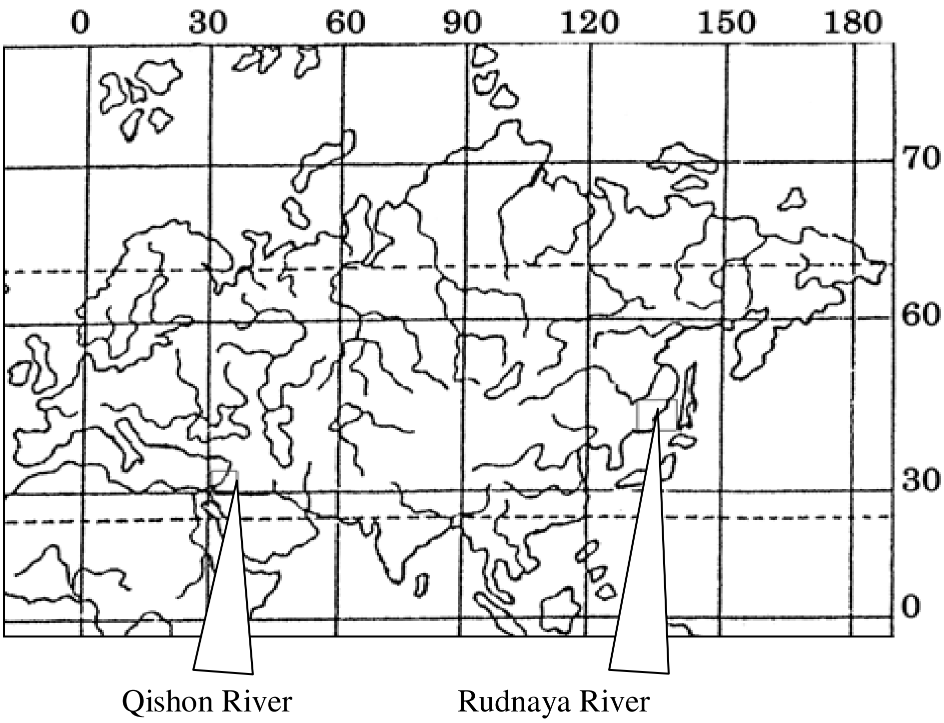

Figure 1. *Map of the study site.*

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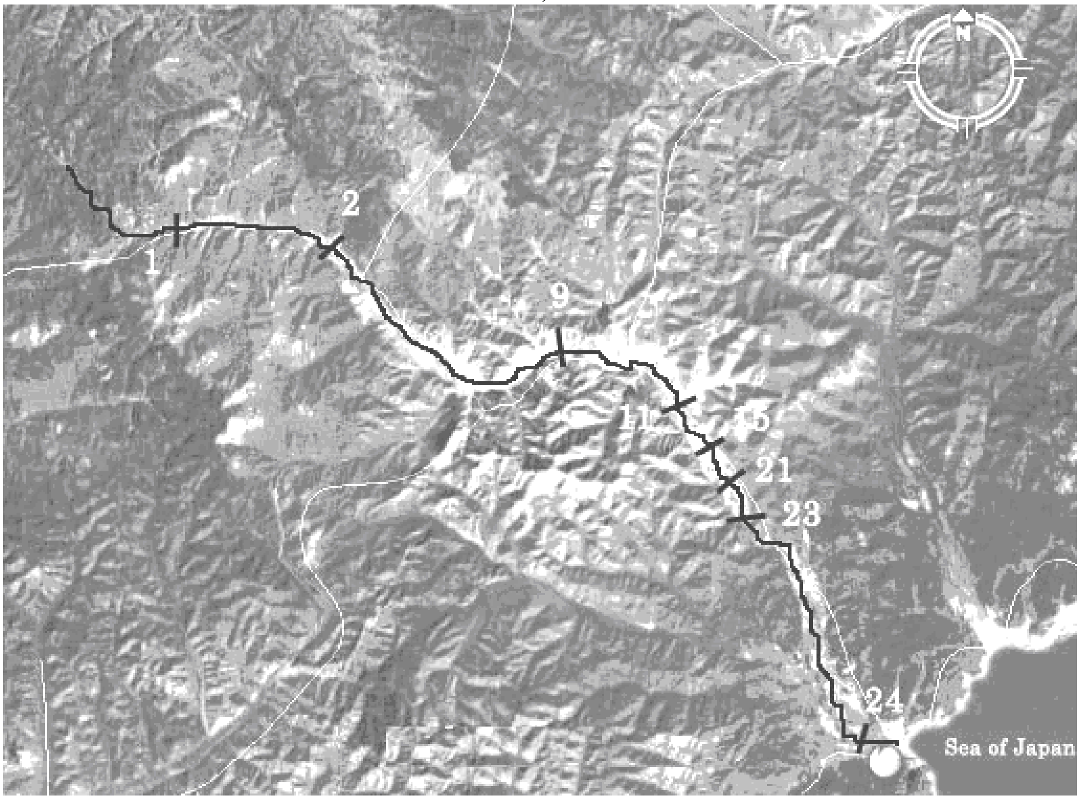
a)



b)

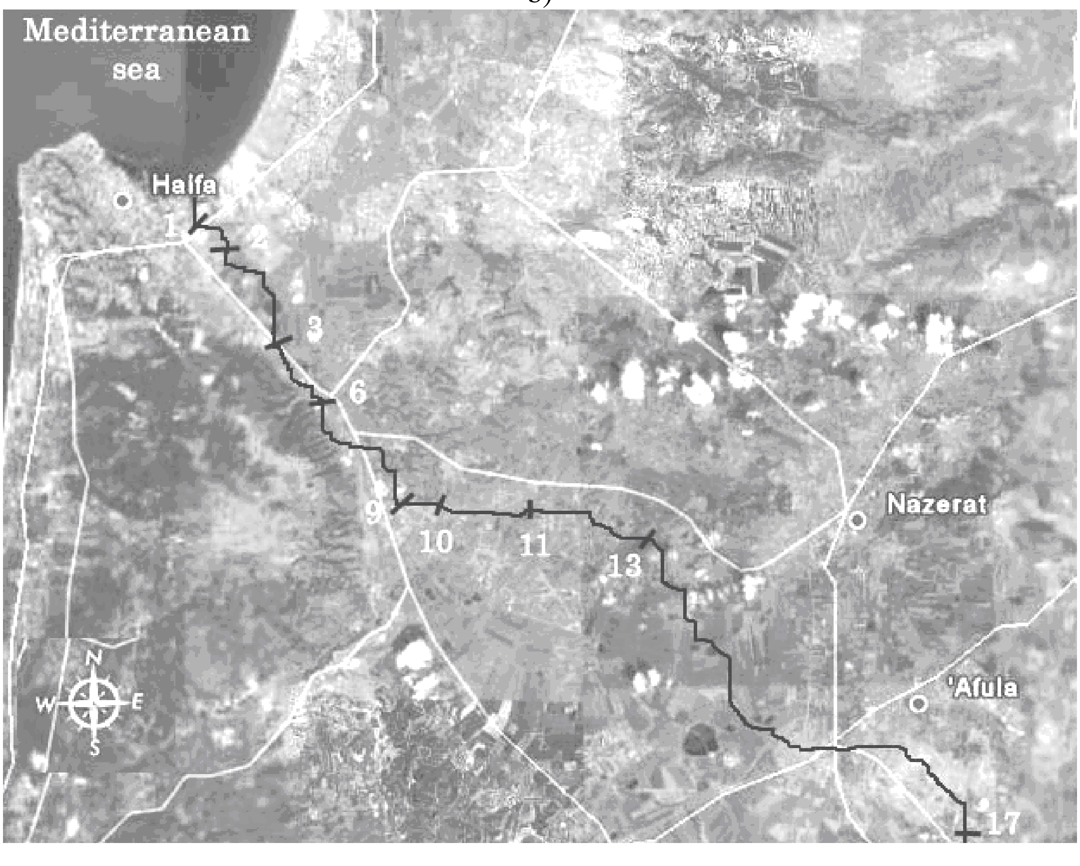


Figure 2. *Sampling stations over the Rudnaya River (a) and Qishon River (b).*

Materials and methods

Materials

For our study we have collected 649 samples of planktonic and periphytonic algae from 24 stations over the Rudnaya River in 1978-1990 (Figure 2a), as well as 117 algological samples from 19 stations over the Qishon River (Figure 2b) that were collected during the winter and summer seasons, from February 2002 to November 2005.

The samples were obtained by scooping up for phytoplankton and by scratching for periphyton and were fixed in 3% formaldehyde. Algae were studied with a dissecting Swift and Amplival microscopes under magnifications of 740–1850 and were photographed with the digital camera Inspector 1. The diatoms were prepared with the peroxide technique (Swift 1967) modified for glass slides (Barinova 1997). The diatoms were studied both under light microscope and scanning electron microscope JEOL JSM 35C. The taxonomy of this study mainly follows the systems adopted in the "Süswasserflora von Mitteleuropa".

Table 1. shows the chemical data for Rudnaya River come from Elpatievsky et al. (1976).

In parallel with sampling for algae in Qishon River, we measured conductivity, mineralization and pH with HANNA HI 9813. In addition to our sampling we have used data of chemical analysis regularly performed by "Mekorot Water Co." shown in Table 2.

Table 1. *Chemical variables over the Rudnaya River stations.*

Station	1	2	9	11	15	21	23	24
pH	7.54	7.54	7.56	7.56	7.72	8.3	8.3	7.61
HCO_3^-, mg/l	39.0	39.0	40.0	40.0	52.0	63.0	63.0	40.0
Cl^-, mg/l	4.9	4.9	7.2	7.2	6.4	12.7	12.7	8.6
SO_4^{3-}, mg/l	11.8	11.8	27.5	27.5	24.0	116.0	116.0	35.5
Ca^{2+}, mg/l	9.0	9.0	17.0	17.0	16.3	63.0	63.0	11.0
Mg^{2+}, mg/l	2.1	2.1	4.5	4.5	4.0	3.8	3.8	2.5
K^+, mg/l	0.5	0.5	1.2	1.2	1.1	1.8	1.8	1.4
Na^+, mg/l	3.5	3.5	5.3	5.3	5.2	13.2	13.2	6.7
SiO_2, mg/l	7.2	7.2	6.8	6.8	5.8	6.3	6.3	5.2
B_2O_3, mg/l	0	0	0	0	0	9.4	9.4	1.4
F, mg/l	0.06	0.06	0.1	0.1	0.1	0.42	0.42	0.17
TDS, mg/l	71.2	71.2	110.6	110.6	100.4	272.2	272.2	118
Cu, mkg/l	2.2	2.2	6.0	6.0	2.5	8.3	8.3	9.7
Zn, mkg/l	16.5	16.5	180.3	180.3	47.8	78.7	78.7	100.0
Pb, mkg/l	5.7	5.7	17.0	17.0	10.4	30.8	30.8	40.5
Sn, mkg/l	4.5	4.5	5.9	5.9	3.0	8.5	8.5	19.7
Ag, mkg/l	0.8	0.8	0.2	0.2	0.5	0.6	0.6	0.8
As, mkg/l	0	0	1.8	1.8	1.5	4.4	4.4	5.5
Index S	1.32	1.76	2.22	2.18	2.05	2.26	2.13	2.18
No of Species	35	13	26	16	15	24	17	22

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Table 2. *Chemical variables over the Qishon River stations.*

Station	17	13	11	10	9	6	3	2	1
T	22.4	22.8	24.7	25.8	25.8	24.7	24.8	29.4	30
pH	7.89	7.83	8.07	7.91	7.85	8.05	7.97	8.1	8.58
E ms/cm	3.56	6.05	5.5	5.11	4.87	5.04	4.93	9.42	9.97
TDS, mg/l	4000	6000	5000	5000	4500	5000	4500	8000	8000
TSS 105	322	172	133	68	-	114	200	36	74
O_2, mg/l	8.8	8.2	9.4	11.1	8.5	9.1	6.8	20.1	29.6
Saturated	98	92	105	136	104	110	90	235	370
Sulfides, mg/l	0	0.14	1.8	0.42	0	1.2	0	0.04	0.51
PO_4^+, mg/l	0	0	0.3	0	0	0.4	0	0	1.2
Total P, mg/l	0.5	0.6	0.5	0.9	-	0.7	0.6	1.9	2.3
NO_3^-, mg/l	27	13.4	11.3	6	8.1	6.2	7.2	11.1	6
NO_2^-, mg/l	0.1	0.087	0.006	0.35	-	0.33	0.059	0.33	0.33
NH_4^+, mg/l	0.05	0.05	0.05	0.05	-	0.05	0.05	1.3	0.6
N org., mg/l	2.5	1.5	1.8	2.9	-	1.7	2.3	4.7	5.7
Total N	29.6	15	13.2	9.3	-	8.2	9.6	16.1	12.03
BOD, mg/l	9	6.3	6	11.1	-	10.2	8	12.3	15.3
Min. oil, mg/l	0.5	0.5	0.5	0.5	0.5	0.5	-	0.5	0.5
Total oil, mg/l	0.5	0.5	0.5	0.5	0.5	0.5	-	0.5	0.7
E. Coli t/l	3300	9000	3500	14000	-	24000	12000	12000	500
Chl *a*, mg/l	0.005	0.021	0.013	0.024	-	0.021	0.005	0.093	0.021
Cl^-, mg/l	-	-	1306	-	-	773	-	10263	11663
COD, mg/l	-	-	32	-	-	58	-	49	58
TOC, mg/l	-	-	8.8	-	-	14.2	-	13.6	15
Detergents, mg/l	-	-	0.2	-	-	0.24	-	0.17	0.26
Benzene, mg/l	-	-	0.05	-	-	0.05	-	0.05	-
Toluol, mg/l	-	-	0.05	-	-	0.05	-	0.05	-
Xylen, mg/l	-	-	0.05	-	-	0.05	-	0.05	-
Phenol, mg/l	-	-	0.002	-	-	0.002	-	0.002	-
microtox	-	-	22	-	-	13	-	0	-
Chlorine, mg/l	-	-	0.06	-	-	0.06	-	-	-
Index S	2.51	2.49	2.48	2.03	2.31	2.2	2.53	2.33	2.31
No of Species	20	28	26	36	32	28	18	9	17

Density scores were calculated using a 5-score scale (Whitton & al. 1991) and 6-score scale (Korde 1956). Saprobity indices were obtained for each algal community (Pantle & Buck 1955; Sladeček 1986) and then used for integral assessment of the species habitats. Ecological and horological characteristics of the species are summed up in our database (Barinova & al. 2006).

Our ecological analysis revealed freshwater algae ecological groups in respect to pH, salinity, and saprobity, as well as temperature, streaming, and oxygenation. Each group was separately assessed in respect to its significance for bioindication. Species that respond predictably to these variables can be used as bioindicators reflecting the response of aquatic ecosystems to eutrophication, pH levels (acidification), salinity, and organic pollutants.

Diagrams of species distribution were constructed for each group of ecological indicators. The algal groups were ordinated according to their increasing tolerances for a given environmental variable. A polynomial/linear trend line was defined (as a statistic function in the Microsoft EXCEL program) for distribution of algal groups in response to individual variables, showing the general tendency of the diversity changes in respect to fluctuations of a given variable.

The distribution in the number of species between the groups in the different indicator systems shows the total range of environmental conditions in the river, on one hand, and the prevailing conditions, on the other. The summit of the trend line corresponds to the optimal conditions in respect to the given variable.

Out of the many possible the ordination methods available we have chosen to use Canonical Correspondence Analysis (CCA). We were able to obtain quantitative information on the relationship between species and environmental variables using CCA with the CANOCO for Windows 4.5 package.

Estimation of the explanatory power for each environmental variable was performed using the variable as the sole constraining variable. Statistical significance for each variable was assessed using the Monte Carlo unrestricted permutation test involving 999 permutations (ter Braak 1987; 1990).

The CCA biplot represents the ordination of species in relation to the combination of the different environmental variables. Environmental variables are represented by arrows, the maximal value for each variable is located at the arrow head. Therefore, species marked near arrow head are bioindicators in respect this variable. Species marked near opposite end of arrow are biosensors, which is sensitive even to presence of given variable.

Results and discussion

Rudnaya River

Data on water hydrochemistry of the Rudnaya River are cited in table I (Elpatievsky et al. 1976). Unfortunately, the existing data pertain to metal concentrations only except the data on stations 1 and 2, which show normal distribution of chemical elements in the natural unpolluted water sources in the Russian Far East. Insignificant pH fluctuations suggest that the river waters are fresh over the most of the watercourse. Even at the mouth station 24 pH does not exceed 7.6. An increase of pH up to 8.3 was measured at stations 21 and 23 only. These stations are situated down current of the polluting tributaries of the Rudnaya River.

The analysis of table 1 shows that concentrations of HCO_3^-, Cl^-, Ca^{2+}, Na^+, TDS, Cu, Pb, Sn in the Rudnaya River, in general and at the station 21 and 23 in particular are higher than the background level. The concentration of borates, sulfates, and fluorides increase up to ten times at these stations. Notable also is a significant increase of Zn at the stations 9 and 11.

As it was expected, the saprobity index is the lowest at the clear water station 1 (S=1.32) up current of the major pollution sources. Similar values of saprobity indices are obtained for the majority of water sources in the Russian Far East (Barinova & Medvedeva 1987). The influences of polluting discharges are reflected in the increase in the saprobity index up to 2.18-2.26. The maximal biological diversity of algal communities was observed at the clear-water station 1, appreciably decreasing down the current.

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Qishon River

The physico-chemical environmental variables and their dynamics over the Qishon River stations are indicated in Table 2. The pH and conductivity show that Qishon River is fresh water in the upper and middle reaches, is influenced by sea tides in the lower reaches (chloride fluctuated from 773 mg per liter to 11663 mg per liter (Qishon River Authority http://www.kishon.org.il/) and remains alkaline all year-round. The concentration of N-NO_3 is 0.6-10.5 mg per liter. The concentration of P-total is 0.2-7.93 mg per liter. In winter, conductivity tends to increase from station 10 to the mouth, while pH tends to decrease in the same direction. Connection between conductivity and salinity levels as well as other chemical variables and Index of saprobity S indicated in the Table 2. In general, pH in Qishon River is relatively constant fluctuating between 9.1 and 7.5 down the river channel corresponding to the regional norm for carbonate provinces (Meybeck & Helmer 1989).

In samples from Qishon River we found 175 species of algae from 7 divisions (Barinova et al. 2004; 2006). In samples from Rudnaya River we found 184 species of algae from 7 divisions (Medvedeva et al. 1986a,b; Medvedeva & Barinova 1992; Barinova & Medvedeva 1989, 1992a,b). As we can see on the Table 3, the species diversity in each river is significantly different, that reflects their regional ecological preferences. The comparison of found diversity (Table 3) is on the Figure 3.

Table 3. *Abundance and ecological preference of algal species revealed in the Rudnaya River and Qishon River.*

No	Taxon	Code	Rud	Qish	Hab	T	Oxy	D	S	Hal	pH
	Cyanoprokaryota										
1	*Anabaena spiroides* Kleb.	ANSPIH	0	1-3	P	-	st-str	-	o	i	-
2	*Anabaena variabilis* f. *rotundospora* Hollerb.	ANAVRQ	0	1-6	B	-	-	-	-	-	-
3	*Anabaena* sp.	AN001Y	0	1-3	-	-	-	-	-	-	-
4	*Aphanocapsa elachista* W. et G.S. West	MICPUR	1	0	-	-	-	-	-	-	-
5	*Aphanothece elabens* (Bréb.) Elenk.	APHACQ	0	2	P-B	-	-	-	-	-	-
6	*Aphanothece microscopica* Näg.	APHAMR	2	0	B	temp	-	-	o	hb	
7	*Aphanothece stagnina* (Spreng.) A. Braun in Rabenh.	ATS01Y	0	1	P-B	-	-	-	b-a	hl	ind
8	*Arthrospira fusiformis* (Woronich.) Komárek et Lund	ARTHSQ	0	1	P	-	-	-	-	mh	-
9	*Calothrix fusca* f. *parva* (Erceg.) V. Poljansk.	CAFUSR	6	0	-	-	-	-	-	-	-
10	*Chamaesiphon amethystinus* (Rostaf.) Lemm.	CHAMAQ	0	1-5	Ep	-	str	-	-	-	-
11	*Chroococcus minor* (Kütz.) Näg.	GLOCAR	1	0	B	-	-	-	o-b	-	-
12	*Crinalium endophyticum* Crow	CRINAQ	0	1	Ep	-	-	-	-	-	-
13	*Hydrococcus rivularis* (Kütz.) Menegh.	HYDRCQ	0	4	B	-	-	-	x	-	-

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No	Taxon	Code	Rud	Qish	Hab	T	Oxy	D	S	Hal	pH
14	*Limnothrix amphigranulata* (Van Goor) Meffert	LIA01Y	0	6	B	-	st	-	-	mh	-
15	*Lyngbya kuetzingii* Schmidle	LYNKUL	3	0	B	-	st-str	-	o-b	-	-
16	*Lyngbya limnetica* Lemm.	LYL01Y	0	2	P-B	-	st-str	-	o-b	hl	-
17	*Lyngbya pusilla* (Rabenh.) Hansg.	LYPUSR	4	0	-	-	-	-	-	-	-
18	*Lyngbya scottii* f. *minor* (F.E. Fritsch) Elenk.	LYSCOR	3	0	-	-	-	-	-	-	-
19	*Lyngbya* sp.	LY001Y	0	1-4	-	-	-	-	-	-	-
20	*Merismopedia glauca* (Ehrb.) Kütz.	MRG01Y	1	0	P-B	-	-	-	o-a	i	ind
21	*Merismopedia punctata* Meyen	MPUN0A	3	0	P-B	-	-	-	o-a	i	ind
22	*Merismopedia tenuissima* Lemm.	MRT01Y	0	2-6	P-B	-	-	-	b-a	hl	-
23	*Microcystis aeruginosa* (Kütz.) Kütz.	MIA01Y	0	2-6	P	-	-	-	o-a	hl	-
24	*Oscillatoria animalis* Gom.	OSAN1Y	0	3	P-B	-	str	-	o	-	-
25	*Oscillatoria brevis* Gom.	OSB01Y	0	1-4	P-B	-	st	-	b-p	-	-
26	*Oscillatoria formosa* Gom.	OSFO0A	0	1	P-B	-	st	-	b-p	-	-
27	*Oscillatoria guttulata* Van Goor	OSGU1Y	0	2	P	-	st	-	a	-	-
28	*Oscillatoria mougeotii* Kütz.	OSCMOQ	0	1	P-B	-	st	-	o-a	-	-
29	*Oscillatoria princeps* Gom.	OSP01Y	0	1	P-B	-	st-str	-	b-p	-	-
30	*Oscillatoria* sp.	OS001Y	0	1-6	-	-	-	-	-	-	-
31	*Phormidium ambiguum* Gom.	PRA01Y	5	0	B	temp	st-str	-	b	i	ind
32	*Phormidium autumnale* (Ag.) Gom.	PRAU1Y	1-6	0	B	-	st-str	-	b	-	-
33	*Phormidium foveolarum* Gom.	PHOFOQ	0	2	B	-	-	-	b-o	-	-
34	*Phormidium* sp.	PR001Y	0	1-3	-	-	-	-	-	-	-
35	*Phormidium subfuscum* Gom.	PHORSJ	6	0	B	-	st-str	-	b	-	-
36	*Phormidium uncinatum* Gom.	PRU01Y	1-5	0	P-B	temp	-	-	b	i	-
37	*Planktolyngbya regularis* Kom.-Legn. et Tavera	PLR01Y	0	2-3	P	warm	st	-	-	-	-
38	*Pleurocapsa crepidinum* Collins	PCC01Y	0	4	Ep	-	-	-	-	ph	-
39	*Rhabdogloea smithii* (R. et F. Chodat) Komárek	DACTRR	1	0	P	-	st-str	-	-	-	-
40	*Schizothrix pulvinata* (Kütz.) Gom.	SZP01Y	0	2	Ep	-	st-str	-	-		-
41	*Spirulina major* Kütz.	SPM01Y	0	2-4	P	-	st	-	-	ph	-
42	*Spirulina platensis* (Nordst. ex Gom.) Geitler	SPP01Y	0	2	P	-	st	-	b	-	-
43	*Spirulina* sp.	SPIRUQ	0	1	-	-	-	-	-	-	-

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No	Taxon	Code	Rud	Qish	Hab	T	Oxy	D	S	Hal	pH
44	*Xenococcus pallidus* (Hansg.) Komarek et Anagn.	XENCPQ	0	1-2	Ep	-	-	-	-	ph	-
	Chrysophyta										
45	*Hydrurus foetidus* (Villars) Trevisan	HYDFOL	2-6	0	B	-	-	-	o-x	-	-
46	*Lagynion janei* Bourr.	LAGYJQ	0	6	Ep	-	-	-	-	-	-
47	*Stylococcus aureus* Chod.	SYA01Y	0	2-4	Ep	-	-	-	-	-	-
	Xanthophyta										
48	*Characiopsis microcysticola* Skuja	CHAMIR	2	0	-	-	-	-	-	-	-
49	*Gloeobotrys monochloron* Ettl	GLOEBR	6	0	-	-	-	-	-	-	-
50	*Heterothrix monochloron* Ettl	HETERR	1-2	0	-	-	-	-	-	-	-
51	*Tribonema subtilissimum* Pasch.	TRISUR	4	0	B	-	-	-	-	i	-
52	*Tribonema vulgare* Pasch.	TRIVUR	2	0	P-B	-	-	-	o-a	i	-
	Cryptophyta										
53	*Cryptomonas* sp.	CRYPTQ	0	1	-	-	-	-	-	-	-
	Euglenophyta										
54	*Euglena acus* Ehrb.	EUA01Y	0	1-2	P	eterm	st	-	b	i	ind
55	*Euglena ehrenbergii* Klebs	EUE01Y	0	1	P-B	eterm	st-str	-	b	-	ind
56	*Euglena oxyuris* Schmarda	EUOXYL	3	0	P			-	b-a	-	-
57	*Euglena proxima* Dang.	EUP01Y	0	1	P-B	eterm	st-str	-	p	mh	ind
58	*Euglena* sp.	EU001Y	0	1	-	-	-	-	-	-	-
59	*Euglena texta* (Duj.) Hübn.	EUT01Y	0	1-3	P	eterm	st-str	-	b	-	ind
60	*Petalomonas mediocanellata* Stein	PETALR	1	0	B	warm	st-str	-	a	-	ind
61	*Phacus acuminatus* Stokes	PHACAQ	0	1	P-B	eterm	st-str	-	b-a	i	-
62	*Phacus parvulus* Klebs	PHAPAQ	0	5	P	eterm	st-str	-	b	i	ind
63	*Phacus pleuronectens* (Ehrb.) Duj.	PHP01Y	0	1	P-B	-	st-str	-	b-a	i	ind
64	*Phacus pyrum* (Ehrb.) Stein	PHPY1Y	0	1	P	eterm	st-str	-	b	i	ind
65	*Phacus* sp.	PHACUH	0	1	-	-	-	-	-	-	-
66	*Phacus striatus* Francé	PHASTQ	0	1	P-B	eterm	st-str	-	b-a	-	ind
67	*Trachelomonas hispida* Delf.	TRH01Y	1	0	P-B	eterm	st-str		b	i	
	Bacillariophyta										
68	*Achnanthes chlidanos* Hohn et Hellerman	AC9960	4	0	B	-	-	sx	o	i	ind
69	*Achnanthes delicatula* subsp. *hauckiana* (Grun. in Cleve et Grun.) Lange-Bert. et Ruppel	ACDE1R	1	0	-	-	-	-	-	-	-

No	Taxon	Code	Rud	Qish	Hab	T	Oxy	D	S	Hal	pH
70	*Achnanthes lanceolata* f. *capitata* O. Müll.	ACLC1L	2	0	B	-	-	-	x-b	i	ind
71	*Achnanthes lanceolata* f. *ventricosa* Hust.	ACLV1L	1-2	0	B	warm	-	sx	x-b	i	alf
72	*Achnanthes lanceolata* (Bréb.) Grun. var. *lanceolata*	AL001Y	1-3	0	P-B	warm	st-str	sx	o-x	i	alf
73	*Achnanthes leariformis* Lange-Bert.	AC9959	3-6	1	B	eterm	st-str	es	x-o	i	ind
74	*Actinocyclus normanii* (Greg. ex Grev.) Hust. ex Van Landingham	ACTINQ	0	1	P	-	st-str	-	-	mh	-
75	*Amphora coffeaeformis* (Ag.) Kütz.	AMC01Y	0	1-6	B	-	st-str	-	-	mh	-
76	*Amphora montana* Krasske	AMMONO	0	1	B	-	ae	-	-	i	alf
77	*Amphora ovalis* (Kütz.) Kütz.	AMO01Y	1-2	1	B	temp	st-str	sx	a-b	i	alf
78	*Amphora pediculus* (Kütz.) Grun.	AMP01Y	1	1	B	temp	st	es	o-a	i	alf
79	*Amphora veneta* Kütz.	AM004A	0	1-2	B	-	-	es	o	i	alf
80	*Anomoeoneis sphaerophora* (Ehrb.) Pfitz.	AN009A	0	1-2	P-B	warm	st-str	-	x-b	hl	alb
81	*Anomoeoneis sphaerophora* f. *sculpta* Kramm.	ANOSSQ	0	1	B	-	-	-	-	mh	-
82	*Aulacoseira granulata* (Ehrb.) Simons.	AUL01Y	1	1-3	P-B	temp	st-str	es	b-a	i	alf
83	*Bacillaria paxillifer* (O. Müll.) Hendey	BAP01Y	0	1-4	P-B	-	-	es	o	mh	ind
84	Cal*oneis leptosoma* (Grun.) Kramm. in Kramm. et Lange-Bert.	CALLER	1	0	B	-	-	-	o	-	-
85	*Caloneis molaris* (Grun.) Kramm.	CALMOR	1	0	B	-	str	es	-	i	ind
86	*Caloneis permagna* (J.W. Bailey) Cleve	CLP01Y	1	1-2	B	-	-	-	-	hl	-
87	*Caloneis silicula* (Ehrb.) Cl. var. *silicula*	CASILR	1	0	-	-	-	-	-	-	-
88	*Caloneis silicula* var. *truncatula* (Grun.) Cl.	CALSTL	1	0	B	-	st	-	-	i	alf
89	*Caloneis silicula* var. *ventricosa* (Ehrb.) Donk.	CALSVL	1	0	B	-	st	-	-	i	-
90	*Campylodiscus bicostatus* W. Smith in Roper	CMPCBH	0	1	B	-	-	-	-	mh	-
91	*Cocconeis placentula* var. *euglypta* (Ehrb.) Grun.	CCCPEQ	1-4	1	P-B	temp	st-str	sx	-	i	alf
92	*Cocconeis placentula* Ehrb. var. *placentula*	CCP01Y	1-3	0	P-B	temp	st-str	es	o-b	i	alf
93	*Cocconeis placentula* var. *pseudolineata* Geitl.	CCCPPQ	0	1	P	-	st-str	sx	-	i	alf
94	*Craticula accomoda* (Hust.) D.G. Mann	CRA01Y	0	1	P	-	-	sp	o-a	i	
95	*Craticula ambigua* (Ehrb.) Mann	CRA00A	1	0	B	warm	st	es	o	i	alf

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96	*Craticula cuspidata* (Kütz.) D.G.Mann	CRC01Y	1	1	B	temp	st	es	o	i	alf
97	*Craticula halophila* (Grun. ex Van Heurck) Mann	CRATGO	0	1	B	-	st-str	es	-	mh	alf
98	*Cyclotella meneghiniana* Kütz.	CYM01Y	1	1-6	P-B	temp	st	sp	o-a	hl	alf
99	*Cyclotella stelligera* (Cleve et Grun. in Cleve) Van Heurck	CYSTER	1	0	P-B	-	st	es	x	i	ind
100	*Cyclotella tuberculata* Makar. et Log.	CYCTUQ	0	1	P	-	-	-	-	hl	-
101	Cylindrotheca gracilis (Bréb. ex Kütz.) Grun. in Van Heurck	CYLIGQ	0	2	B	-	st	-	o	hl	-
102	*Cymatopleura librile* (Ehrb.) Pant.	CL001A	1-3	0	P-B	-	-	-	o	i	alf
103	*Cymbella affinis* Kütz.	CYAFFR	2	0	B	temp	st-str	sx	b-o	i	alf
104	*Cymbella aspera* (Ehrb.) Perag. in Pelletan	CYASPR	2	0	B	-	st-str	es	b-o	i	alf
105	*Cymbella cistula* (Ehrb.) Kirchn.	CYCISR	1-4	0	B	-	st-str	sx	o-b	i	alf
106	*Cymbella cornuta* (Ehrb.) R. Ross	CYLANR	2	0	B	-	-	sx	o	i	alf
107	*Cymbella cuspidata* Kütz.	CYCUSR	1	0	B	temp	-	-	o-a	i	ind
108	*Cymbella ehrenbergii* Kütz.	CYEHRR	1	0	B	-	st-str	-	b-o	i	alb
109	*Cymbella hybrida* Cleve	CYMHYQ	0	1	B	-	-	-	-	hl	alb
110	*Cymbella microcephala* Grun. in Van Heurck	CYMBMO	0	1-2	B	-	-	es	b	i	alf
111	*Cymbella naviculiformis* (Auersw. ex Heib.) Cleve	CM009A	1	0	B	-	-	es	o	i	ind
112	*Cymbella reinhardtii* Grun.	CM099A	1	0	B	-	-	-	-	-	-
113	*Cymbella* sp.	CYMBEH	0	1	B	-	-	-	-	-	-
114	*Cymbella subcuspidata* Kramm.	CYHETL	1	0	B	-	-	-	-	i	acf
115	*Cymbella tumidula* Grun. in A. Schmidt	CM109A	1	0	B	-	-	-	-	i	alf
116	*Cymbella turgidula* Grun.	CYTURL	1	0	B	-	st-str	es	-	-	ind
117	*Diatoma hiemale* (Roth) Heib.	DIHIER	2-4	0	P-B	cool	st-str	sx	b-o	hb	ind
118	*Diatoma mesodon* (Ehrb.) Grun.	DT021A	1-6	0	B	cool	st-str	sx	o-b	hb	-
119	*Diatoma tenue* Ag.	DITENR	1-4	0	P-B	-	st	sx	b-a	hl	ind
120	*Diatoma vulgare* Bory	DIVULR	1-3	0	P-B	-	st-str	sx	b-a	i	ind
121	*Didymosphenia geminata* (Lyngb.) M. Schm. in A. Schmidt	DYDGER	1	0	B	-	st-str	sx	o-a	i	ind
122	*Diploneis ovalis* (Hilse) Cleve	DIPLOR	1	0	B	-	-	sp	b	i	alb
123	*Encyonema elginense* (Kramm.) D.G. Mann	ENCELQ	0	2	B	-	st	sx	-	hb	acf

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124	*Encyonema minutum* (Hilse ex Rabenh.) D.G. Mann	ENCMML	1	0	B	-	-	es	o-b	oh	ind
125	*Encyonema silesiacum* (Bleisch in Rabenh.) Mann	ENCSIQ	1	3	B	-	st-str	sx	x-o	i	ind
126	*Entomoneis alata* (Ehrb.) Ehrb.	ENO01Y	0	1-3	P-B	-	st	-	-	mh	alf
127	*Entomoneis paludosa* (W. Sm.) Reim.	ENP01Y	0	1-3	B	-	-	-	-	-	-
128	*Epithemia adnata* var. *porcellus* (Kütz.) R. Ross	EPIAPR	1	0	B	-	-	-	b	i	alb
129	*Eunotia bilunaris* (Ehrb.) Mills	EUNBIR	1	0	B	temp	-	es	b	i	acf
130	*Eunotia diodon* Ehrb.	EUNDIR	1	0	B	cool	st	-	o-x	i	acf
131	*Eunotia exigua* (Breb ex Kütz.) Rabenh.	EUNGRR	1	0	B	-	-	-	a	hb	ind
132	*Eunotia minor* (Kütz.) Grun.	EU110A	1	0	B	-	-	es	x	-	-
133	*Eunotia praerupta* Ehrb.	EUNPPR	1	0	B	cool	st-str	sx	b	hb	acf
134	*Eunotia steineckei* Petersen	EUNEXR	1	0	B	-	-	es	o-b	hb	acf
135	*Fallacia pygmaea* (Kütz.) Stickle et Mann	FP001Y	0	1-4	B	-	-	es	b-o	mh	alf
136	*Fallacia subhamulata* (Grun.) Mann	FS001Y	1	0	B	-	-	-	-	i	ind
137	*Fragilaria capucina* Desm. var. *capucina*	FRACAQ	3	3	B	-		es	o	i	alf
138	*Fragilaria capucina* var. *rumpens* (Kütz.) Lange-Bert.	FR009G	1-5	0	B	-	st-str	es	o	i	acf
139	*Fragilaria capucina* var. *vaucheriae* (Kütz.) Lange-Bert.	FRAVCR	3-4	0	P	-	-	sx	o-b	i	alf
140	*Fragilaria construens* f. *construens* (Ehrb.) Hust.	STRSCQ	0	1	P-B	temp	st-str	sx	o	i	alf
141	*Fragilaria crotonensis* Kitt.	FRACRR	1	0	P	-	st	es	a-b	hl	alf
142	*Fragilaria fasciculata* (Ag.) Lange-Bert.	FR057A	0	1-2	B	-	st	sx	o	hl	alf
143	*Fragilaria pulchella* (Ralfs ex Kütz.) Lange-Bert.	CTEKRL	2	0	Ep	-	-	-	b	hl	-
144	*Fragilaria ulna* var. *acus* (Kütz.) Lange-Bert.	SYNACR	1	0	P	-	st-str	es	b	i	alb
145	*Fragilaria vaucheriae* (Kütz.) Peters.	FRAVVR	1-4	0	P	-	-	sx	o-b	i	alf
146	*Fragilariforma bicapitata* (Mayer) Will. et Round	FRFOBR	1	0	B	-	-	-	o-b	hb	ind
147	*Fragilariforma virescens* (Ralfs) Williams et Round	FRFVIR	1	0	P-B	-	st	es	o	i	ind
148	*Frustulia rhomboides* (Ehrb.) De Toni	FRURHR	1-2	0	B	-	st	es	x-b	hb	acf
149	*Frustulia vulgaris* (Thw.) De Toni	FU001A	1-3	0	P-B	-	st	es	x-b	i	alf

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150	*Gomphoneis quadripunctatum* (Østr.) Dawson ex Ross et Sims	GOMPQR	1-2	0	B	-	-	es	-	i	ind
151	*Gomphonema acuminatum* Ehrb. var. *acuminatum*	GOMACR	1	0	P-B	-	st	es	x-b	i	alf
152	*Gomphonema acuminatum* var. *coronatum* (Ehrb.) W. Sm.	GOMAAR	1	0	P-B	-	st	-	b	i	ind
153	*Gomphonema affine* Kütz.	GO020A	0	1-5	P-B	-	st	es	o-b	-	-
154	*Gomphonema angustatum* (Kütz.) Rabenh.	GOA01Y	1-4	1	P-B	-	st-str	es	b	i	alf
155	*Gomphonema angustum* Ag.	GO073A	0	1	P-B	-	st-str	es	o-b	i	ind
156	*Gomphonema clavatum* E. Reichardt	GO029A	1	0	B	-	str	es	o-b	i	ind
157	*Gomphonema minutum* (Ag.) Ag.	GOMMIO	0	1	B	-	-	es	o-b	oh	alf
158	*Gomphonema parvulum* Kütz.	GO013A	1-3	1	B	temp	str	es	x	i	ind
159	*Gomphonema productum* (Grun.) Lange-Bert. et E. Reichardt	GO003B	1-5	0	B	-	str	es	b	i	alf
160	*Gomphonema truncatum* Ehrb. sensu Patrick et Reim.	GO023A	1	0	P-B	-	-	es	o-x	-	-
161	*Gyrosigma acuminatum* (Kütz.) Rabenh.	GY005A	1	1-5	B	cool	-	-	o-x	i	alf
162	*Hannaea arcus* f. *arcus* (Ehrb.) Patr.	HANNAR	1-6	0	B	-	str	es	o	i	alf
163	*Hannaea arcus* f. *recta* (Cl.) Foged	HANNRR	1-5	0	B	-	-	sx	-	-	-
164	*Hannaea arcus* var. *amphioxys* (Rabenh.) Patr.	HANAAL	1-3	0	B	cool	str	-	x	i	alf
165	*Hantzschia amphioxys* (Ehrb.) Grun. in Cl. et Grun.	HA001A	1-2	1	B	temp	-	es	b-o	i	ind
166	*Licmophora* sp.	LICMOQ	0	1-2	-	-	-	-	-	-	-
167	*Luticola mutica* (Kütz.) Mann	LUM01Y	1-2	1	B	-	st-str	sp	o	i	ind
169	*Luticola muticopsis* (Van Heurck) D.G. Mann	LUS01Y	0	1	B	-	st-str	-	-	-	-
189	*Melosira varians* Ag.	ME015A	2	0	P-B	temp	st-str	es	a-b	hl	alf
170	*Meridion circulare* (Grev.) Ag. var. *circulare*	MECI0A	1-6	0	B	-	str	es	o-b	i	alf
171	*Meridion circulare* var. *constrictum* (Ralfs) Van Heurck	MECIRR	1-2	0	P-B	-	st-str	sx	x	hb	-
172	*Navicula angusta* Grun.	NA037A	0	1	B	-	-	sx		hl	acf
173	*Navicula capitata* Ehrb. var. *capitata*	NACAPR	1	0	B	temp	-	es	o-b	hl	alf

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174	*Navicula capitata* var. *hungarica* (Grun.) Ross	NACUSR	1	0	B	-	-	es	o	i	-
175	*Navicula crucicula* (W. Sm.) Donk.	NACRUR	1	0	B	-	-			mh	ind
176	*Navicula erifuga* Lange-Bert.	NAE01Y	0	1-5	B	-	-	es	x-o		
177	*Navicula gregaria* Donkin	NAG01Y	1-4	1	P-B	temp	-	es	x-b	mh	alf
178	*Navicula peregrina* (Ehrb.) Kütz.	NAPERR	1	0	B	-	-	es	-	mh	alf
179	*Navicula perminuta* Grun. in Van Heurck	NAPERQ	0	1-6	B	-	-	es	-	hl	
180	*Navicula radiosa* Kütz.	NA003A	1	0	B	temp	st-str	es	o	i	ind
181	*Navicula recens* (Lange-Bert.) Lange-Bert.	NAR01Y	0	1-5	P-B	-	-	es	o-b	i	-
182	*Navicula schroeterii* Meist.	NAS01Y	0	1	B	-	-	es	a-b	i	alf
183	*Navicula* sp.	NA001Y	0	1	-	-	-	-	-	-	-
184	*Navicula spicula* Hickie	NASPIQ	0	1-6	P-B	-	-	-	-	mh	-
185	*Navicula stroemii* Hust.	NA650A	0	1	B	eterm	-	es	o	oh	alf
186	*Navicula tripunctata* (O. Müll.) Bory	NATRIO	0	2	B	-	st-str	es	b	i	ind
187	*Navicula trivialis* Lange-Bert.	NATRVO	0	1-3	B	-	-	sp	b-o	i	alf
188	*Navicula veneta* Kütz.	NA054A	0	1-6	B	-	-	es	x-o	hl	alf
189	*Navicula viridula* (Kütz.) Ehrb.	NAV01Y	1	0	B	-		es	o	hl	alf
190	*Naviculadicta protracta* Grun.	NADICR	1	0	B	-	-	es	x-b	mh	ind
191	*Neidium affine* (Ehrb.) Cl.	NE003A	2-3	0	B	-	-	-	o	i	alf
192	*Neidium ampliatum* (Ehrb.) Kramm.	NEAMPO	1	0	B	-	st	es		hb	ind
193	*Neidium bisulcatum* (Lagerst.) Cleve	NEBISR	1	0	B	-	-	es	o-b	hb	alf
194	*Neidium iridis* var. *diminutum* (Pant.) Wislouch et Kolbe	NEIRDR	1	0	B	-	-	-	o	i	ind
195	*Neidium iridis* (Ehrb.) Cl. var. *iridis*	NEIRIR	1	0	B	-	st	es	o-x	hb	ind
196	*Nitzschia acicularis* (Kütz.) W. Sm.	NI042A	0	1	P-B	temp	-	es	o-b	i	alf
197	*Nitzschia amphibia* Grun.	NIA01Y	1-3	1	P-B	temp	-	sp	o	i	alf
198	*Nitzschia aurariae* Choln.	NITZAQ	0	1-6	B	-	-	-	-	oh	-
199	*Nitzschia communis* Rabenh.	NITCOR	2	0	P-B	-	st-str	sp	o	i	alf
200	*Nitzschia compressa* var. *balatonis* (Grun.) Lange-Bert.	NIC02Y	0	1-2	B	-	-	-	-	hl	
201	*Nitzschia desertorum* Hust.	NITDSQ	0	1-2	B	-	st-str	-	b	mh	alf
202	*Nitzschia frustulum* var. *bulnheimiana* (Rabenh.) Grun. in Van Heurck	NI008A	1-5	1	B	temp	-	sp	b	hl	alf

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203	*Nitzschia grandifera* Hust.	NITGRO	0	1	B	-	-	-		hl	-
204	*Nitzschia inconspicua* Grun.	NITINO	0	1-5	B	-	-	es	a-b	-	-
205	*Nitzschia laevis* Hust.	NITLEO	0	1	B	-	-	-	-	mh	-
206	*Nitzschia linearis* (Ag.) W. Sm.	NI031A	1-4	2	B	temp	-	es	x	i	alf
207	*Nitzschia monachorum* Lange-Bert.	NITMOQ	0	1	B	-	st	-	-	-	-
208	*Nitzschia obtusa* W. Sm.	NI036A	0	1-6	B	-	-	es	b	mh	-
209	*Nitzschia palea* (Kütz.) W. Smit	NI017A	1-6	1-6	P-B	temp	-	sp	o-x	i	ind
210	*Nitzschia pseudofonticola* Hust.	NI028A	1	1	B	-	-	es	o-p	i	alf
211	*Nitzschia reversa* W. Sm.	NIR01Y	0	1-3	P	-	-	-	-	hl	-
212	*Nitzschia scalpelliformis* (Grun.) Grun. in Cleve et Grun.	NISC1Y	0	1-4	B	-	-	sp	-	hl	-
213	*Nitzschia sigma* (Kütz.) W. Sm.	NIS01Y	0	1-4	B	temp	-	es	-	mh	ind
214	*Nitzschia solita* Hust.	NISL1Y	0	1-3	B	-	st	es	a-b	mh	alf
215	*Nitzschia umbonata* (Ehrb.) Lange-Bert.	NI184A	2	0	P	-	st-str	es	b-o	i	ind
216	*Nitzschia vermicularis* (Kütz.) Hantzsch in Rabenh.	NI049A	1	0	B	-	-	-	o	i	alf
217	*Pinnularia borealis* Ehrb.	PINBOQ	2	1	B	-	ae	es	o-b	i	ind
218	*Pinnularia brevicostata* Cl.	PINBRR	1	0	B	cool	-	-	-	i	ind
219	*Pinnularia gibba* var. *linearis* Hust.	PINGIR	1	0	B	-	-	-	-	i	ind
220	*Pinnularia globiceps* Greg.	PINGLR	1	0	B	-	-	-	-	i	acf
221	*Pinnularia infirma* Kramm.	PINPUR	1	0	B	-	-	-	-	i	ind
222	*Pinnularia intermedia* (Lagerst.) Cleve	PI047A	2	0	B	-	st	-	x	i	ind
223	*Pinnularia interrupta* W. Smith	PINMER	1-3	0	B	-	-	-	o-x	i	ind
224	*Pinnularia major* (Kütz.) Rabenh.	PINMAR	1-2	0	B	temp	st-str		x	i	ind
225	*Pinnularia microstauron* var. *brebissonii* (Ehrb.) Cleve	PIMIBL	2	0	B	-	st-str	es	o-x	i	ind
226	*Pinnularia microstauron* (Ehrb.) Cleve var. *microstauron*	PINMMR	1-3	0	B	temp	-	sp	x	i	ind
227	*Pinnularia viridis* (Nitzsch) Ehr.	PINVIR	1-3	0	P-B	temp	-	-	o-x	i	ind
228	*Placoneis elginensis* (Greg.) E. Cox	PLACER	2	0	B	-	-	sx	x-o	i	ind
229	*Placoneis gastrum* (Ehrb.) Mereschk.	PLAGAR	5	0	B	-	-	sx	x-o	i	ind
230	*Placoneis placentula* f. *rostrata* A. Mayer	PLAPLR	1	0	B	-	-	-	-	i	alf

No	Taxon	Code	Rud	Qish	Hab	T	Oxy	D	S	Hal	pH
231	*Pleurosigma salinarum* Grun.	PL050A	0	1-6	B	-	-	-	-	mh	
232	*Pleurosira laevis* (Ehrb.) Compère	PLELEQ	0	1-6	B	temp	-	-	-	mh	alf
233	*Reimeria sinuata* (Greg.) Kociolek et Stoermer	REIMER	1-3	0	B	-	st	sx	-	i	ind
234	*Rhoicosphenia abbreviata* (C. Ag.) Lange-Bert.	RC002A	0	1-2	P-B	-	-	es	x-o	i	alf
235	*Rhopalodia brebissonii* Kramm.	RHOPAQ	0	1	B	-	-			hl	
236	*Rhopalodia gibba* (Ehrb.) O. Müll.	RHPG1Y	1	0	B	temp	-	es	x-o	i	alb
237	*Sellaphora bacillum* (Ehrb.) D.G. Mann	NAVBAR	1-2	0	B	-	-	sx	o-b	i	alf
238	*Sellaphora pupula* (Kütz.) Mereschk.	SELLUL	1-2	0	B	eterm	st	sp	o-x	hl	ind
239	*Sellaphora rectangularis* (Greg.) Lange-Bert. et Metzeltin	SELLRL	1-2	0	B	temp	-	sx	-	hl	ind
240	*Stauroneis anceps* Ehrb. var. *anceps*	STAUAR	2-3	0	P-B	-	-	sx	x	i	ind
241	*Stauroneis anceps* var. *linearis* Rabenh.	STAALR	1	0	B	-	-	sx	b	i	alf
242	*Stauroneis phoenicenteron* (Nitzsch) Ehrb.	STAPHR	1	0	B	temp	-	es	x-o	i	ind
243	*Stauroneis producta* Grun.	STAUPQ	0	1	B	-	st	sx	o	mh	ind
244	*Stauroneis smithii* Grun.	SA003A	1	0	P-B	-	st-str		x-o	i	alf
245	*Staurosirella leptostauron* (Ehrb.) Williams et Round	STRSLL	3-5	0	B	-	st	es	a-b	hb	alf
246	*Staurosirella pinnata* (Ehrb.) Williams et Round	STRSPL	2-3	0	B	temp	st-str	es	b-a	hl	alf
247	*Stephanodiscus hantzschii* Grun. in Cl. et Grun.	STH01Y	0	1-4	P	temp	st	es	a-b	i	alf
248	*Surirella angusta* Kütz.	SU001A	1-3	1	P-B	-	st-str	es	o	i	alf
249	*Surirella biseriata* Bréb. ex Godey	SURBIR	1	0	P-B	-	st-str	sx	o-b	i	alf
250	*Surirella brebissonii* Kramm. et Lange-Bert.	SUBREQ	1	1	B	-	st-str	-	x	i	alf
251	*Surirella capronii* Bréb. ex Kütz.	SURCAO	0	1	P-B	-	st		x	i	ind
252	*Surirella minuta* Bréb. in Kütz.	SURMIR	1-4	0	B	-	st-str	es	o-a	i	ind
253	*Surirella ovalis* Bréb.	SUV01Y	0	1-3	P-B	-	st-str	es	o	mh	alf
254	*Surirella peisonis* Pant.	SUPIEQ	0	1	B	-	-	-	a	-	-
255	*Surirella splendida* (Ehrb.) Kütz.	SURSPR	1-2	0	P-B	-	-	-	o-b	i	alf
256	*Surirella tenera* Greg.	SURTER	1	0	P-B	-	st	es	o	i	alf

No	Taxon	Code	Rud	Qish	Hab	T	Oxy	D	S	Hal	pH
257	*Synedra inaequalis* Kobayasi	SYINAL	1	0	-	-	-	sx	-	-	-
258	*Synedra* ulna var. *amphirhynchus* (Ehrb.) Grun.	SYNUAR	2-4	0	B	-	-	es	-	i	alf
259	*Synedra ulna* var. *contracta* Østr.	SYNUCR	1	0	-	-	-	es	-	-	-
260	*Tabellaria fenestrata* (Roth) Kütz.	TAFERR	1-2	0	P-B	-	st-str	es	x	hb	acf
261	*Tabellaria flocculosa* (Roth) Kütz.	TA001A	1-2	0	P-B	eterm	st-str	es	o-a	hb	acf
262	*Thalassiosira weissflogii* (Grun. in Van Heurck) Fryx. et Hasle	THAWEQ	0	1-2	P-B	-	-	sp	o	hl	alf
263	*Tryblionella acuminata* W. Sm.	TRYACA	0	1-2	P	-	st	sx	b-p	mh	alf
264	*Tryblionella apiculata* Greg.	TYA01Y	0	1-6	B	-	-	es	o-a	mh	alf
265	*Tryblionella debilis* Arnott in O'Meara	TRYBDQ	0	1-3	P-B	-	ae	es	o	i	alf
266	*Tryblionella gracilis* W. Sm.	TYG01Y	1	1-3	B	-	-		a-b	hl	alf
267	*Tryblionella hungarica* (Grun.) Mann	TYH01Y	0	1-6	P-B	-	-	sp	a-b	mh	alf
268	*Tryblionella punctata* W. Sm.	TRYBPQ	0	1	B	eterm	-	-	-	mh	-
269	*Ulnaria acus* (Kütz.) Aboal	FRAUAR	1	0	P-B	-	st-str	es	o-a	i	alb
270	*Ulnaria ulna* (Nitzsch) Compère in Jahn et al.	FRU01Y	1-5	1-5	P-B	temp	st-str	es	b-o	i	ind
	Chlorophyta										
271	*Actinastrum hantzschii* var. *subtile* Wolosz.	ACHS1Y	0	1	P-B	-	-	-	b	i	-
272	*Characium ornithocephalum* A. Br.	COR01Y	0	3	Ep	-	-	-	-	i	-
273	*Chlamydomonas* sp.	CHM01Y	0	1	P	-	-	-	b-p	-	-
274	*Chlorococcum* sp.	CHC01Y	0	1-2	-	-	-	-	-	-	-
275	*Cladophora glomerata* (L.) Kütz.	CLAG1Y	0	1-6	P-B	-	st-str	-	b-o	i	alf
276	*Closterium acerosum* (Schrank) Ehrb. ex Ralfs	CLSA1Y	1	0	P-B	-	st-str	-	a-b	i	ind
277	*Closterium peracerosum* Gay	CLOPEH	0	1-4	P-B	-	st-str	-	b	-	-
278	*Coelastrum astroideum* de Not.	COEA1Y	0	1-5	P	-	st-str	-	b	-	-
279	*Coelastrum microporum* Näg.	COEM1Y	0	1	P-B	-	st-str	-	b	i	ind
280	*Cosmarium subprotumidum* Nordst.	COSSSQ	0	1	P-B	-	st-str	-	-	-	acf
281	*Desmodesmus abundans* (Kirchn.) Hegew.	SCEQUR	1-3	0	P-B	-	st-str	-	o-a	-	-
282	*Desmodesmus armatus* var. *armatus* (Chod.) Hegew.	DEA01Y	0	1	P-B	-	st-str	-	o-a	-	-

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No	Taxon	Code	Rud	Qish	Hab	T	Oxy	D	S	Hal	pH
283	*Desmodesmus armatus* var. *spinosus* (Fritsch et Rich) Hegew.	DESASH	0	2	P	-	st-str	-	b	-	-
284	*Desmodesmus communis* (Hegew.) Hegew.	SCEQQL	1-3	0	P-B	-	st-str	-	b	i	ind
285	Desmodesmus costato-granulatus (Skuja) Hegew.	DECG1Y	0	2	P-B	-	st-str	-	b	-	-
286	*Desmodesmus intermedius* (R. Chod.) Hegew.	DEIT1Y	0	2	P-B	-	st-str	-	b	-	-
287	*Desmodesmus opoliensis* (P. Richt.) Hegew.	SCEOPR	2	0	P-B	-	st-str	-	b	-	-
288	*Desmodesmus protuberans* (Fritsch et Rich) Hegew.	DEP01Y	0	1	P-B	-	st-str	-	-	-	-
289	*Desmodesmus spinosus* (R. Chod.) Hegew.	DES01Y	0	1	P-B	-	st-str	-	o-b	-	-
290	*Dunaliella* sp.	DUNALQ	0	1-6	-	-	-	-	-	-	-
291	*Gloxidium rotatoriae* Korsch.	GLOXIRL	1	0	-	-	-	-	-	-	-
292	*Gongrosira* sp.	GONGRQ	0	1	Ep	-	-	-	-	-	-
293	*Microspora quadrata* Hazen	MICSPR	5	0	B	-	-	-	b	-	-
294	*Monoraphidium contortum* (Thur.) Kom.-Legn.	MOCONA	0	2	P-B	-	st-str	-	b	-	-
295	*Monoraphidium griffithii* (Berk.) Kom.-Legn.	MOG01Y	1	1	P-B	-	st-str	-	b	i	-
296	*Monoraphidium irregulare* (G.M. Smith) Komárkova-Legnerova	ANKANL	1-2	0	P	-	-	-	-	i	-
297	*Monoraphidium minutum* (Näg.) Kom.-Legn.	MOM01Y	0	6	P-B	-	st-str	-	b-a	-	-
298	*Mougeotia* sp. ster.	MU001Y	1-3	0	B	-	-	-	o	-	-
299	*Oedogonium* sp. ster.	OE001Y	1	2-4	B	-	-	-	-	-	-
300	*Oocystis lacustris* Chod.	OOLA0A	0	2	P-B	-	st-str	-	b-o	hl	-
301	*Oocystis submarina* Lagerh.	OOC01Y	0	1	P-B	-	st	-	-	i	-
302	*Pandorina morum* (Müll.) Bory	PAM01Y	0	4	P	-	st	-	b	i	-
303	*Pediastrum duplex* Meyen	PDD01Y	0	3-4	P	-	st-str	-	o-a	i	ind
304	*Pediastrum tetras* (Ehrb.) Ralfs	PETETH	0	2	P-B	-	st-str	-	o-a	i	ind
305	*Raphidocelis sigmoidea* Hind.	RCS01Y	0	1-4	P	-	st-str	-	-	-	-
306	*Raphidocelis* sp.	RAPHIQ	0	1	-	-	-	-	-	-	-
307	*Rhizoclonium hieroglyphicum* (Ag.) Kütz.	RHZ01Y	1-6	6	B	-	st-str	-	o	hl	-
308	*Scenedesmus acuminatus* var. *acuminatus* (Lagerh.) Chod.	SA001Y	2-4	1	P-B	-	st-str	-	b	i	ind

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No	Taxon	Code	Rud	Qish	Hab	T	Oxy	D	S	Hal	pH
309	*Scenedesmus acuminatus* var. *biseriatus* Reinh.	SCEACR	2	0	P	-	-	-	-	i	-
310	*Scenedesmus bijugatus* (Turp.) Kütz.	SCEBIR	2	0	P	-	-	-	o-a	i	ind
311	*Scenedesmus incrassatulus* Bohl.	SCEINH	0	1-3	P-B	-	st-str	-	-	-	-
312	*Scenedesmus obliquus* var. *alternans* Christjuk	SCEOAL	1-4	0	-	-	-	-	-	-	-
313	*Scenedesmus obliquus* var. *obliquus* (Turp.) Kütz.	SCEOBQ	1	1	P-B	-	st	-	b-p	i	-
314	*Scenedesmus obtusus* Meyen	SO001Y	0	2	P-B	-	st-str	-	b	-	-
315	*Schroederia setigera* (Schröd.) Lemm.	SDS01Y	1-2	0	P	-	st-str	-	b-o	i	-
316	*Spirogyra* sp. ster.	SPG01Y	3-6	4	B	-		-	-	-	-
317	*Stigeoclonium tenue* (Ag.) Kütz.	SCT01Y	1-6	0	B	-	st-str	-	b-p	-	-
318	*Stylosphaeridium epiphyticum* (Korsch.) Korsch.	STYE1Y	0	2	Ep	-	-	-	-	-	-
319	*Tetraedron minimum* (A. Br.) Hansg.	TETMMA	0	1-2		-	-	-	-	-	-
320	*Ulothrix tenerrima* Kütz.	ULOTTL	2-6	0	B	-	-	-	o-a	i	-
321	*Ulothrix zonata* (Weber et Mohr) Kütz.	ULZONL	1-6	0	P-B	-	st-str	-	o-a	i	ind
322	*Uronema confervicolum* Lagerh.	URC01Y	0	2-4	B	-	st-str	-	o-a	-	-
	Rhodophyta										
323	*Audouinella pygmaea* (Kütz.) Weber-van Bosse	AUDOUO	0	5-6	B	-	str	-	x-o	-	alf

Note*: Hab – habitat (Ep – epiphytes, B – benthic, P-B – plankto-benthic, P- planktonic); T – temperature (eterm – eurytermic; temp – temperate; warm – warm water; cool – cool water); Oxy – streaming and oxygenation (st – standing water; st-str – low streaming water; str – streaming water); S – degree of saprobity on the Pantle-Buck's (Pantle & Buck 1955) (x – xenosaprobes, x-o – xeno-oligosaprobes, o-x – oligo-xenosaprobes, x-β – xseno-betamesosaprobes, o – oligosaprobes, o-β – oligo-betamesosaprobes, β-o – beta-oligosaprobes, o-α – oligo-alphamesosaprobes, β – betamesosaprobes, β-α – beta-alphamesosaprobes, α-β – alpha-betamesosaprobes, α – alphamesosaprobes); D– degree of saprobity on the Watanabe's (Watanabe 1986) (sx – saproxenous, es – eurysaprobes, sp – saprophiles); Hal – halobity degree (hb – oligohalobes-halophobes, i – oligohalobes-indifferent, mh - mesohalobes, hl – halophiles, ph - polyhalobes); pH – pH degree (alf – alkaliphiles, ind – indifferents; acf – acidophiles, alb - alcalibiontes).*

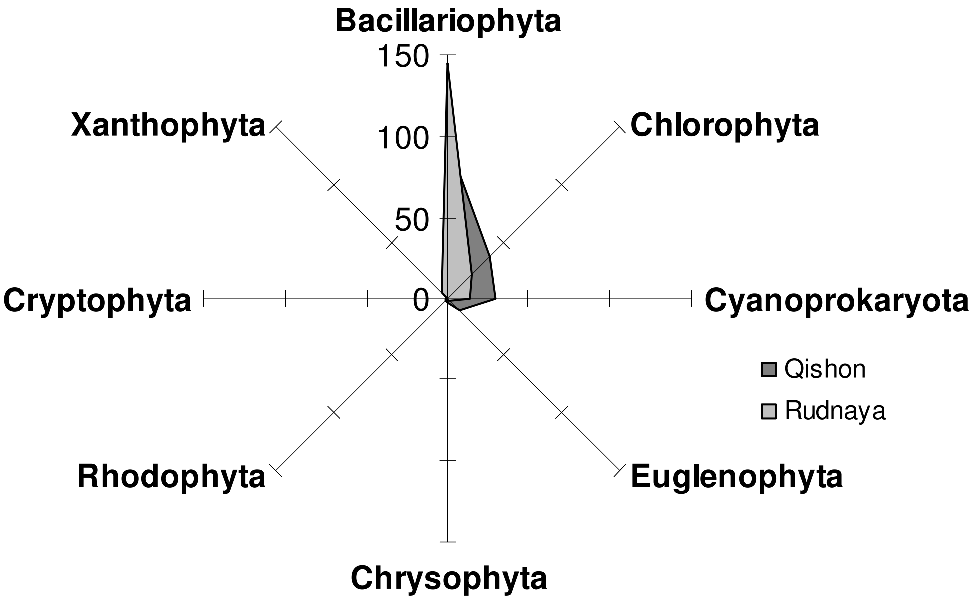

Figure 3. *Distribution of the species community between the algal Divisions in the Rudnaya River and Qishon River.*

The diversity of the species is similar in the two rivers with diatoms prevailing. Figure 3 shows that green algae are second in importance in the both rivers, followed by the cyanoprokaryotes. The presence of red algae can be noted as a unique element of the Qishon River algoflora.

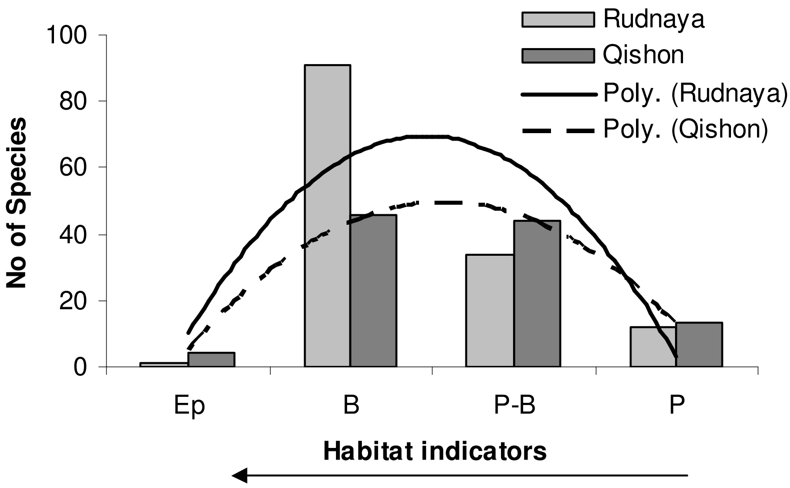

Figure 4. *Distribution of the species diversity in both rivers between habitat ecological groups.*

Distribution of species diversity over the substrate habitation groups in both rivers is shown in Figure 4. The arrow specifies a direction of strengthening of communication with substrate. In the Rudnaya River, the substrate bound species prevail. In the Qishon River, the benthic and plankto-benthic algae are represented by almost even species numbers because the river is low streaming. However the trend lines for the both distributions are similar. Their peaks occur between the groups of benthic and plankto-benthic algae.

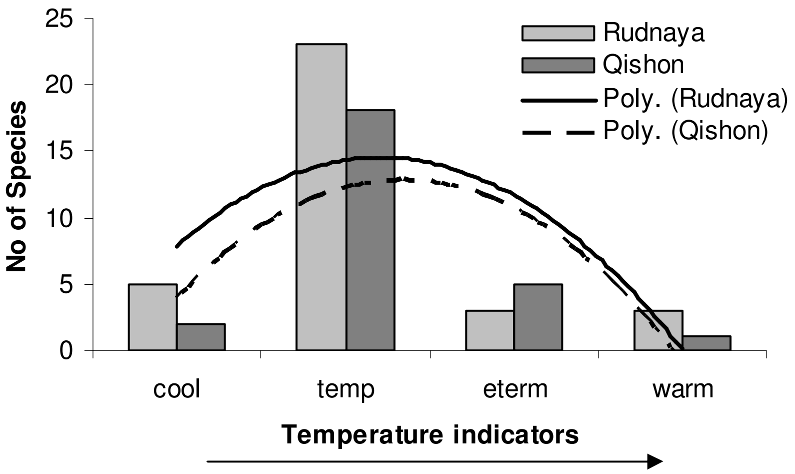

Figure 5. *Distribution of the species diversity in both rivers between temperature indicator groups.*

The whole range of the temperature indicators is represented (Figure 5), predominated by the temperate indicators in both rivers. The arrow specifies strengthening parameter. The trend lines of both distributions are similar, and their peaks occur between the groups of temperate and eurythermic algae.

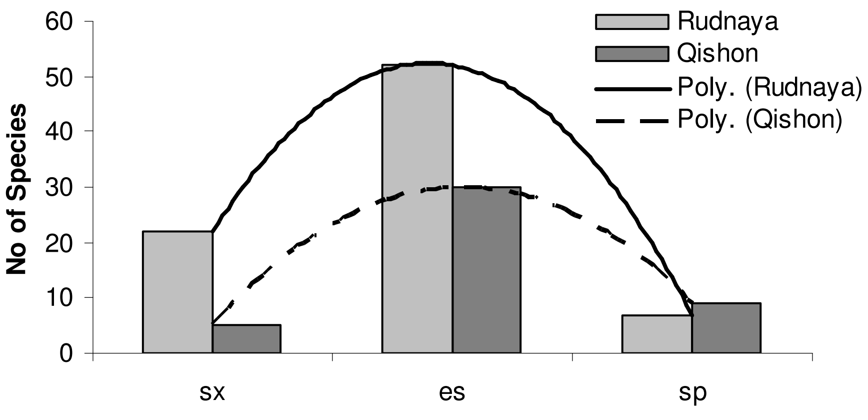

Figure 6. *Distribution of the species diversity in both rivers between indicator groups of organic pollution (Watanabe's system).*

Figure 6 shows distribution of saprobity indicators defined by Watanabe's method (1986). The arrow specifies strengthening parameter. Both distributions are dominated by eurysaprobic group; however the peak for the Qishon River is displaced toward the saprophile diversity, hence, these indicators show a somewhat greater organic pollution in the Qishon River, than in the Rudnaya River.

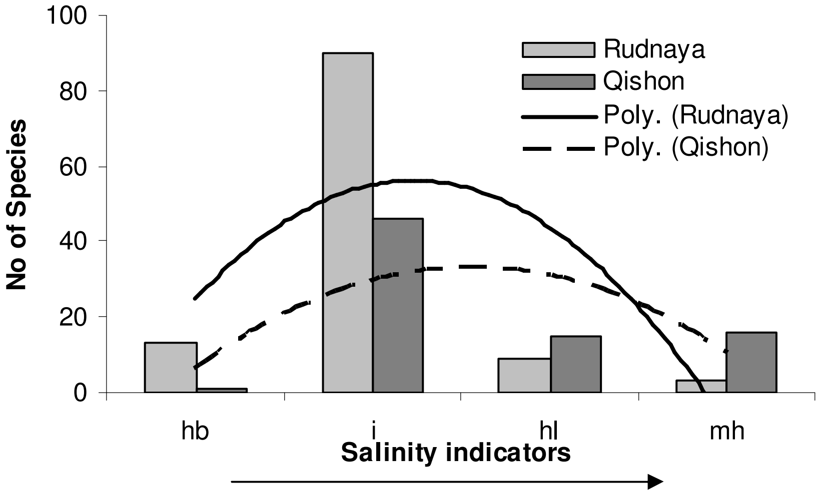

Figure 7. *Distribution of the species diversity in both rivers between salinity indicator groups.*

Salinity indicators represent the oligohalobe and medohalobe groups for both rivers (Figure 7). The arrow specifies strengthening parameter. Among the oligohalobes, the group of indifferents dominates in both rivers. The peak of a trend line for the Qishon River is somewhat displaced towards the indicators of high chloride concentrations. The group of mesohalobes in the Qishon River is also relatively prominent. It testifies to an appreciable influence of marine tidal waters on the algal diversity in the Qishon River, whereas the waters of the Rudnaya River are fresher.

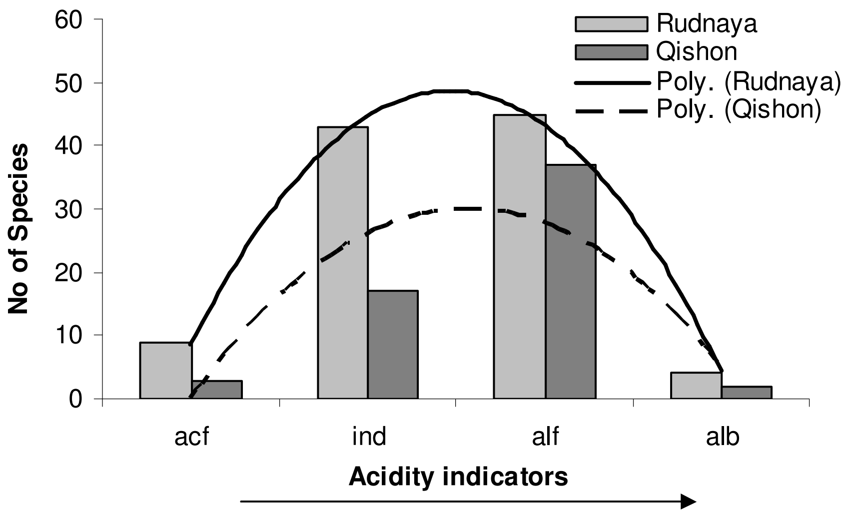

Figure 8. *Distribution of the species diversity in both rivers between acidity indicator groups.*

Algae in both rivers represent the whole spectrum of pH indicators (Figure 8). The arrow specifies strengthening parameter. In the Rudnaya River the group indifferents, preferring neutral waters, predominates. In the Qishon River a prevalence of alcalic species is better marked. Hence, with due attention to the peaks of the trend lines, we conclude that the algae from the Rudnaya River show preference of neutral, subacidic or alkalic waters characteristic of silicate bedrocks, whereas in the Qishon River indicators reflect the regional norm for carbonate provinces (Meybeck & Helmer 1989).

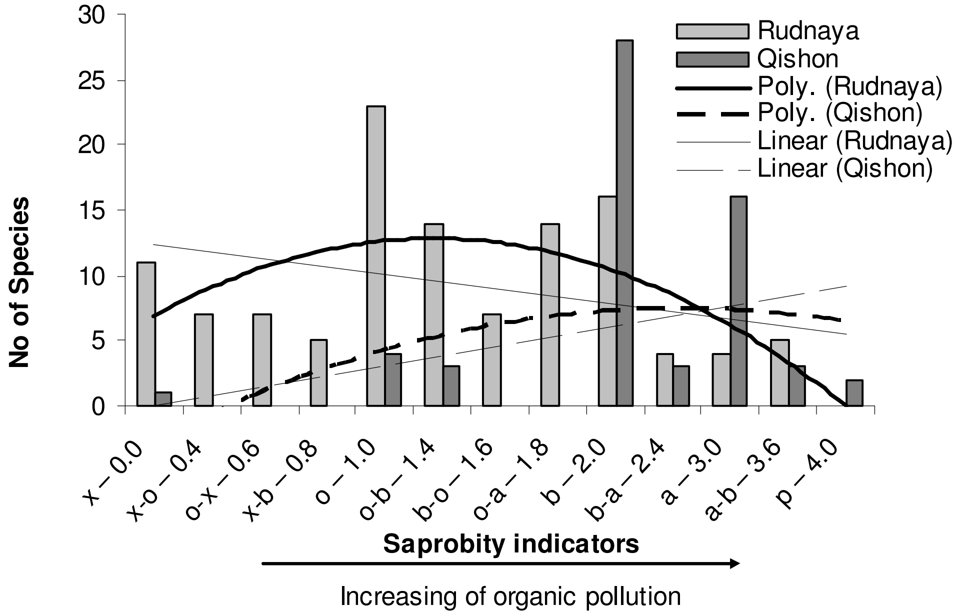

Figure 9. *Distribution of the species diversity in both rivers between indicator groups of organic pollution (Sládeček system).*

The indicators of organic pollution defined by the method of Pantle and Buck (1955) modified by Sládeček (1986) came from a wide range of ecological groups (Figure 9). The arrow specifies strengthening parameter.

In the Rudnaya River, the group of oligosaprobiontes is the largest, whereas in the Quishon River, the betamesosaprobiontes is better represented. The polynomial trend lines reflect a greater number of clear-water species in the Rudnaya River, while the indicators of moderate pollution are more numerous in the Quishon River. The oligo- and xenosaprobic groups are particularly prominent in the Rudnaya River, while the alphmesosaprobic species are more prominent in the Qishon River, which is fairly obvious when the line trends are compared. Therefore, the organic content is greater in the Qishon then in the Rudnaya River.

At the same time, the polluted sections of these rivers differ in the composition of pollutants. The Rudnaya River is clear in the upper reaches being polluted down of Dal'negorsk industrial town. In distinction, the Qishon River is most heavily polluted by agricultural wastes in the upper reaches, with the industrial wastes added downstream. These distinctions are reflected by the dynamics of the saprobity indices in both rivers.

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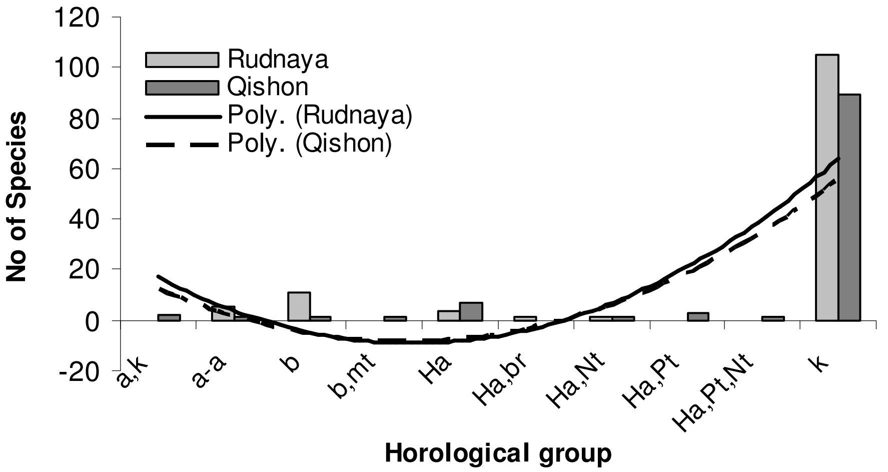

Figure 10. *Distribution of the species diversity in both rivers between chorological groups.*

For geographical analysis, we revealed differentiation of algal species over the major chorological groups (Figure 10). Despite the minor differences in the content of the boreal and holarctic species, the trend lines are similar for both river being dominated by cosmopolitan species.

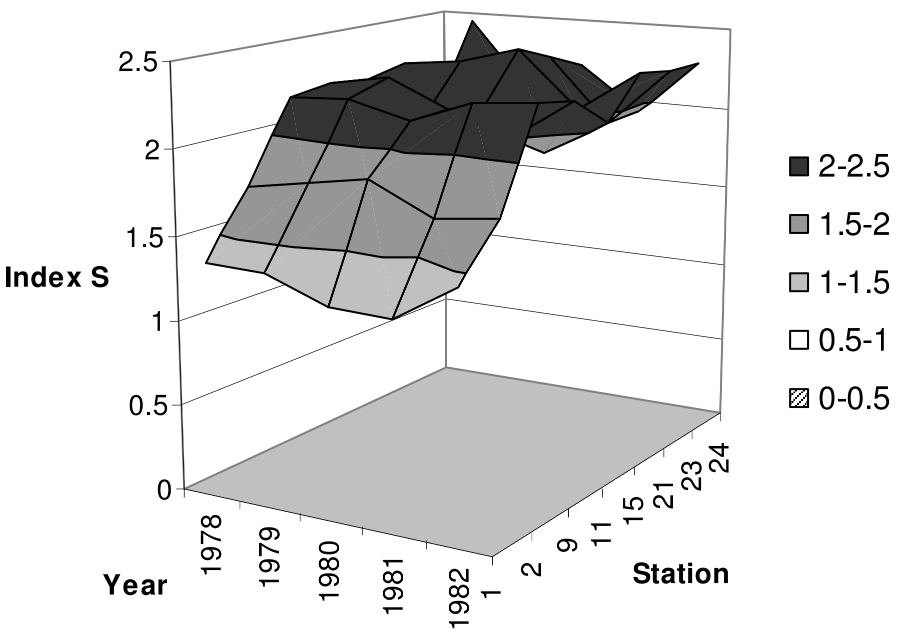

Figure 11. *Saprobity index S dynamic over the sampling station of the Rudnaya River.*

Fig. 11 shows that the saprobity index S for the Rudnaya River (Barinova, Medvedeva 1989;1992a,b; Medvedeva et al. 1986b) fluctuates from the oligosaprobic zone, Class II in the upper reaches (where indices ranged 0.5-1.5) to the betamesosaprobic zone, and Class III near the mouth (where indices ranged 1.5-2.5). During the whole period of observation, the concentration of organic pollutants tended to increase from the upper reaches towards the mouth, where we found a weak 2-year cyclicity of the index.

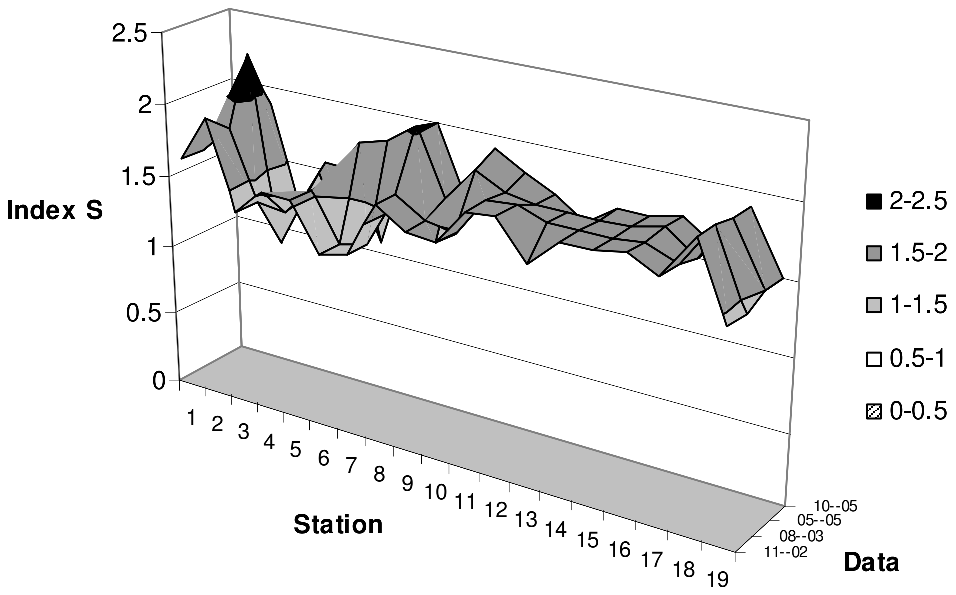

Figure 12. *Saprobity index S dynamic over the sampling station of the Qishon River.*

Fig 12 shows the dynamics of the saprobity index S in the Qishon River during the period 2002 – 2005 (Barinova et al. 2004). The index fluctuates, as in the Rudnaya River, from the oligosaprobic zone, Class II to the betamesosaprobic zone, Class III. The least polluted water was found in the upper reaches (where indices ranged 1.43-1.5). Then, across the agricultural area and before the industrial zone of Haifa the water quality degraded while fluctuations of the index increased (1.93-2.04). This is considered as evidence of misbalance of the system over this segment. At stations 2 and 3, over the zone of industrial toxic wastes, the saprobity index decreased (1.0-1.36) then rising again toward its maximal values in the tidal zone (2.29).

The dynamics of the saprobiyty indices in both rivers show a lesser anthropogenic impact for Rudnaya River than for Qishon River. This is attested by the low amplitude fluctuations and the evidence of natural cyclicity in the Rudnaya River, whereas in the Qishon River the fluctuations are greater and the pollution is more dramatic in the upper reaches.

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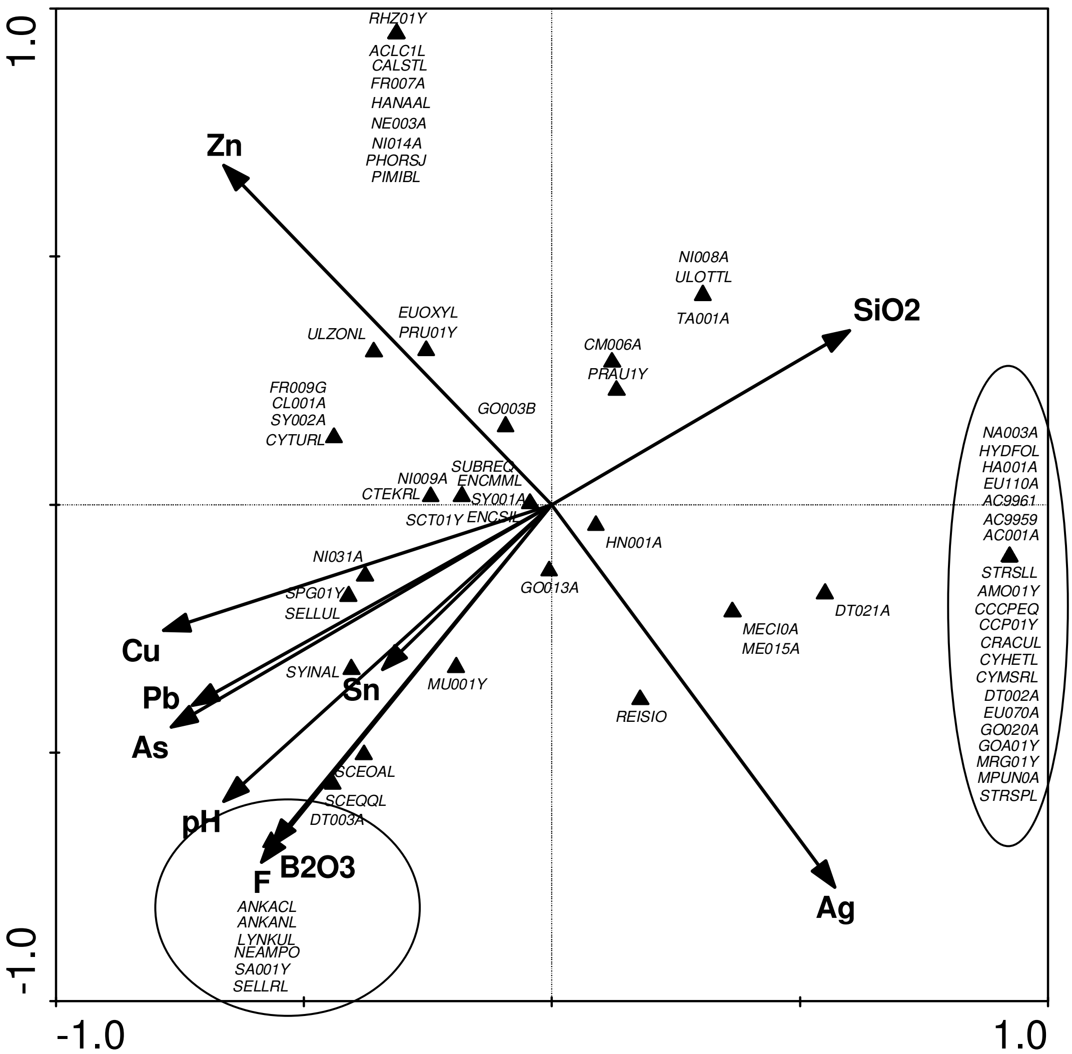

Figure 13. *Biplot of environmental variables and species scores in a CCA of the Rudnaya River. Full names of species are presented in Table 3.*

Figure 13 presents the main factors influencing algal species abundance in the Rudnaya River. It can be seen that the borate salts, fluorides, copper, lead and their associated arsenic all have the same anthropogenic source. It seems that their concentration is related to the pH fluctuations. In distinction, both zinc and silver are of natural origins and their influence on biodiversity is different, even opposite to that of anthropogenic elements.

As a whole, the species of polluted waters are fairly tolerant to individual pollutants, which is in sharp contrast to the group of the neutral pH clear-water species (marked out by the ellipse to the right).

Marked by the lower left ellipse is a biosensor group sensitive to borates and fluorides. This group includes the green algae *Ankistrodesmus acicularis*, *A. angustus*, *Scenedesmus acuminatus*, that are used for biotesting of toxicants, the blue-green algae *Lyngbya kuetzingii* and also the diatoms *Neidium ampliatum* and *Sellaphora rectangularis.*

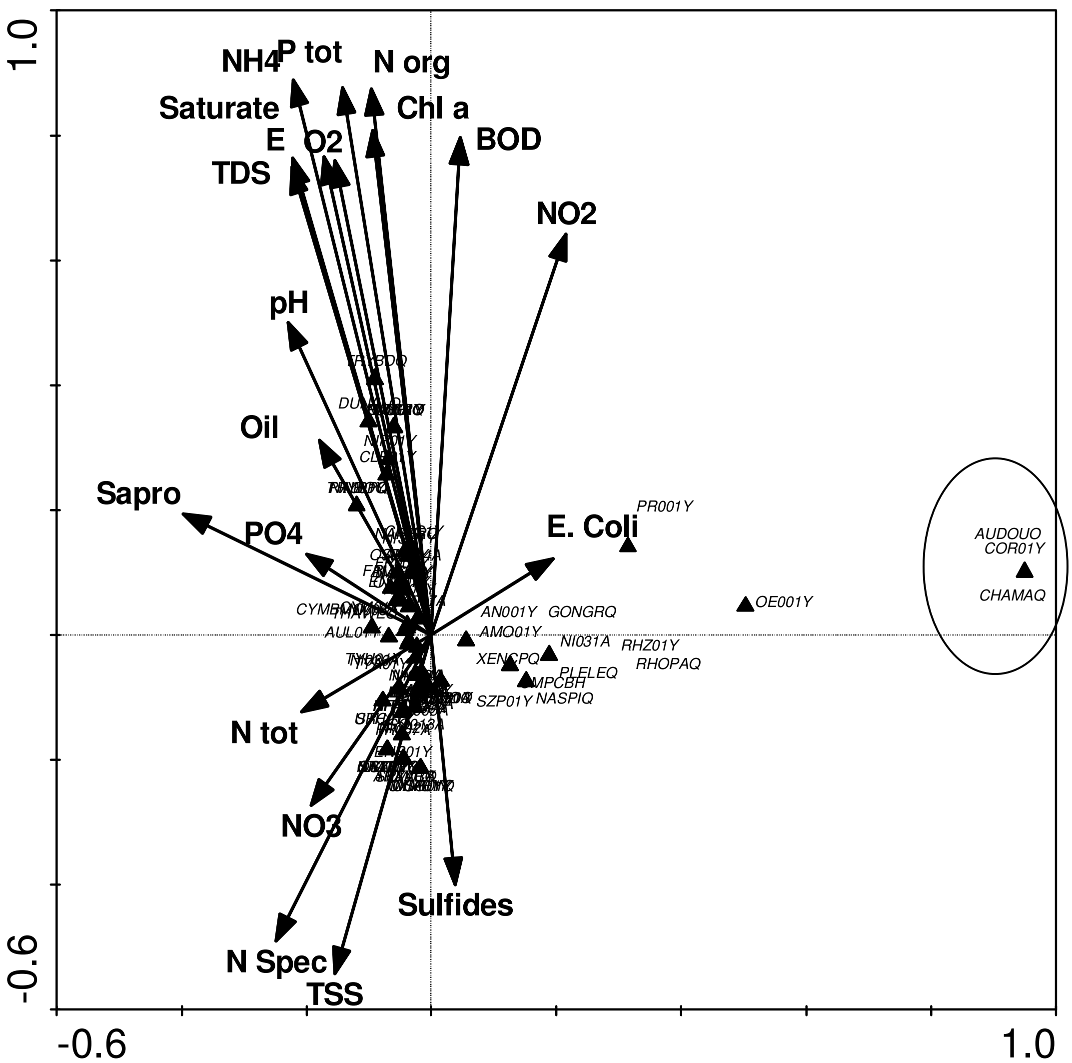

Figure 14. *Biplot of environmental variables and species scores in a CCA of the Qishon River. Full names of species are presented in Table 3.*

The pallet, Figure 14, gives the results of calculation of all environmental factors influencing the algal diversity in the Qishon River. According to the pallet the environmental factors can be divided into two separate groups. The first group includes factors of salinity and the pollution by ammonia, oil and sulfites, as well as the ecosystems activity factors – the concentrations of oxygen, nitrogen, phosphates, BOD and the chlorophyll *a*. The second group of factors includes nitrates and the related total nitrogen, as well as the water turbidity (TSS) and anoxia (sulfides) factors.

We identified a group of species that prefers clear and clean fresh water with low species diversity (right circle). This group includes the red algae *Audouinella pygmaea,* the seldom encountered green algae *Characium ornithocephalum* and the rare blue-green species *Chamaesiphon amethystinus*.

Conclusion

In two polluted rivers we revealed algal diversity consisting of 184 algal species and cyanoprokaryotes in the Rudnaya River, and 176 in the Qishon River. The diversity of species was higher in the Rudnaya River. Species diversity in the rivers is significantly different but the distribution of species over the higher taxa were very similar for both rivers.

Based upon the indicator analysis, accepted in the EC (European Parliament 2000), we conclude, that the water is cleaner and the algal diversity is higher in the Rudnaya River than in the Qishon River. The bioindication analysis of species preferences over the ecological groups in respect of salinity, acidification, and oxygenation shows similar distributions. Autecology of algal species is similar in both river communities but the Qishon is more alkalic and organically more polluted than the Rudnaya River. The indices of saprobity S affirm this conclusion. In addition, the Rudnaya River shows a weak 2-year cyclicity of organic pollution which may be a consequence of natural climatic cycles. The impact of pollution here increases downstream to the mouth, whereas the Qishon River is more polluted in the upper reaches, with periodically fluctuating pollution near the Haifa Chemicals. The impact of this pollution decreases down to the mouth.

The CCA determines the most significant factors affecting the species diversity in both rivers. As we know, the most effective application of this statistical approach is the comparison of communities' preferences from different phytogeographical provinces and seasons (Rédei et al. 2003).

As a result, we found a group of biosensors in Rudnaya River sensitive to borates and fluorides: *Ankistrodesmus acicularis*, *A. angustus*, *Scenedesmus acuminatus*, which are used in biotesting of toxicants, as well as *Lyngbya kuetzingii, Neidium ampliatum,* and *Sellaphora rectangularis.*Low clean water requiring species richness was identified in Qishon River. This group includes the red algae *Audouinella pygmaea,* low abounded green algae *Characium ornithocephalum*, as well as the rare blue-green species *Chamaesiphon amethystinus*. These species can be used as biosensors of high pollution in carbonate provinces.The similarity of species diversity distribution over the major bioindicating groups for the both rivers and the specificity of their response to the increasing pollutant concentrations leads us to the following conclusion.

We found that algal biodiversity is more sensitive to technogenic pollution in the silicate province being more tolerant to the same organic pollutants in the carbonate province.This can be related to the presence of metal ions in the water of silicate province with ph less than 7. In contrast, in the carbonate province, the metals are precipitated and their toxic impact is lower.

Thus, our comparison of two polluted rivers shows, that the combination of bioindicational methods and statistics are effective to determine the main factors affecting algal diversity, and are helpful in recognition of indicators or biosensing species for the most important environmental variables.

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