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Soil algae in museum samples from some Southwest Asia sites. I.

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Introduction

Soil algae attracted the attention of scientists since the first description of *Nostoc commune* Vaucher as aero-terrestrial species by DILLENIUS (1741) till nowadays (e.g. ETTL & GÄRTNER, 1995). The floristic studies of soils began by the work of GRÄBNER (1895) and later, in 1948, FEHÉR was the first who compiled information on the geographical distributon of soil algae based on 685 identified taxa. Recently edaphic algae of nearly every biome have been studied (GRONDIN & JOHANSEN, 1995). Nevertheless, data about the soil algal flora of some regions could be classified as scarce. Such a region still is the Southwest Asia (COMPÈRE, 1981; METTING, 1981). There only several algae from the deserts of south Iran (in the region of Bandar-Abbas and Zahedan) and Syria have been reported by NOVICHKOVA-IVANOVA (1980).

Several types of research dealing with soil algae have been done. Besides the already mentioned floristic studies, taxonomic investigations on selected algal groups and studies on economically important nitrogen-fixing algae in rice fields and deserts were the most popular among them (GRONDIN & JOHANSEN, 1995). Most of these works deal with fresh soil samples. First data on long term accumulation of resting stages of surface algae which can remain viable for years have been provided by BRISTOL (1919, 1920) and after that the moisture relations of terrestrial algae were studied by FRITSCH (1922), FRITSCH & HAINES (1923) and FRAYMONTH (1928). In 1941, LIPMAN was able to culture a cyanoprokaryote which has been in a dry soil in a herbarium sheet for 87 years. However, the number of such studies with samples kept in air-dry conditions for years still is relatively small (*e.g.*, BECQUEREL, 1942; PARKER et al., 1969). HILTON & TRAINOR (1963) provided data on taxa present after desiccation for one year and subsequently TRAINOR (1970, 1985) published a list of taxa which survived both 10 and 25 years. There was reported that from 31 taxa of 17 genera in the original fresh Connecticut cornfield soil, after 10 years the number of taxa was 11 and after 25 years of desiccation this number was

7. Recently, TRAINOR & GLADYCH (1995) published data on the same soil sample 35 years after it was collected. In this paper they reported 5 survivors or 16% of original taxa in the fresh soil. It is noteworthy to mention that all the survivors were green algae from the genera *Chlamydomonas*, *Chlorella*, *Chlorococcum*, *Protosiphon* and *Tetracystis*. A research on the temperature tolerance of soil algae has been also carried out (*e.g.* TRAINOR, 1962, 1983, 1985) but a full review on this problem is beyond the scope of our study. As far as some of the results are relevant to the desiccation of soil samples, we will underline that according to TRAINOR (1985) the survivors which stand drastic temperature treatment again are green algae. The distribution and abundance of soil algae in relation to pH has also been studied and the general conclusion from these studies is that cyanoprokaryotes are less abundant on acidic soils than on neutral to alkaline soils (RAJU, 1972; METTING, 1981; STARKS et al., 1981). They have never been reported in soils with pH of 5 or less (BROCK, 1973). Generally, green algae are more common in soils with lower pH in comparison to blue-greens (FOGG, 1956; HOLM-HANSEN, 1968; RAJU, 1972; BROCK, 1973; KING & WARD, 1977; CARSON & BROWN, 1978; STARKS et al., 1981). In the same time, it was shown that even soils with the same pH had clearly distinct communities (ALI & SANHU, 1972). Chlorophytes were reported to be abundant in forest soils, whereas in arid and semi-arid environments cyanoprokaryotes were more common (STARKS et al., 1981).

In the present paper data about the species composition and distribution of algae in 32 localities from Southwest Asia are provided. These results have been obtained after processing of soil samples 19 years after keeping in air-dry conditions.

Material and methods

There have been analysed 32 samples collected from the surface soil layer from 32 localities in Turkey, Iraq, Iran, Syria and Lebanon during the period 30 October - 21 December 1972 (Fig. 1) by P. Beron, T. Michev and V. Beshkov. The brief description of the localities provided below follows their travel-notes. Generally, most of them are situated in arid or semi-arid areas (ABRANSON & DIXON, 1977). Due to practical reasons the localities were assigned to the following habitat types: tillable fields and other arable lands, untillable fields, steppes, semi-deserts, meadows and small forests / groups of single trees or shrubs.

After 19 years keepment in air-dry conditions the collected soils were cultivated in the media of Bristol modified by GOLLERBAKH (1936) with addition of microelements according to ALLEN & ARNON (1955). The algae have been determined on semi-permanent slides after cultivation period of 1 week, 3 weeks, 1, 2, 3 and 5 months in order to follow different stages of algal growth. Determination of algae was done according to the floras of GOLLERBAKH et al. (1953), STARMACH (1966, 1968), MATVIENKO & DOGADINA (1978), PALAMAR-MORDVINTZEVA (1982),

KOMÁREK & FOTT (1983), ETTL & GÄRTNER (1988), BOURRELLY (1990) and KORSCHIKOV (1987), to the Syllabus of ETTL & GÄRTNER (1995), as well as according to the monographs by PRINTZ (1964) and TUPA (1974). The classification system follows ETTL & GÄRTNER (1995) with some modifications by STOYNEVA (1998) and KOMÁREK & ANAGNOSTIDIS (1999). The distributon of each species was evaluated according to its frequency quotient FQ (DARNELL, 1979). The floristic similarity of the investigated sites was estimated according to the index of SÖRENSEN (1948) - SSI. The values of SSI were grouped in 7 classes: I - with SSI = 1-10%, II - with SSI = 11-20%, III - with SSI = 21-30%, IV - with SSI = 31-40%, V - with SSI = 41-50% and VI - with SSI = 51-60%.

Localities (Fig. 1):

Loc. 1 - 30 km northern to the town of Rascht (northern Iran), untillable field at the bank of the rivulet Sefitrud, sampled on 7.11.1972;

Loc. 2 - 35 km northern to the town of Sandjan (Iran), steppe, sampled on 6.11.1972;

Loc. 3 - 3,500 m a.s.l. at the mountainside below the Demavend peak (Iran), soil among *Astragallus* sp., sampled on 13.11.1972;

Loc. 4 - 258 km northern to the town of Shiraz (Iran), arable land at 1,770 m a.s.l., sampled on 21.11.1972;

Loc. 5 - 30 km northern to the town of Shiraz (Iran), sampled on 22.11.1972;

Loc. 6 - village of Shapur (southern Iran), near a ditch in a orange-orchard, sampled on 25.11.1972;

Loc. 7 - near to Omidiych (Iran), tillable field, sampled on 29.11.1972;

Fig. 1. Map of the Asia Minor region with the studied localities
1-32 - number of site in compliance with the number in the text

Loc. 8 - near to the town of Qurnach (Iraq), alluvial soil from a date-forest, sampled on 30.11.1972;

Loc. 9 - 72 km western to the town of El-Qut (Iraq), reaped wheat-field at the bank of the Tigris River, sampled on 1.12.1972;

Loc. 10 - near the village of Algaye (Iraq), date-forest, sampled on 2.12.1972;

Loc. 11 - Babylon-ruines (Iraq), soil near to a freshwater canal, sampled on 4.12.1972;

Loc. 12 - Samara-reservoir (Iraq), soil from the shore, sampled on 5.12.1972;

Loc. 13 - semi-desert near to the shore of the lake Habbaniya (Iraq), sampled on 6.12.1972;

Loc. 14 - in the vicinity of Damascus (Syria), a cabbige-garden, sampled on 7.12.1972;

Loc. 15 - near to the Krak des Chevaliers (Syria), arable land, sampled on 11.12.1972;

Loc. 16 - 50 km eastern to the town of Homs (Syria), semi-desert, sampled on 11.12.1972;

Loc. 17 - Ansariya-crest, 50 km southern to the town of Banias (Syria), soil under oaks in a karstic region, sampled on 12.12.1972;

Loc. 18 - 10 km northern to the town of Banias (Syria), soil under a cactus, sampled on 12.12.1972;

Loc. 19 - near to the village of Zahli (Lebanon), arable land, sampled on 8.12.1972;

Loc. 20 - 20 km eastern to Beirut (Lebanon), meadow above 900 m a.s.l., sampled on 9.12.1972;

Loc. 21 - near the Grotte de Jeita, 15 km north of Beirut (Lebanon), soil from star-pine and oak forest, sampled on 10.12.1972;

Loc. 22 - place "The Cedars" (Lebanon) situated at 1,900 m a.s.l., soil from a cedar-forest, sampled on 10.12.1972;

Loc. 23 - near to the village of Zegorta (Lebanon), olive-forest, sampled on 10.12.1972;

Loc. 24 - 30 km eastern to the Anamur (southern Turkey), arable land near to the sea-shore, sampled on 16.12.1972;

Loc. 25 - 56 km northern to Antalya (southern Turkey), reaped wheat-field, sampled on 17.12.1972;

Loc. 26 - near Pamukkale (Turkey), soil from a cotton-field, sampled on 18.12.1972;

Loc. 27 - near Bergama (western Turkey), meadow, sampled on 20.12.1972;

Loc. 28 - near Troya (Turkey), arable land, sampled on 21.12.1972;

Loc. 29 - 60 m to the shore of the Lake Van (Turkey), soil from a wheat-field at 1,720 m a.s.l., sampled on 3.11.1972;

Loc. 30 - Tahir-pass (Turkey) at 2 475 m a.s.l., meadow, sampled on 30.10.1972;

Loc. 31 - in the vicinity of the spring of the Euphrates River (Turkey), soil from a pine-forest at 1 500 m a.s.l., sampled on 31.10.1972;

Loc. 32 - 10 km to the village of Tutak (eastern Turkey), soil from a wheat-field, sampled on 31.10.1972.

Results and discussion

In total, 114 species and 4 forms from 68 genera of 3 divisions have been determined. Their distribution and relative abundance at the localities is shown on Table 1.

Most of the species (72%) were rarely distributed and occurred in 1-3 studed sites (FQ = 3-9%). Among them the highest is the number of taxa (49 or 42%) found in one site only. 18 species were found in 4-6 sites, 7 - in 7-9 sites, 3 - in 10-12 sites and 2 - in 13-15 sites (*Microcystis pulverea* - in 13 and *Nostoc linckia* - in 15 sites). Only one species (*Leptosira terrestris*) was found in 16 studied sites and had FQ = 50%.

The distribution of species in the studied habitats was as follows: 46% of the species occurred in one habitat type; 24% - in two habitat types; 13% - in three habitat types; 10% - in four habitat types; 4% - in five habitat types and 2% - in seven habitat types (Table 1).

The number of species per site varied from 2 (loc. 2) to 28 (loc. 9). The number of species per site in tillable fields and other arable lands ranged from 10 to 15 (with two exceptions - loc. 9 and 29 with 28 and 3 species, respectively), in untillable fields - from 8 to12, in steppe sites - from 2 to 4, in semi-desert sites - from 7 to 9, in meadows - from 9 to 17 and in sites located in small forests or under groups of single trees or shrubs - from 3 to 21.

The values of SSI varied between 0 and 56% (Table 2). 27% of the studied sites contained quite different algal flora and did not show any similarity (SSI = 0). Most of the sites were with extremely low similarity (I and II class) - 16% and 31%, respectively. Low similarity (III and IV class) was detected between 17% and 6% of sites, respectively. Only 2% of the studied sites had SSI values of V class and only two sites (13 and 14) had SSI = 56%. The most poor in species and most peculiar were the steppe soil from the 2nd locality, the soil collected among the Babylon-ruines (loc. 11) and the wheat-field soil from the 29th locality. They contained 2, 4 and 3 species, respectively and clearly differred from the other studied sites. Low similarity with the other sites was calculated also for the soils collected from localities 3, 16, 17, 18 and 22. Poor in species composition (4-7 taxa) were the soils from localities 5, 10, 11, 16, 22 and 23. All these soils were from different habitats or were collected under different trees and shrubs (see localities above).

Cyanoprokaryotes were the most abundant species in most of the studied soils. *Nodularia harveyana* dominated in the samples from steppe sites (loc. 2, 5) and once was a sub-dominant in a soil from an arable land (loc. 15). *Cylindrospermum* was the dominant genus in semi-desert soils (loc. 13, 16). The variation in dominants there was at species level - *C. muscicola* dominated at site 13 and *C. licheniforme* dominated at site 16. *C. licheniforme* and other species of this genus occurred also mainly as co- or subdominants and more rarely as monodominants in soils collected from forests or under single trees or cacti (loc. 8, 17,

Table 1

Distribution of algal species in the studied Southwest Asia sites and their relative abundance

1-32 - number of site in compliance with the number in the text; xxx - dominant or co-dominant species, xx - sub-dominant species, x - presence of the species

ALGAE/SITES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
CYANOPROKARYOTA																																
Anabaena oscillarioides Bory													x		xx																	
Anabaena oscillarioides Bory f. *minor* Brist.								xxx	xxx			x															x					
Anabaena oscillarioides Bory f. *turkestanica* (Kissel.) Elenk.									x																							
Anabaena sphaerica Born. et Flah. f. *conoidea* Elenk.									x			xxx																				
Anabaena sp. st.								x					x		x																	
Calothrix elenkinii Kossinsk.																				x	x		x							x		xx
Chlorogloea cf. *microcystoides* Geitl.																						x										
Chroococcus turgidus (Kutz.) Nag.																		x														
Cylindrospermum licheniforme (Bory) Kutz.								xxx	x			x				xxx		xxx			x		xxx	x								
Cylindrospermum majus Kutz.																											x	x				
Cylindrospermum muscicola Kutz.							x	xx	x				xxx	x																		
Cylindrospermum stagnale (Kutz.) Born. et Flah.								x									xx											xx				
Cylindrospermum sp. juv.																						x			x	x						
Hammatoidea simplex Woron.																																x
Leptolyngbya angustissima (W. et G. S. West) Anagn. et Kom.												x																				
Leptolyngbya bijugata (Kongiss.) Anagn. et Kom.								x																								
Leptolyngbya boryana (Gom.) Anagn. et Kom.				x									x	x		x																
Leptolyngbya foveolarum (Rabenh. ex Gom.) Anagn. et Kom.	x							x	x			x								x		x		x							x	

ALGAE/SITES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Leptolyngbya gracilima (Zopf. ex Hansg.) Anagn. et Kom.													x			xx											x					
Leptolyngbya notata (Schm.) Anagn. et Kom.									x			x												x								
Lyngbya hieronomusii Lemm.									x																							
Microcoleus delicatulus G. et S. West																														x		
Microcoleus sociatus W. et G. S. West																														x		
Microcoleus vaginatus (Vauch.) Gom.									x																							
Microcystis incerta (Lemm.) Starm.										x			x														x					
Microcystis hansgirgiana (Hansg.) Elenk.																						x	x									
Microcystis pulverea (Wood) Forti emend. Elenk.					xx	x	x	x	x			x	x	x	x								x		xxx		x				x	
Nodularia harveyana Thuret		xxx			xxx		x	x	x						xx																	
Nodularia sp.																				x												
Nostoc calcicola Breb.	xxx			x		x	xxx			xxx		xx			xx						x				xx			x				
Nostoc commune Vauch.			xxx	xxx		x			x												xx	x					xxx			xxx	x	
Nostoc ellipsosporum Rabenh.	x																															
Nostoc linckia (Roth) Born.et Flah.	x				x	xxx		x	x				x	xxx	x			x	xxx		x		x		x	x					x	
Nostoc minitissimum Kutz.										x																						
Nostoc muscorum Ag.		x		x																							x					
Nostoc paludosum Kutz.																			x													
Nostoc punctiforme (Kutz.) Har.									x					x			x		x		xx			x	xxx	xxx	x	xxx			x	x
Nostoc spongiaeforme Ag.																										x						
Oscillatoria jantiphora (Fior. Mazz.) Gom.									x																					x		
Phormidium ambiguum Gom.								x	x								x	x												x		xxx
Phormidium autumnale (Ag.) Gom.							x		x			x	x																			
Phormidium molle (Kutz.) Gom.						x	x																									
Phormidium molle (Kutz.) Gom. f. tenue (Wor.) El.				x				x																								
Phormidium papillaterminatum Kissel.																										x						

ALGAE/SITES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Phormidium cf. *retzii* (Ag.) Gom.	x																															
Phormidium spp.																																
Plectonema puteale (Kirchn.) Hansg.							x	xxx				x	x	x						x										x		
Plectonema sp.																			x													
Pseudophormidium edaphicum (Elenk.) Anagn. et Kom.									x																							
Schizothrix friesii (Ag.) Gom.									x																							
Schizothrix lardacea (Ces.) Gom.	x						x		x								x			x	x									x		
Scytonema alatum (Berk.) Borzi														x																		
Scytonema julianum Menegh.																				x												
Scytonema ocellatum Lyngb.							x																									xxx
Scytonematopsis woronichinii E. Kiss.									x																							
cf. *Scytonematopsis* sp.								x						x						x											x	
Stigonema ocellatum Lyngb.	x																x			x												
Tolypothrix distorta (Fl. Dan.) Kutz.								x																						x		
Tolypothrix tenuis Kutz.									x																					x		
Tolypothrix sp. (fragment)																								x								
Trichormus rotundosporus (Hollerb.) Kom. et Anagn.												x																				
Trichormus variabilis (Kutz.) Kom. et Anagn.								x										x													x	x
CHRYSOPHYTA																																
Xanthophytina																																
Botrydiopsis intercedens Pasch.				x																												
cf. *Chlorogibba pentagonia* Pasch.																								x			x					
Heterococcus cf. *caespitosa* Vischer												x																				
Keriosphaera cf. *gemma* Pasch.																						x										
Peurogaster lunaris Pasch.										x																						

ALGAE/SITES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Bacillariophytina																																
Gomphonema sp.							x																									
CHLOROPHYTA																																
Actinochloris terrestris (Visch.) Ettl et Gartn.						x																										
Apatococcus constipatus (Printz) Printz																												xx				
Apatococcus lobatus (Chod.) J. B. Peters.						x	x								x	xxx									x	x	x				x	
cf. *Borodinelopsis* sp.						x																						x				
Bracteacoccus minor (Chod.) Petr.			x	x				x																								x
Chlamydocapsa cf. *maxima* (Mainx) Ettl et Gartn.						x								x																		
Chlamydomonas spp.									x		x		x	x																		x
Chloroclonium gloeophillum Borzi																x	xx															
Chloroclonium parvulum Borzi																												x				
Chlorococcum infusionum (Schr.) Meneghini																x		x														
Chloroplana terricola Hollerb.																													x			x
Chlorosarcina sp.																															x	
Chlorosarcinopsis minor (Gern.) Hernd.																										x						
Chlorosarcinales sp. div.											x		x	x													x	x			x	
Chlorosphaeropsis alveolata Hernd.							x																									
Cosmarium humile (Gay) Nordst.																		x														
Cylindrocapsa cf. *involuta* Reinsch.																		x														
Cylindrocapsa sp.									x		x		x		xx									x								
Desmococcus olivaceus (Pers. ex Ach.) Laund.			xx	x		x		x				x	x	x					x					x			x					
Dysmorphococcus cf. *coccifer* Korsch.																												x				
Folicularia sp.									x																						x	x
Gloeocystis polydermatica (Kutz.) Hind.					x																											
Hormidium sp. (fragments)													x																			
Hormotillopsis gelatinosa Train. et Bold						x																									x	
Keriochlamys styriaca Pasch.																								x		x						

ALGAE/SITES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Klebshormidium flaccidum (Kutz.) Silva, Matt. et Blackw.																	x										x					
Klebshormidium subtile (Kutz.) Trak. ex Tell				x																					x		x					
Korshpalmella microscopica (Kors.) Fott										x																				x		
Leptosira terrestris (Fritsch et John) Printz	xxx					x		x			x	x	x	x					x	x	x				x	xxx		x		x	xxx	x
Leptosira terricola (Bristol) Printz																	x							x								
Leptosiropsis torulosa Jao						x	x		x						x								x			x					x	
Palmelopsis sp.										x																						
Protoderma sarcinoidea (Groov. et Bold) Tupa									x								xx												xxx	x		
Protoderma sp.																								x								
Protosiphon botryoides Klebs										x				x	x			x	x						x							
Pseudodendocloniopsis botryoides Vish.													x																		x	
Pseudodendoclonium akinetum Tupa									x														x	x			x				x	
Pseudodendoclonium basiliense Vish.															x	x													x			
Pseudodictyochloris dissecata Vin.													x						x													
Schizochlamydella solitaria (G. M. Sm.) Fott																																
Schizochlamydella cf. *sphaerica* S. Watan.																																x
Scotiella tuberculata Bourr.																									x		x					
Sphaeroplea soleirollii (Duby) Mont																	xxx															
Tetracystis aggregata Brown et Bold						x		x																							x	x
Tetracystis sarcinalis Schwarz				x																												
Tetracystis sp.												x							x		x											
Tetraedron minimum (Al. Br.) Hansg.																									x							
Thorakomonas cf. *irregularis* Kors.																	x															
Trohiscia granulata (Reinsch) Hansg.																	x															
Ulothrix implexa Kutz.																												x				
Uronema confervicolum Lagerh.																											x					

18, 23). *Nostoc* is the most abundantly represented genus in the studied arable lands and tillable fields (loc. 4, 6, 7, 9, 14, 15, 19, 24, 25, 26, 28, 29). In most of the tillable fields *Nostoc punctiforme* was the dominant species (loc. 24, 25, 26) whereas in the most of other arable lands (loc. 6, 14, 15, 19) *Nostoc linckia* dominated. In forest (incl. soils under single trees and shrubs) and in meadow soils more often *Nostoc commune* dominated (loc. 3, 21, 22, 27, 30). *Nostoc calcicola* dominated or co-dominated in an untillable field (loc. 1), in a tillable field (loc. 7) and in a date-forest soil (loc. 10). Representatives of genera *Stigonema*, *Scytonema*, *Scytonematopsis*, *Calothrix* and *Tolypothrix* (Table 1) more often occurred as dominants, subdominants and abundant species in meadow soils (loc. 20, 30) and untillable fields (loc. 1, 32) than in arable lands (loc. 15). *Phormidium ambiquum* dominated in the soil from an untillable field (loc. 32). Various representatives of *Anabaena* and mainly *A. oscillarioides* and its forms *minor* and *turkestanica* (Table 1) also occurred as dominants or co-dominants in a forest soil (loc. 10), in tillable fields and arable lands (loc. 9, 15) and in a semi-desert soil (loc. 13). *Anabaena sphaerica* f. *conoidea* dominated only once in the soil collected near the Samara Reservoir (loc.12). *Microcystis* often occurred as co-dominant or subdominant or was abundantly developed in soils from forests or under trees (loc. 8, 10, 13, 23), arable lands (loc. 6, 15), tillable fields (loc. 9, 25) and from a steppe (loc. 5). *Plectonema puteale* became abundantly developed once, after 5 months of cultivation in a sample from 8 locality.

Green algae also occurred as dominants, co-dominanats or subdominants in some of the processed samples. *Leptosira terrestris* dominated or co-dominated the soils from untillable fields (loc. 1, 32), a tillable field (loc. 26) and a forest soil (loc. 31). *Cylindrocapsa* sp. dominated in the soil sample collected among the Babylon ruines (loc. 11) and was a sub-dominant in the soil from an arable land (loc. 15). *Sphaeroplea soleiroilii* dominated in the soil collected under a group of oak trees (loc. 17). *Protoderma sarcinoidea* was a sub-dominant in the same soil (loc. 17) and dominated in a soil from a tillable field (loc. 29). Some green algae occurred as co-dominants or subdominants in soils collected from semi-deserts (loc. 16 - *Apatococcus lobatus*), under single trees or shrubs (loc. 3 - *Desmococcus olivaceus*, 17 - *Chloroclonium gloeophllum*) and arable lands (loc. 28 - *Apatococcus constipatus*). During this study chlorophytes had not been found as monodominants in the soils collected from steppes, meadows and untillable fields.

The taxonomic structure of the investigated algal flora based on the number of infrageneric and generic taxa is shown on Fig. 2. During the study, some deviations from the descriptions of species and other infrageneric taxa have been detected. Since the modification of algae under culture conditions is a well known phenomenon and since many species occur in nature in different morphological stages (status), which are influenced by environmental conditions and/or are seasonally dependent (Komárek & Anagnostidis, 1999), new taxa have not been described. In the same time, some of the species found yet have not been reported from soil local-

Table 2

NS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	8			1	1	3	2	2	2	1		3	1	2	2		2	1	2	4	4	1	1	1	3	2		2		2	3	1
2		2			1			1	1			1																				
3			3	3		2		2	1			1	1	1					1		1	1		1			2			1	1	1
4				10		2	1	2	1	1		2	2	2	1				1		2	1		1	2		4	1		1	1	1
5					4	2	2	2	3			1	2	2	3			1	1		1		2		2	1	1				2	
6						14	5	4	2	1	1	4	4	5	5	1		1	3	1	4	1	3	1	5	4	4	3		2	7	2
7							13	4	6	1		4	4	3	5	1	1			2	2		2		3	1	2	1		2	4	1
8								20	10		1	7	6	6	3	1	2	4	2	4	2	1	3	3	3	2	3	2		4	7	6
9									28		2	7	6	5	5	1	4	3	2	2	4	3	5	6	3	3	6	1	1	6	5	4
10										7		1	1	1	2			1	1		1				2		1	1		1		
11											4	1	4	3	1				1	1	1			1	1	1	1	2		1	2	2
12												15	5	4	2	1		1	3	2	3	1	2	4	2	2	3	2		2	3	2
13													18	9	5	1		1	4	2	2		2	2	3	2	3	2		2	5	2
14														14	3			2	4	3	3		2	2	5	3	4	3		2	7	3
15															11	3		1	1		1		3	1	2	2	2	1	1		4	
16																7	1	2			.		1	1	1	1	1		1		1	
17																	12	1		2	2		1	1	1	1	2	2	1	3	1	2
18																		9	2		2		2	1	2					1	2	2
19																			9	1	4		1	2	4	3	2	2		1	3	2
20																				9	3	1	1	1	1	1		1		4	3	2
21																					9	1	2	2	3	2	2	3		4	2	3
22																						6	1	1	1	1	1			1	1	
23																							7	2	2	2	2			1	4	1
24																								12	1	2	4	1			3	1
25																									11	5	3	3		1	5	2
26																										10	2	2		1	5	2
27																											17	3		1	5	1
28																												11		1	3	2
29																													3	1		1
30																														13	2	3
31																															17	4
32																																13

Table 2

Similarity of the studied sites according to the index of Sörensen -SSI

NS/1-32 - number of site in compliance with the number in the text and in Table 1; diagonally - number of species for each site; above the diagonal - number of common species; below the diagonal - graphic expression of the values of SSI

SSI = 0
0.1% < SSI < 10%
10% < SSI < 20%
20% < SSI < 30%
30% < SSI < 40%
40% < SSI < 50%
50% < SSI < 60%

ities. All deviations and all peculiarities found will be noted in details and illustrated elsewhere. In spite of using of soil-cultures, some algae could not be correctly and certainly determined due to their appearance in single specimens or in resting stages only, or due to the lack of zoospores in cultured material. Doubtless, further, more detailed studies of these cultures could reveal much more rich species composition. It has to be underlined that the pattern of algal flora obtained during this study reflected not only the environmental conditions of the studed sites, the sampling period and the physical conditions of culturing but also the 19-years keepment of the collected samples in air-dry conditions.

According to the number of infrageneric taxa (Fig. 2B) Cyanoprokaryota is the most rich group (58 species and 4 forms) while according to the number of genera (Fig. 2A) Chlorophyta is the most significant group (40 genera). Chrysophyta is very poorly represented in the studied samples (6 species of 6 genera). This result is on conformity with the general considerations about the members of soil algal flora of METTING (1981). Our results coincided also with the statement of METTING (1981) based on more than 30 publications that blue-green and green algae are well adapted for existence in climatic zones and local microenvironments in which available water is the primary limiting factor. The ability of soil cyanoprokaryotes and green algae to survive prolonged periods without water has been demonstrated by the successful revival of algae from stored soils and herbarium sheets up to 87 years of age (see the Introduction). Circumstantial evidence that Chrysophyta (particularly diatoms and yellow-green algae) are less tolerant of low water potential includes their low abundance and diversity in soils of dry regions (LUND, 1945, 1947; BREDEMUHL, 1949; FRIEDMANN & GALUN, 1974) and their greater susceptibility to desiccation in laboratory tests (BRISTOL-ROACH, 1928; SKINNER, 1932; HILTON & TRAINOR, 1963; TRAINOR, 1970; STARKS et al., 1981; TRAINOR & GLADYCH, 1995). Many suggestions have been proposed about the physiological and biochemical mechanisms of drought resistance of soil algae. Among these are the forming of specialized resting cells, the excretion of extracellular mucilage (envelopes and sheaths), the aggregation of cells and trichomes, etc., as well as the fact that a certain number of individuals are retained in the resistant state at all times (FRITSCH, 1916, 1922; PETERSEN, 1935; MACENTEE et al., 1972; METTING, 1981; STARKS et al., 1981). It is noteworthy to mention that all these devices have been observed during the study for almost all algae and that some

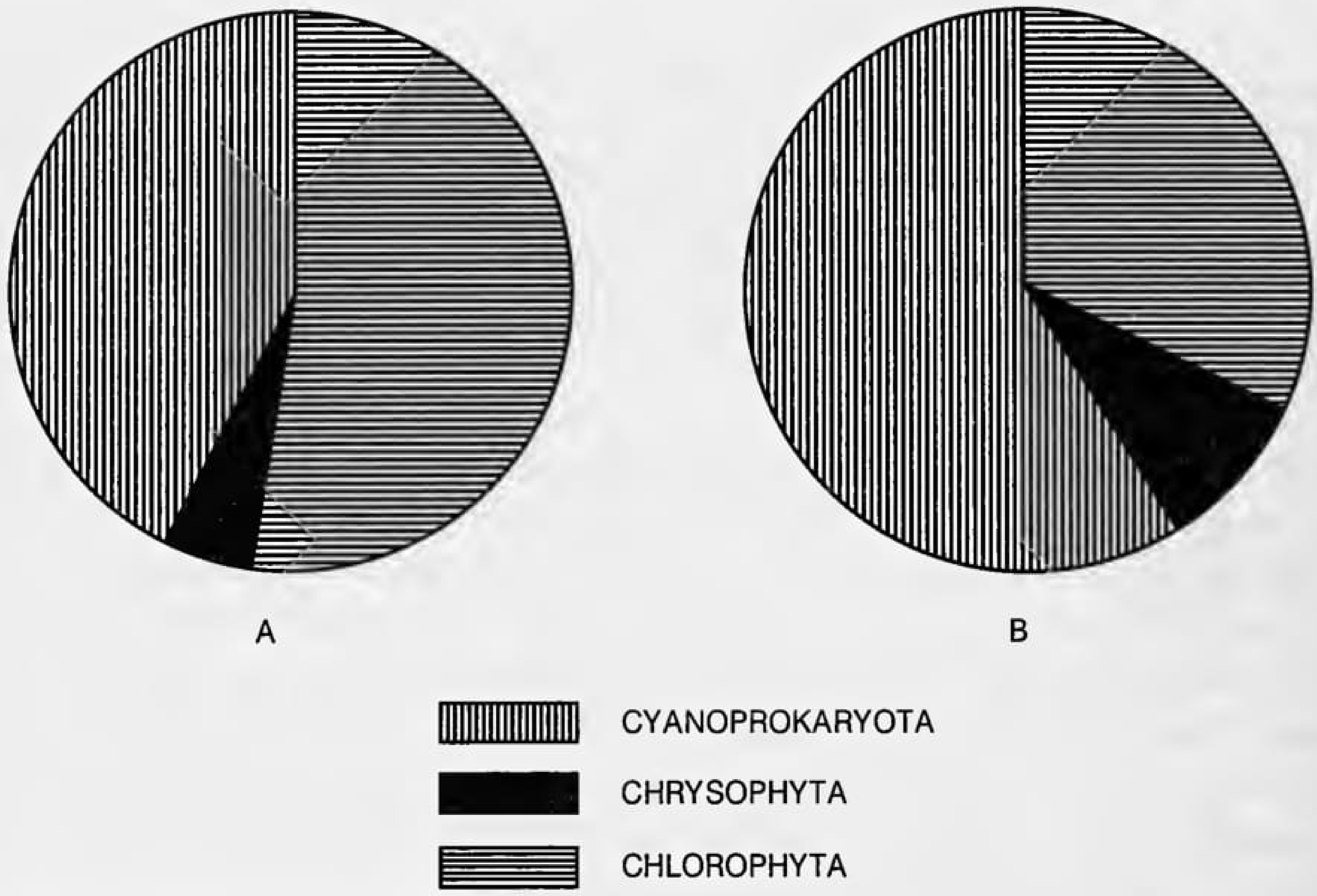

Fig. 2. Taxonomic structure of the soil algal flora of the studied sites: A - based on the number of genera, B - based on the number of infrageneric taxa

of the established species occurred mostly in a resistant state (*e.g.*, *Leptosiropsis torulosa*, *Pseudodendoclonium akinetum*). Some cyanoprokaryotes which normally do not form mucilage sheaths, have been found in thick, yellow to brownish coloured sheaths (*Anabaena oscillarioides* f. *minor*, *Cylindrospermum licheniforme*, *C. muscicola*). The only one detected diatom species (*Gomphonema* sp.) was also in thick mucilage envelopes and stalks. For some of the detected species certain resting stages had not been reported but they themselves had thick cell envelopes or walls which, most probably, mantained their survival during the long-term air-dry conditions (*e.g.*, *Chlorogibba pentagonia*, *Pleurogaster lunaris*, *Keriochlamys styriaca*, *Tetraedron minimum*, *Scotiella tuberculata*, *Thorakomonas* cf. *irregularis*).

The results obtained about the species composition of various sites and particularly these in small forests and under trees and shrubs generally coincided with the suggestion that macrovegetation may influence the surrounding algal flora (SCHTINA, 1956; FAIRCHILD & WILLSON, 1967; CARSON & BROWN, 1978; STARKS et al., 1981). Since the number of studied sites of this type was small we should not go into deep discussion of this problem. We should mention only that there were obvious differences in the algal flora under different vascular plants and that the sample collected under a group of oak-trees could not be grouped together with almost all other samples. This is on conformity with some results of SHUBERT (1979 - cit. acc. to STARKS et al., 1981) that a similarity-index of algal community relationships demonstrated that all woodland types grouped together except bur oak and with the results of DRAGANOV et al. (1992) that algal flora under *Querceto-Ulmetum* showed the lowest similarity with the edaphic algae collected under other associations. In the same time, it is necessary to mention that the "specific algal associations" pointed out for some forests (e.g. METTING & RAYBURN, 1979), have been found also in areas with vastly different vegetation and soil types (STARKS et al., 1981).

Most of the algae found have been referred as ubiquitous and cosmopolitan. For most of them previous data on their preference to soil type or to the type of habitat were confirmed. The possibilities for survival after long-term keepment in air-dry conditions both for cyanoprokaryotes and green algae were confirmed and were shown also for some chrysophyte species. Nevertheless of generally common conclusions and coincidence of our results with these of other authors, there were some differences which concerned mainly details in the distribution of separate species. In the same time, detailed comparison of the detected species composition with other floristic data would not be certain due to the lack of other studies on dessicated material from the same region. A broader discussion on the distribution of the species found combined with more taxonomic data will be provided further on.

As a conclusion, it could be stated that the finding of 114 species and 4 forms from 68 genera of 3 divisions from 32 sites expand the knowledge on the edaphophyton of Southwest Asia. The results from this study confirmed some previous data about the surveillance of soil algae for a long time in museum samples kept for a long time in air-dry conditions and proved the possiblity to use such samples for obtaining a valuable floristic information.

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Почвени водорасли в музейни проби от някои пунктове в Югозападна Азия. I

Майя СТОЙНЕВА

(Р е з ю м е)

В статията са представени данни за видовия състав на водораслите в музейни проби от 32 пункта в Турция, Ирак, Иран, Сирия и Ливан. Пробите са събрани от повърхностния почвен слой през периода 30 октомври - 21 декември 1972. Резултатите са получени след обработването на материалите след 19-годишен престой във въздушно сухо състояние. Определени са 114 вида и 4 форми от 68 рода на 3 отдела. Сред тях Cyanoprokaryota е най-богат на вътреродови таксони (58 вида и 4 форми), Chlorophyta заема първо място според броя на установените родове (40), а отдел Chrysophyta е представен много бедно в изследваните проби (6 вида от 6 рода). Потвърдени са данни на предишни изследователи за предпочитанията към определен почвен тип или към типа на местообитанието за повечето от установените водорасли. Потвърдена е способността на цианопрокариотите и хлорофитите за преживяване след продължително съхранение във въздушно сухо състояние и е установено, че такива възможности имат и някои от хризофитите.