

# Mérgező algavirágzások, algatoxinok, cianobakteriális toxinok vizeinkben

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tanszékvezető egyetemi tanár  
Debreceni Egyetem  
Növénytani Tanszék

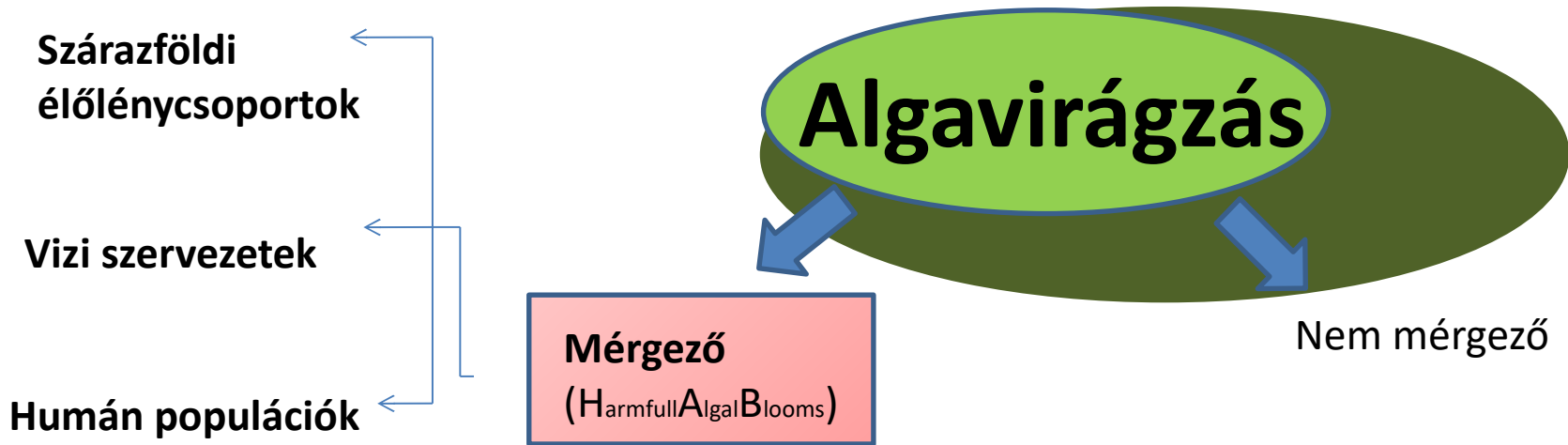
**„ALGAVIRÁGZÁSOK, ALGATOXINOK TAVAINKBAN”**

**TUDOMÁNYOS ELŐADÓÜLÉS**



- Toxikus algák, algatoxinok, mérgező algavirágzások
- Hatások, következmények
- Nemzetközi helyzet-hazai helyzet
- Balaton



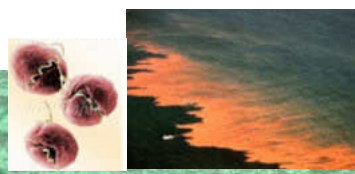


Tengerek, óceánok

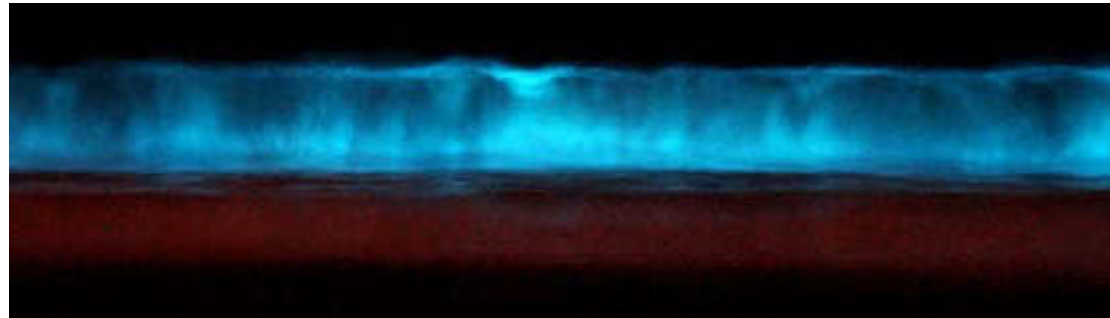
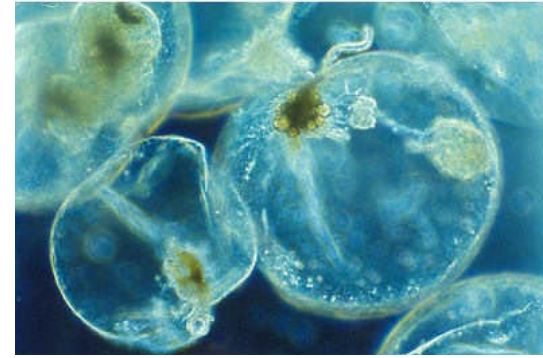
Édesvizek, kontinentális vizek

Dinoflagelláták

Cianobaktériumok (kékalgák)



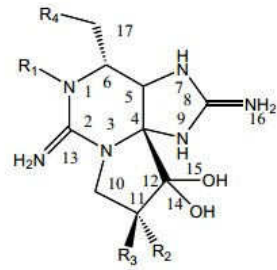
# *Noctiluca scintillans*



# Óceánok, tengerek



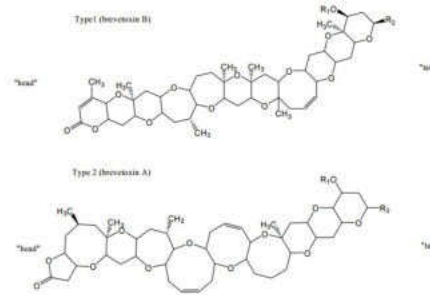
PSP TOXINOK,  
Szaxitoxinok



*Alexandrium sp.*,  
*Gymnodinium sp.*,  
*Pyrodinium sp.*



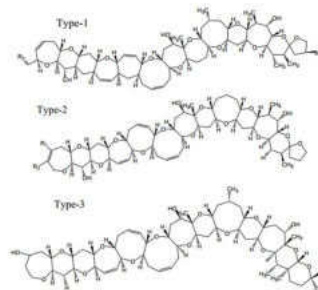
Neurotoxic Shellfish Poisoning  
(NSP), brévetoxinok



*Kerenia brevis*  
(*Gymnodinium breve*)



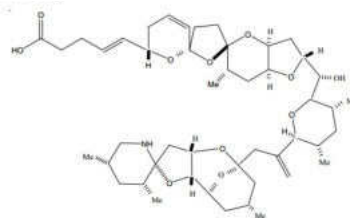
Ciguatera Fish Poisoning,  
ciguatera toxinok



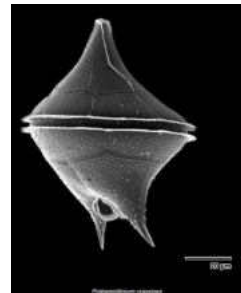
*Gambierdiscus toxicus*



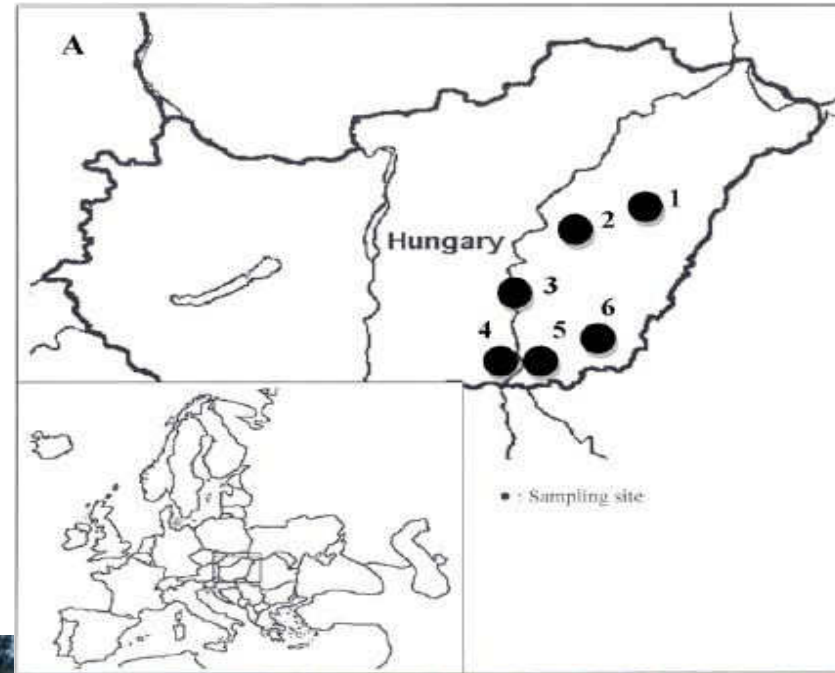
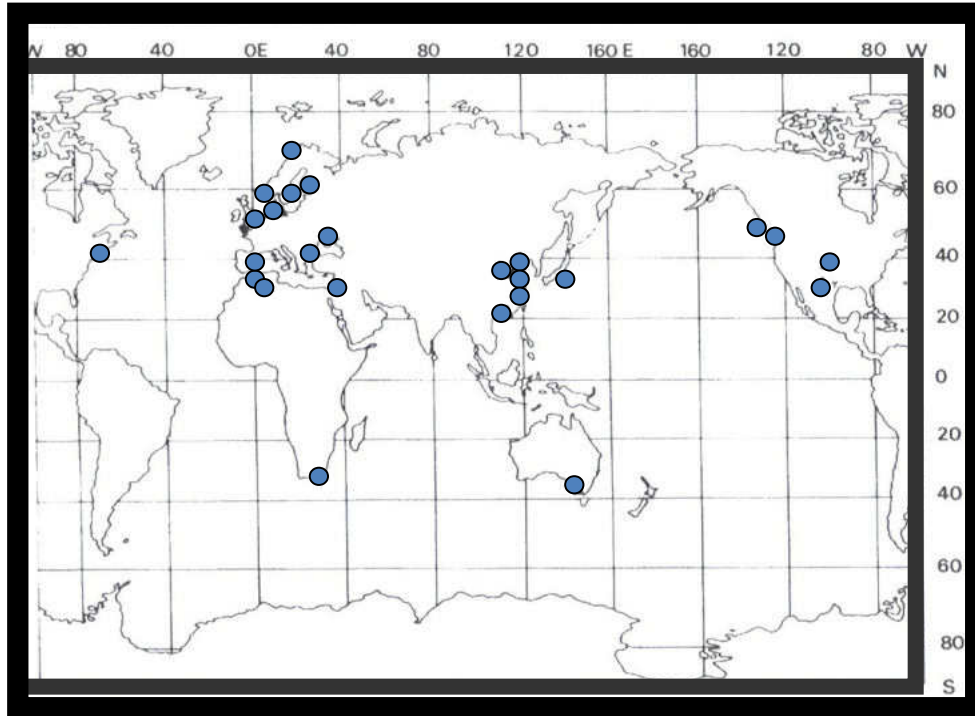
Azaspiracid poisoning (AZP)



*Protoperidinium crassipes*



# Aranyalga



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## Harmful Algae

Volume 17, May 2012, Pages 102-110



# Occurrence of toxic *Prymnesium parvum* blooms with high protease activity is related to fish mortality in Hungarian ponds

Gábor Vasas<sup>a</sup>  , Márta M-Hamvas<sup>a</sup>, Gábor Borics<sup>b</sup>, Sándor Gonda<sup>a</sup>, Csaba Máthé<sup>a</sup>, Katalin Jámbrík<sup>a</sup>, Zsolt László Nagy<sup>c</sup>

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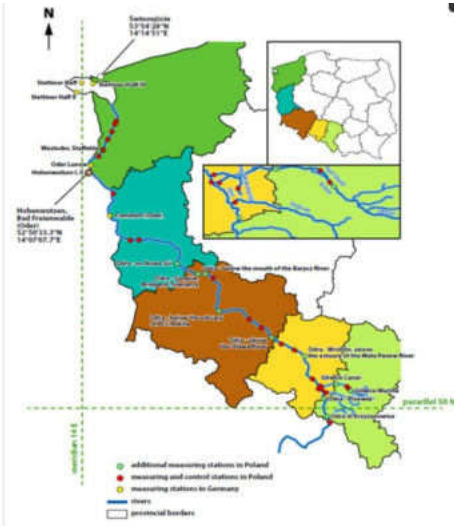
<https://doi.org/10.1016/j.hal.2012.03.007>[Get rights and content](#)

Variable, unit	P1 Hajdúszoboszló	P2 Kisújszállás	P3 Szentés	P4 Sándorfalva	P5 Makó	P6 Battonya
<i>P. parvum</i> cell number (individuum mL <sup>-1</sup> )	40,000	38,000	700	1200	800	300
Fish mortality (kg)	2600	1500	500	700	300	600
Dissolved oxygen (mg L <sup>-1</sup> )	7.7	8.2	11.3	6.6	11.2	8.5
pH	8.2	8.8	9.2	8.9	9.1	8.3
Specific electrical conductivity (μS cm <sup>-1</sup> )	2242	2978	2420	3940	4050	5800
Ammonium (mg L <sup>-1</sup> )	0.05	0.04	0.05	0.08	0.06	0.01
T (°C)	23	28	22	23	22	24
Pond area (Ha)	12	4	1.5	1	4	2





# Odera víz és tározó rendszere (2022-23)



A large overgrowth of toxic algae linked to industrial pollution is the most likely culprit of the mass fish deaths. - LISI NIESNER/REUTERS

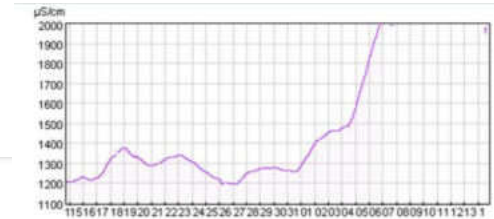
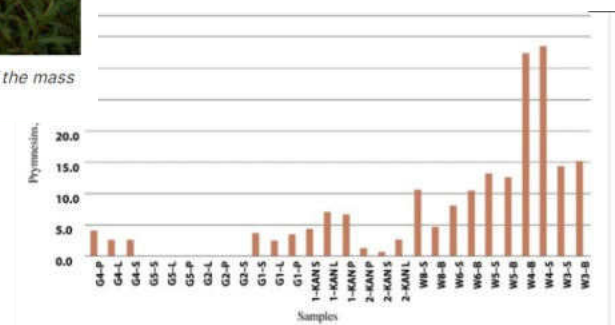
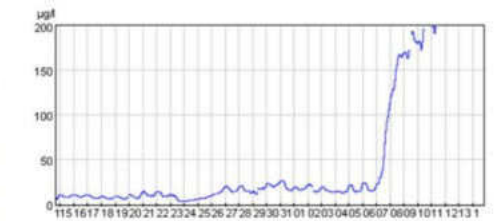
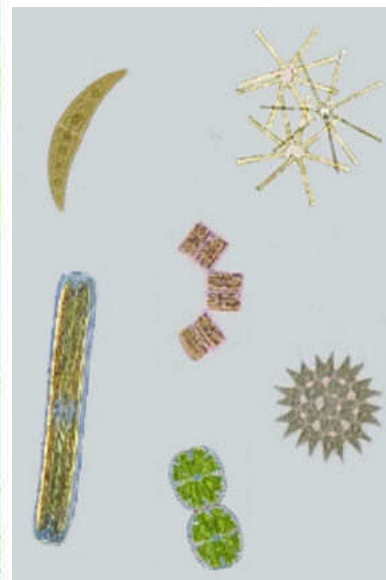
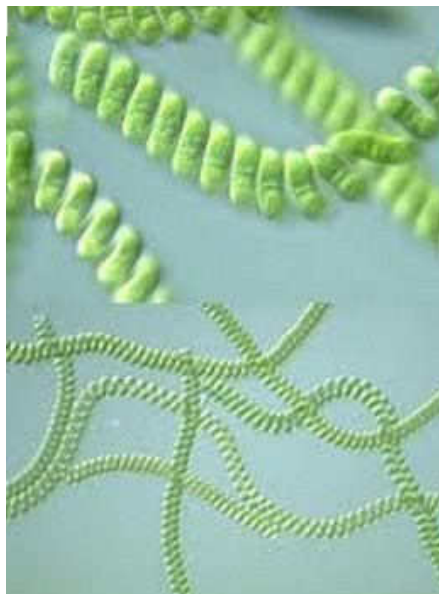
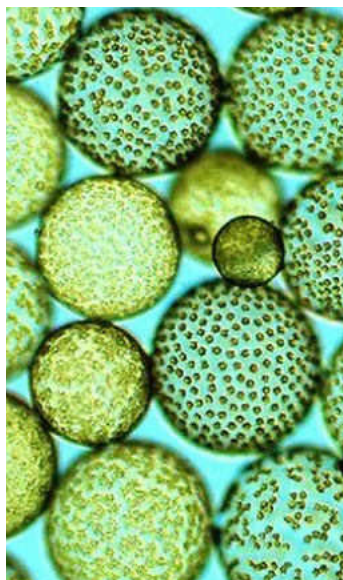
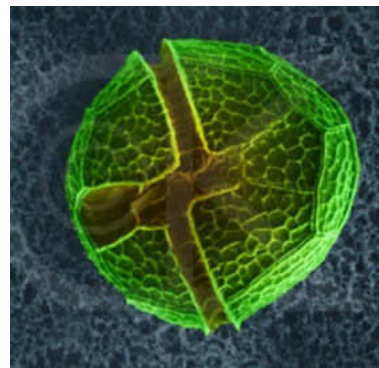
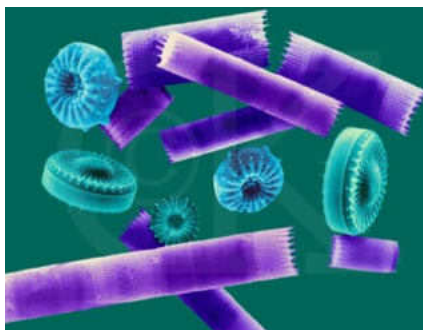
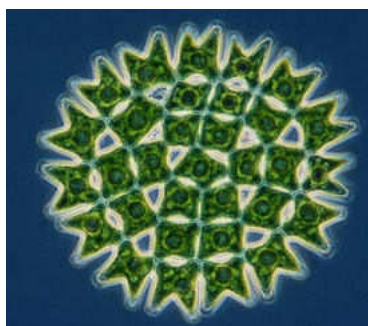
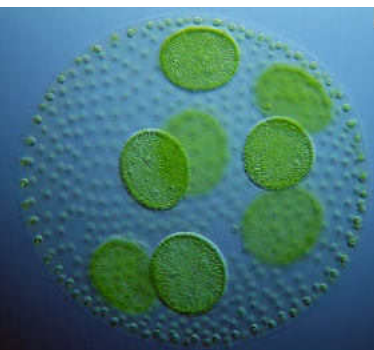
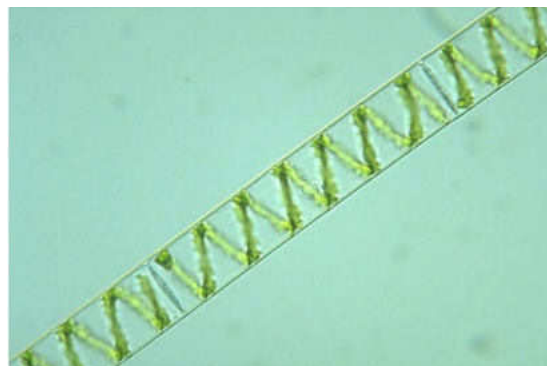


Figure 4 Conductivity at Frankfurt (Oder) during July and August 2022<sup>10</sup>

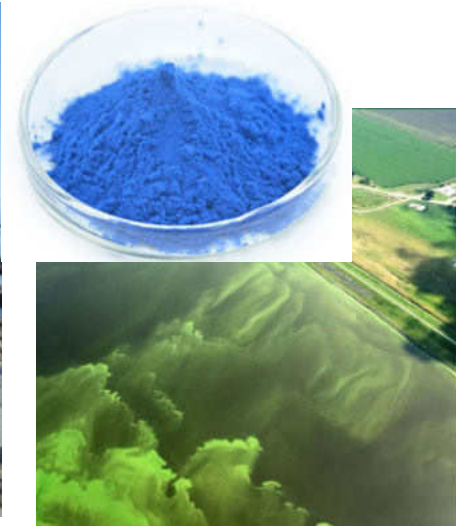




# Cianobaktériumok I.



- Evolúció
- Blue-green alga
- $O_2$
- Fotoszintézis
- Endoszimbiont a elmélet



# Cianobaktériumok II.

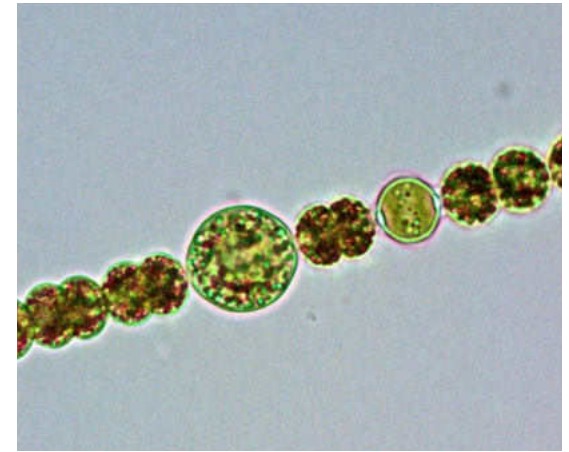
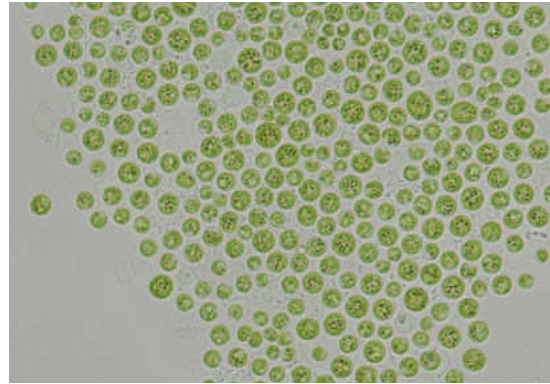
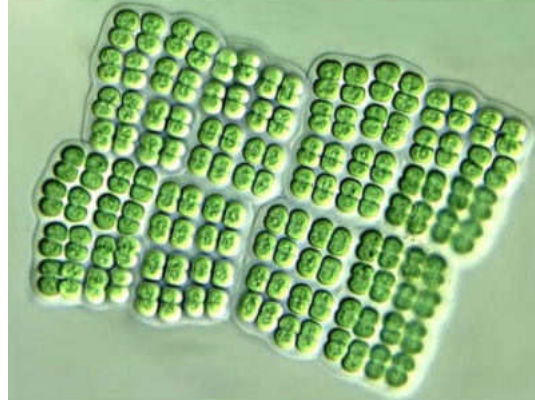


- édesvizek,  
tengerek
- szimbionták
- kő, talaj, jég



# Cianobaktériumok

## III.

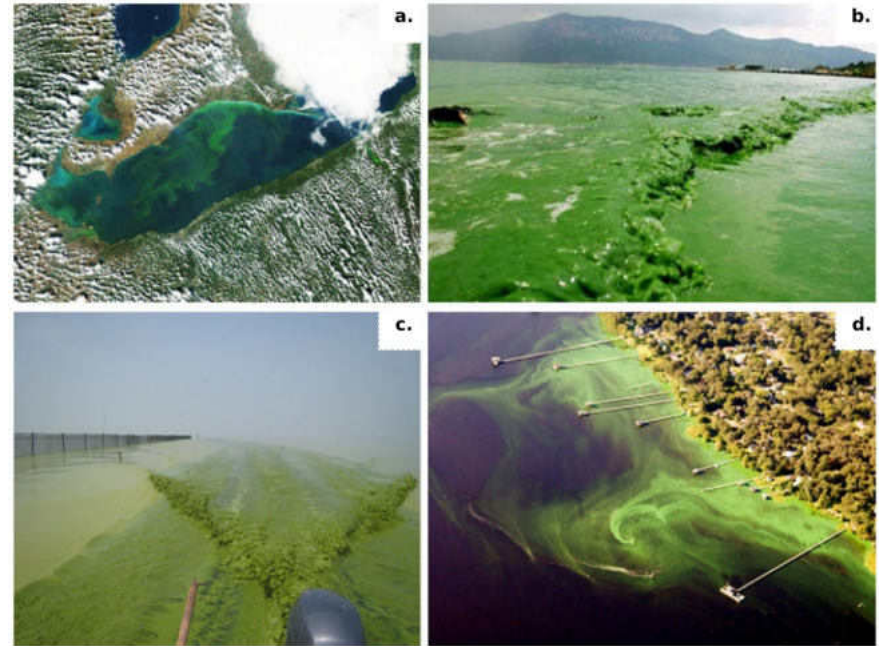
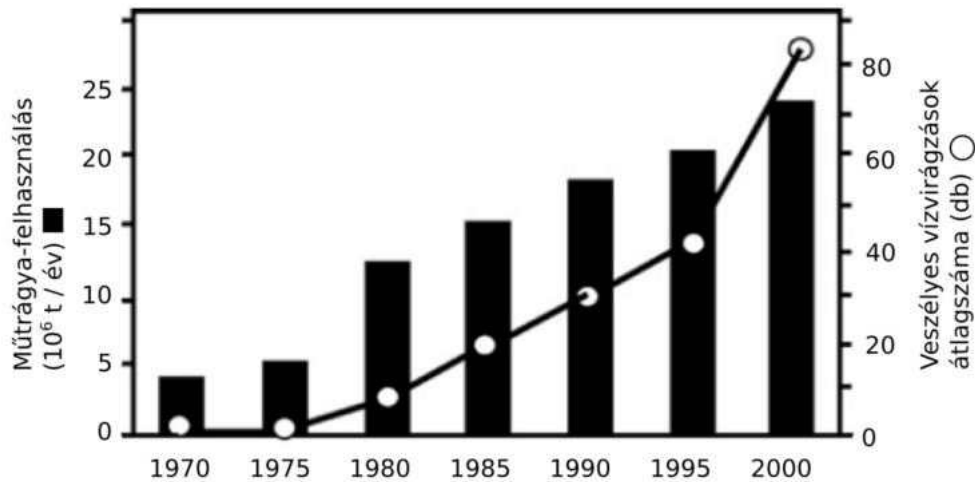


# Cianobaktériumok

## IV.



# Gyakoriság és Kiterjedés





# OKOK ÉS KÖVETKEZMÉNYEK



klímaváltozás



hőmérséklet



fény



cianobaktériumok



eutrofizáció



tápanyagok



**P**

*cianobakteriális  
növekedés*

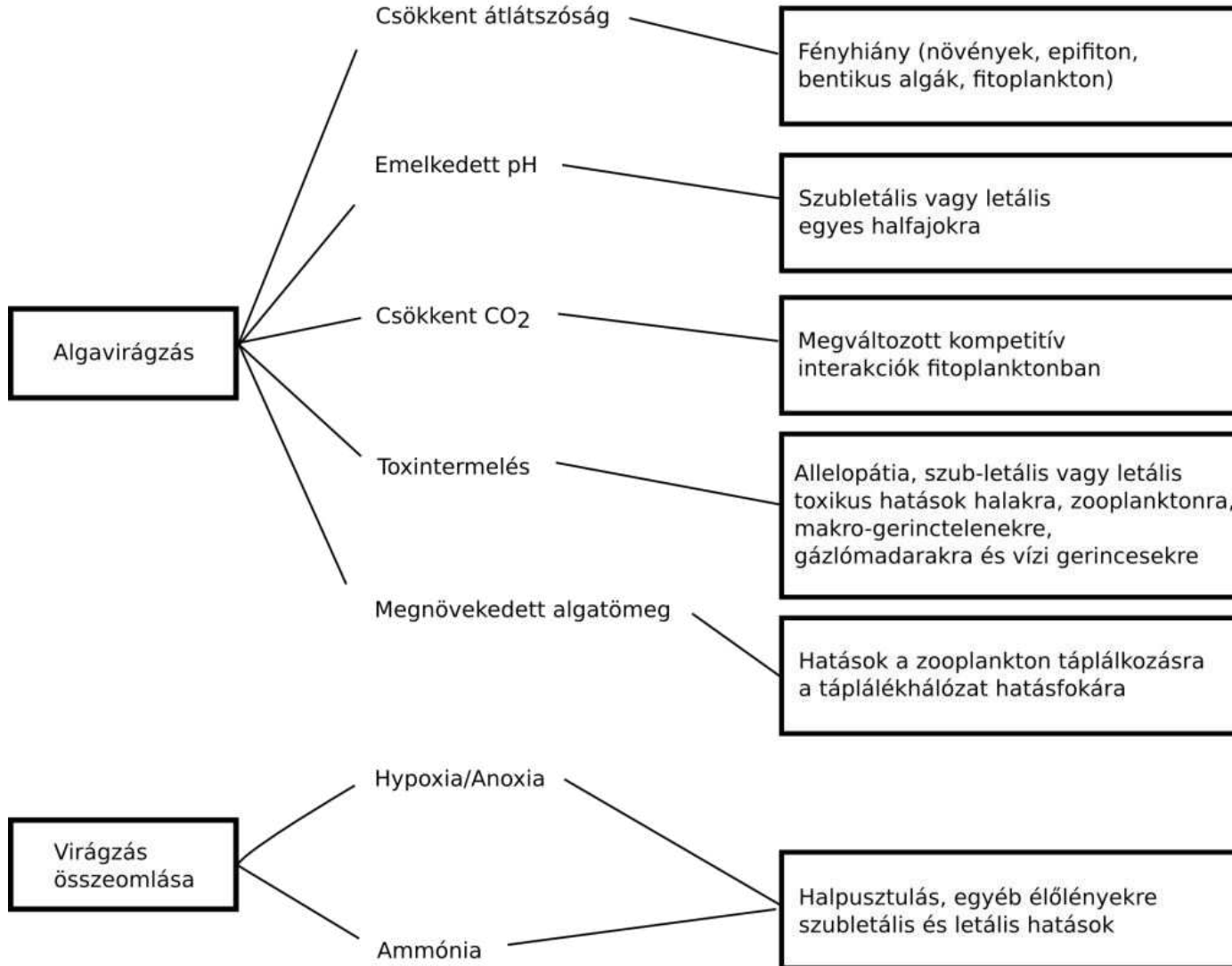


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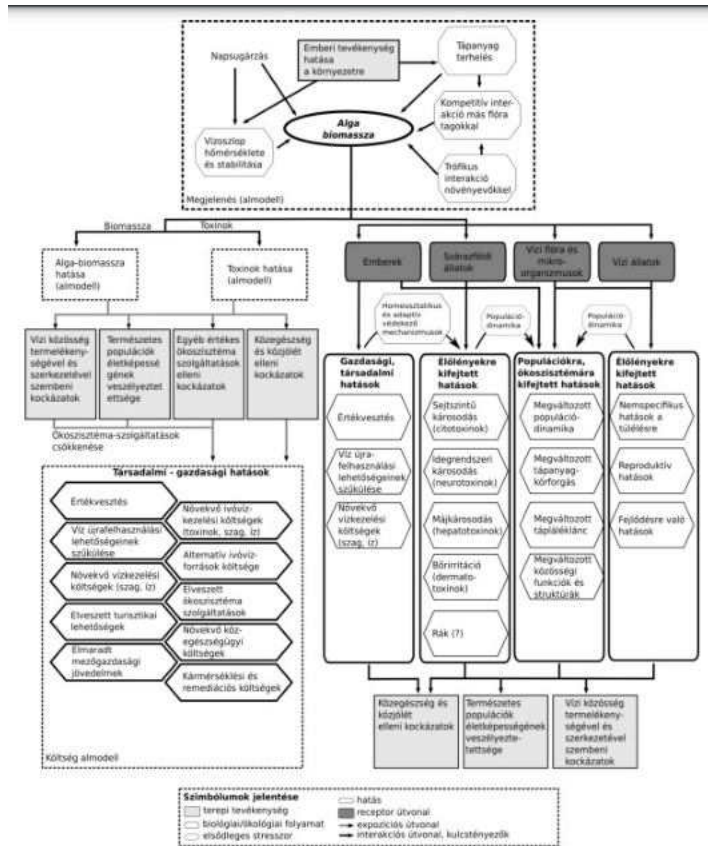
Esemény

Válasz

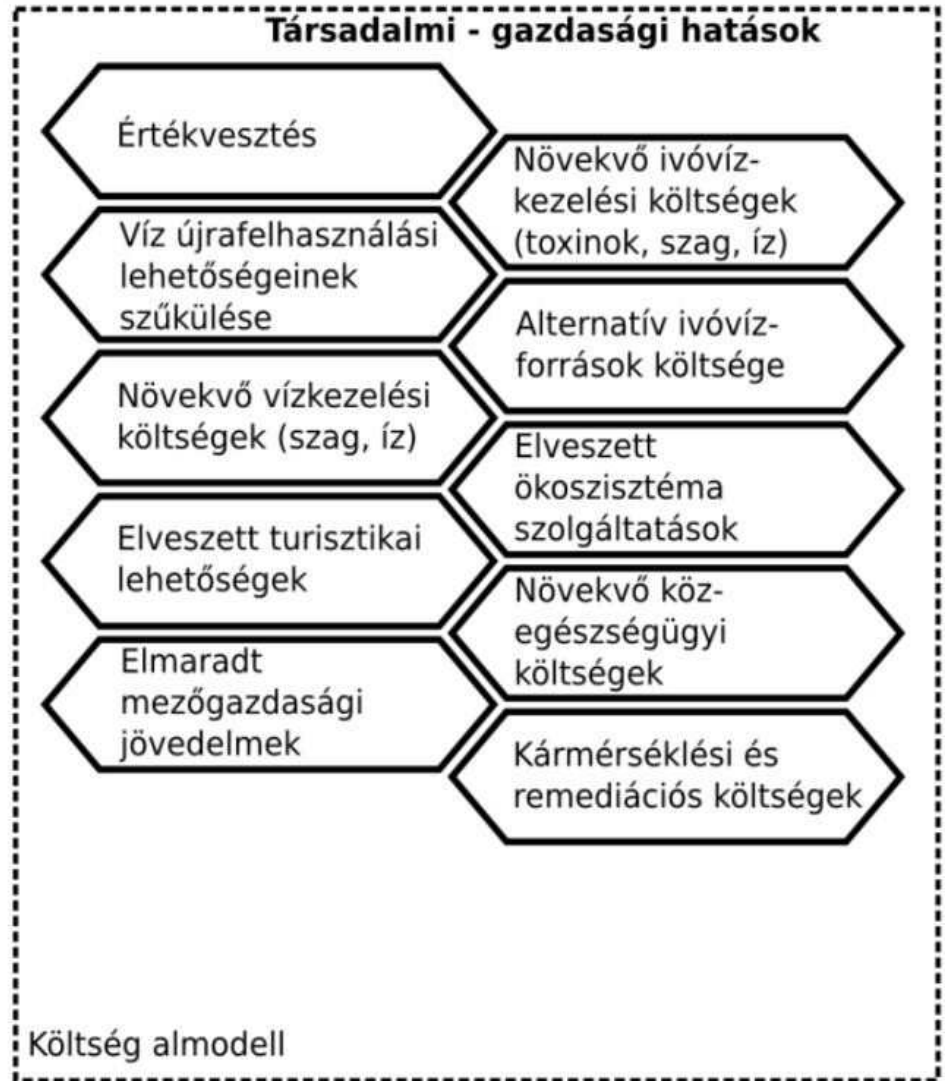
Hatás

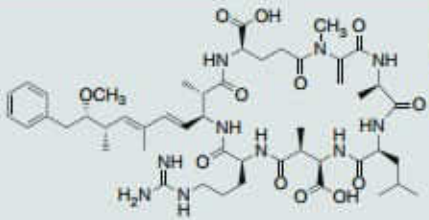
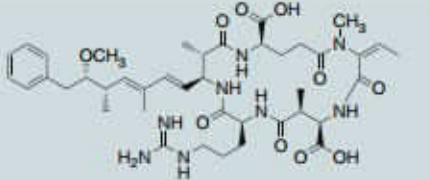
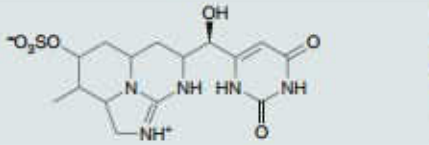
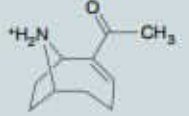
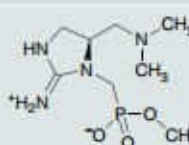
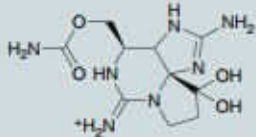
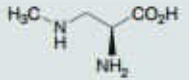


# OKOK ÉS KÖVETKEZMÉNYEK



4. ábra. Mérgező algavirágzások komplex hatása az élővilágra és a társadalomra.



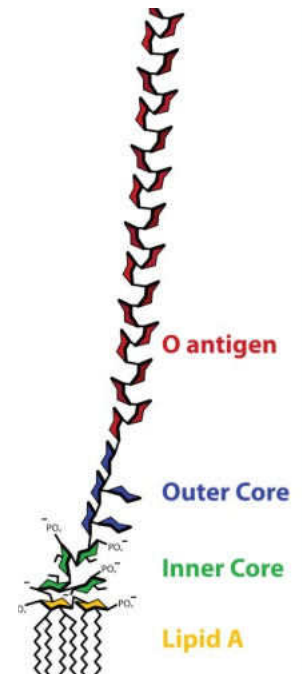
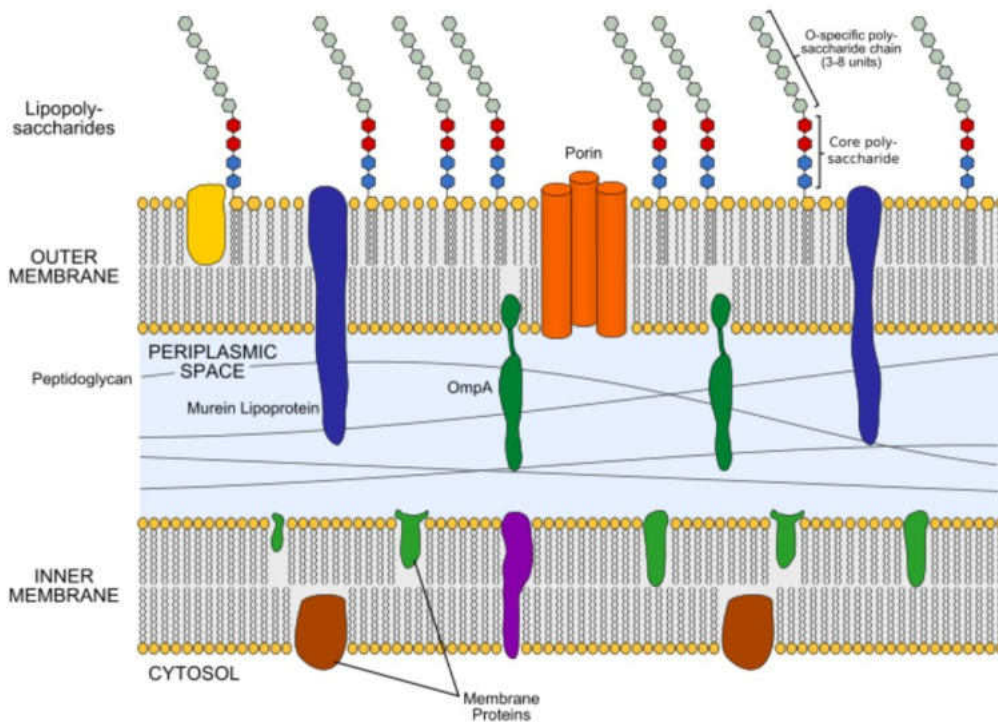
Toxin	Chemical structure	Main producing genera <sup>71</sup>	Modes of action	Toxic effects <sup>a</sup>
Microcystins		<i>Microcystis</i> , <i>Anabaena</i> , <i>Dolichospermum</i> , <i>Leptolyngbya</i> , <i>Nostoc</i> , <i>Phormidium</i> , <i>Planktothrix</i> and <i>Synechococcus</i>	Inhibition of eukaryotic protein phosphatases	Liver and kidney damage, gastroenteritis, tumour promotion, reduced DNA repair and reproductive toxicity
Nodularins		<i>Nodularia</i>	Inhibition of eukaryotic protein phosphatases	Same effects as microcystins plus weak carcinogenicity
Cylindrospermopsins		<i>Cylindrospermopsis</i> , <i>Anabaena</i> , <i>Aphanizomenon</i> , <i>Chrysochloris</i> and <i>Raphidopsis</i>	Inhibition of protein synthesis, DNA damage and cell death	Damage to multiple organs, gastroenteritis and genotoxicity
Anatoxin-a		<i>Anabaena</i> , <i>Aphanizomenon</i> , <i>Cuspidothrix</i> , <i>Dolichospermum</i> , <i>Oscillatoria</i> and <i>Phormidium</i>	Agonist of nicotinic acetylcholine receptors at neuromuscular junctions	Loss of coordination, muscle tremors and respiratory failure
Anatoxin-a(s)		<i>Dolichospermum</i>	Inhibitor of acetyl-cholinesterase	Salivation, incontinence, muscle tremors and respiratory failure
Saxitoxins		<i>Aphanizomenon</i> , <i>Cuspidothrix</i> , <i>Cylindrospermopsis</i> and <i>Dolichospermum</i>	Block voltage-gated sodium channels of neurons	Paraesthesia, numbness, paralysis and respiratory failure
BMAA		<i>Microcystis</i> and <i>Nostoc</i> ; possibly widespread among cyanobacteria <sup>197</sup> but no consensus yet <sup>198</sup>	Excessive stimulation of glutamate receptors in neurons and association with proteins	Loss of coordination, muscle atrophy and possible contributions to neurodegenerative diseases (for example, amyotrophic lateral sclerosis and Alzheimer disease)
Lipopolysaccharides	Not shown	All cyanobacteria	Inflammation and promotion of cytokine production	Skin irritation, fever and gastrointestinal upset



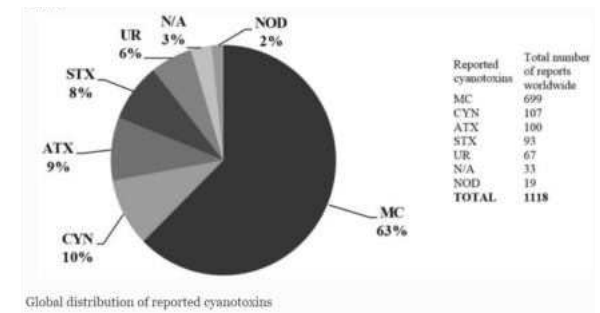
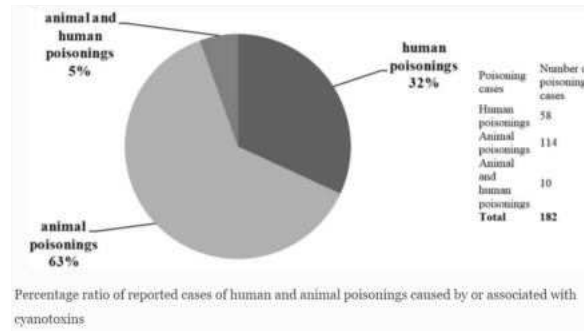
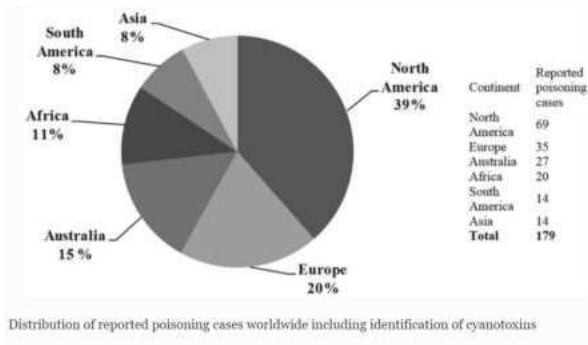
# LPS-Irritáns

Kékalga-Cianobaktérium: Gram-negatív baktérium

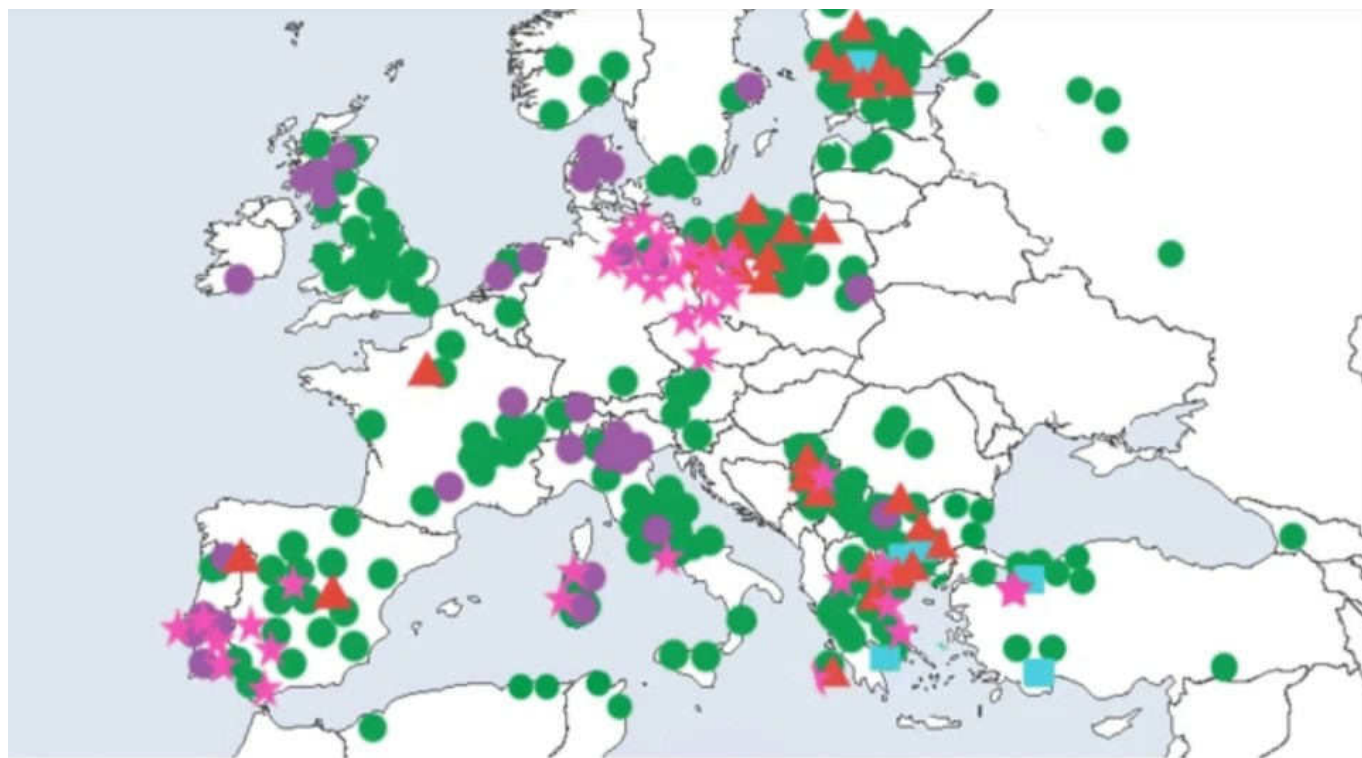
Cianobaktérium LPS jóval kevésbé toxikus mint több heterotróf patogén esetében, fajonként variábilis



# Mérgező algavirágzások (cianobaktérium, kékalga) tér és időbeni megjelenései



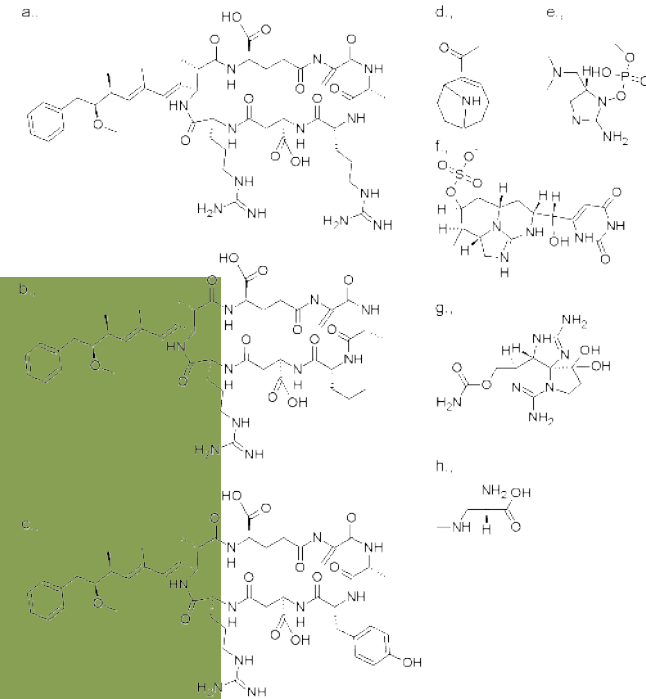
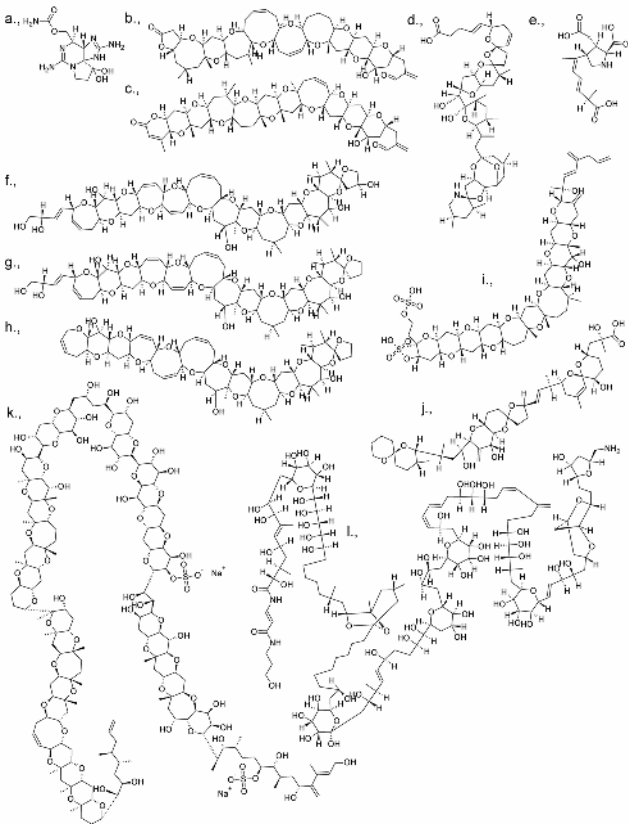
Period	Africa		Asia		Australia and New Zealand		Europe		North and Central America		South America		Total	
	Total	Poison.	Total	Poison.	Total	Poison.	Total	Poison.	Total	Poison.	Total	Poison.	Total	Poison.
...-1949	1	1	0	0	1	1	0	0	6	6	0	0	8	8
1950-1999	11	11	14	7	25	23	32	22	27	25	14	7	123	95
2000-2018	43	7	64	9	25	8	96	17	60	23	49	10	337	74
<b>Total</b>	<b>55</b>	<b>19</b>	<b>78</b>	<b>16</b>	<b>51</b>	<b>32</b>	<b>128</b>	<b>39</b>	<b>93</b>	<b>54</b>	<b>63</b>	<b>17</b>	<b>468</b>	<b>177</b>



### LEGEND

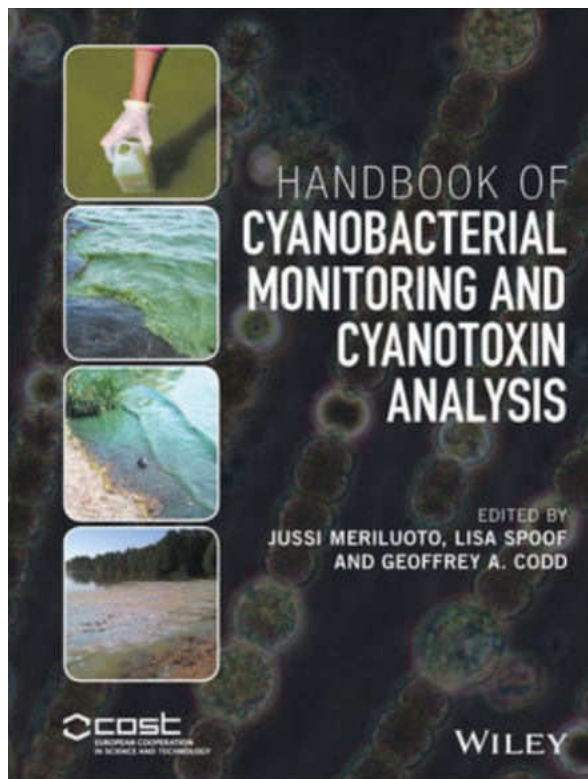
● MICROCYSTINS    ■ NODULARINS    ● ANATOXINS    ▲ SAXITOXINS    ★ CYLINDROSPERMOPSIN

# Metabolitok, Toxinok variabilitása





# Cianobakteriális toxinok mérése, kimutatása



-biológiai, ökológiai, kémiai megközelítés.  
Többféle műszeres és rutin mérés szükséges a  
különböző toxincsaládok detektálásához.

# Cianobakteriális toxintermelés sajátosságai

**Nem fajspecifikus**

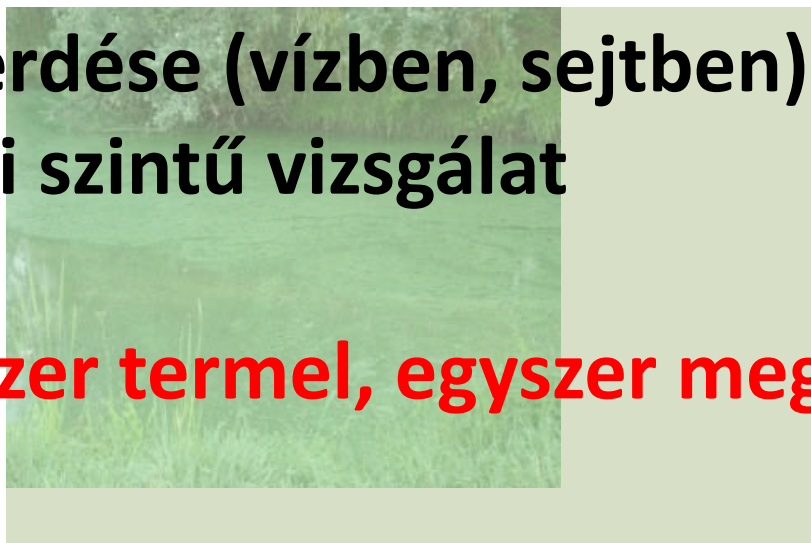
**Nem morfológia függő**

**Komplex genetikai háttér**

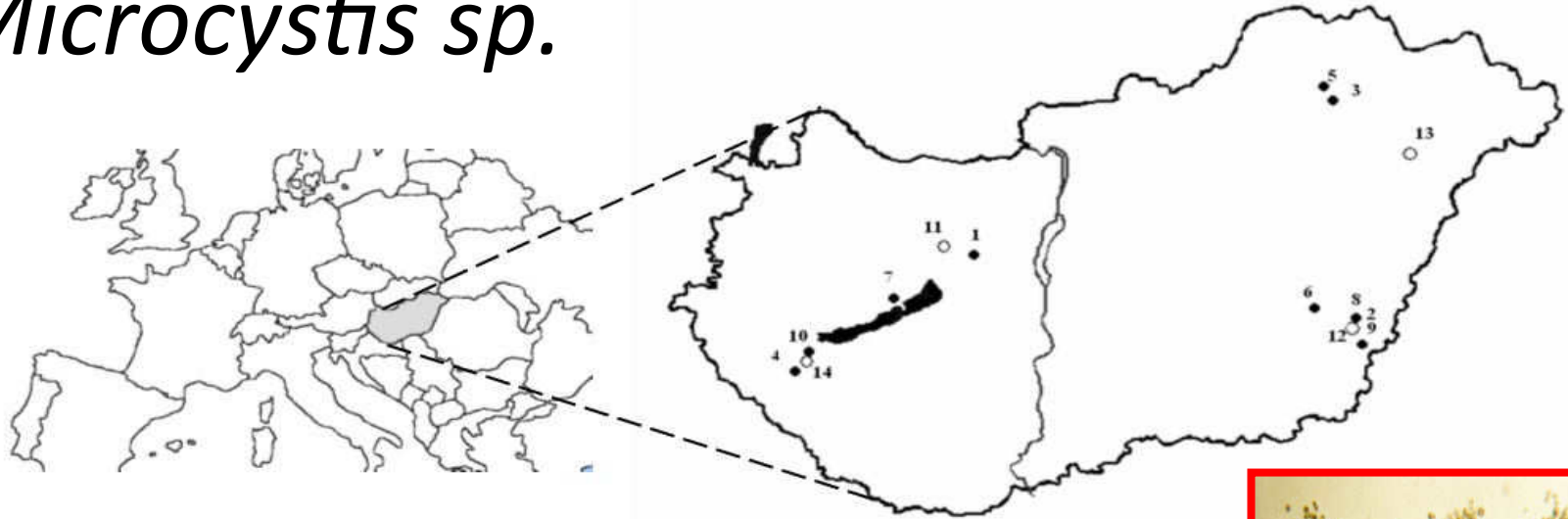
**Kompartment kérdése (vízben, sejtben)**

**Egyedi, közösségi szintű vizsgálat**

**Mi az hogy: egyszer termel, egyszer meg nem?????**

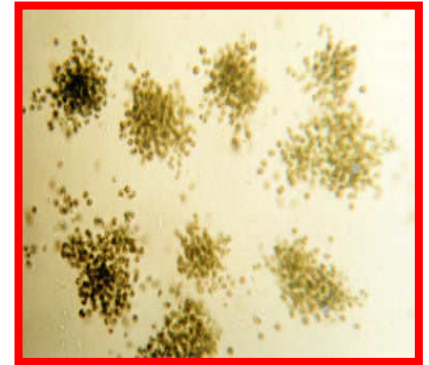


# *Microcystis* sp.



Farkas O, Gyemant Gy, Hajdu G, Gonda S, Parizsa P, Horgos T, Mosolygó Á, Vasas G  
Variability of microcystins and its synthetase gene cluster in *Microcystis* and *Planktothrix* waterblooms in shallow lakes of Hungary  
**ACTA BIOLOGICA HUNGARICA** 65:(2) pp. 1-10. (2014).

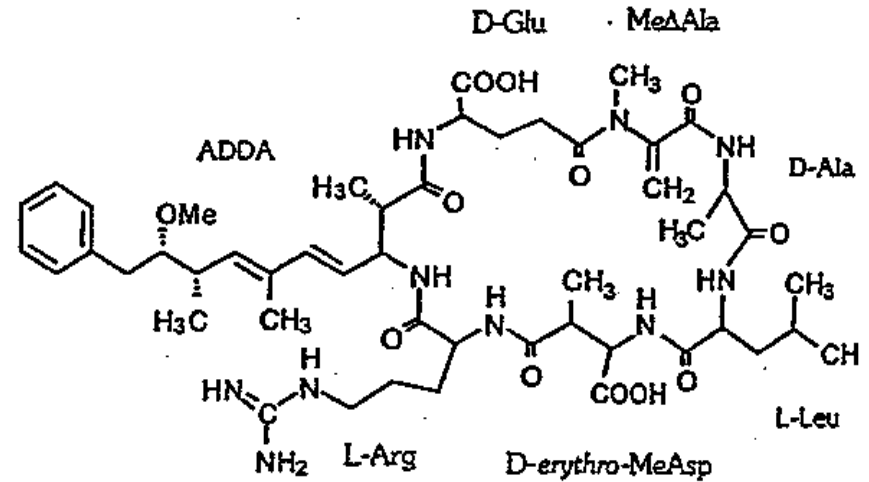
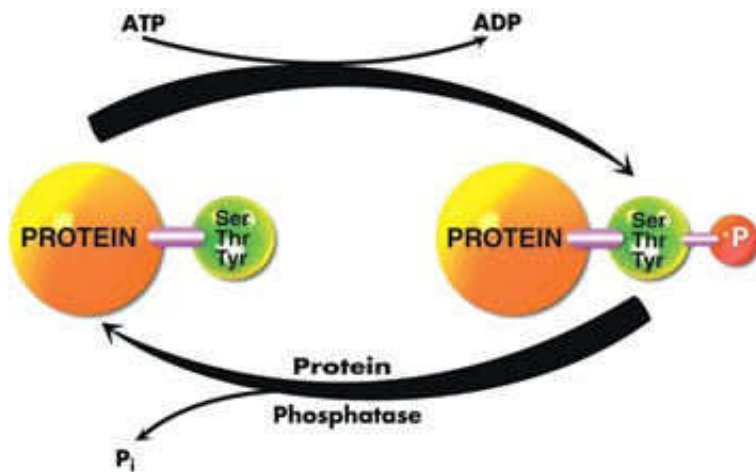
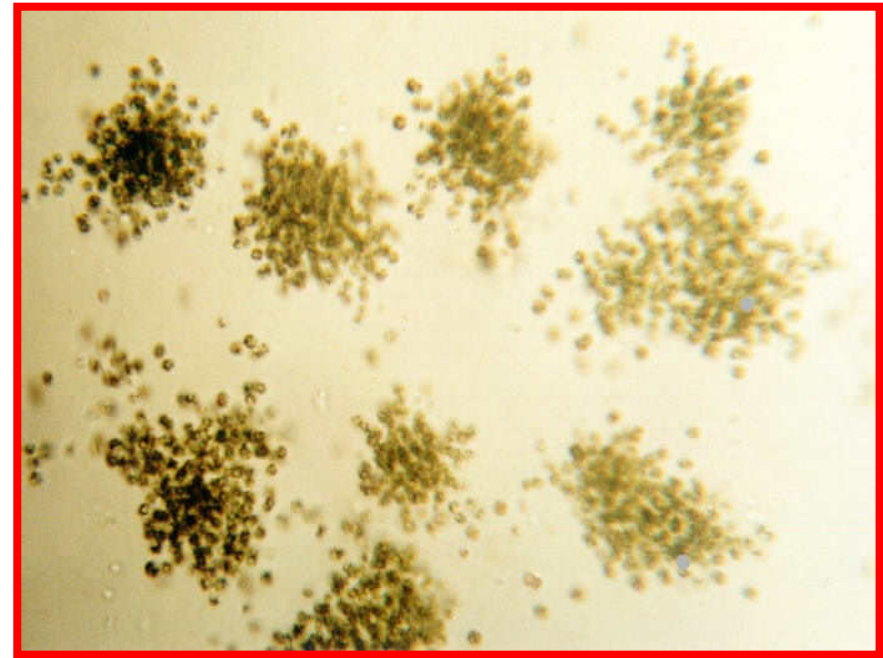
Bacsi I, Surányi G, Gonda S, Gyemant G, Vasas G  
Observation of Sward Destruction Caused by Irrigation with Toxic *Microcystis* Morphospecies Containing Water in Southern Hungary  
**BULLETIN OF ENVIRONMENTAL CONTAMINATION AND TOXICOLOGY** 86:(2) pp. 232-237. (2011)

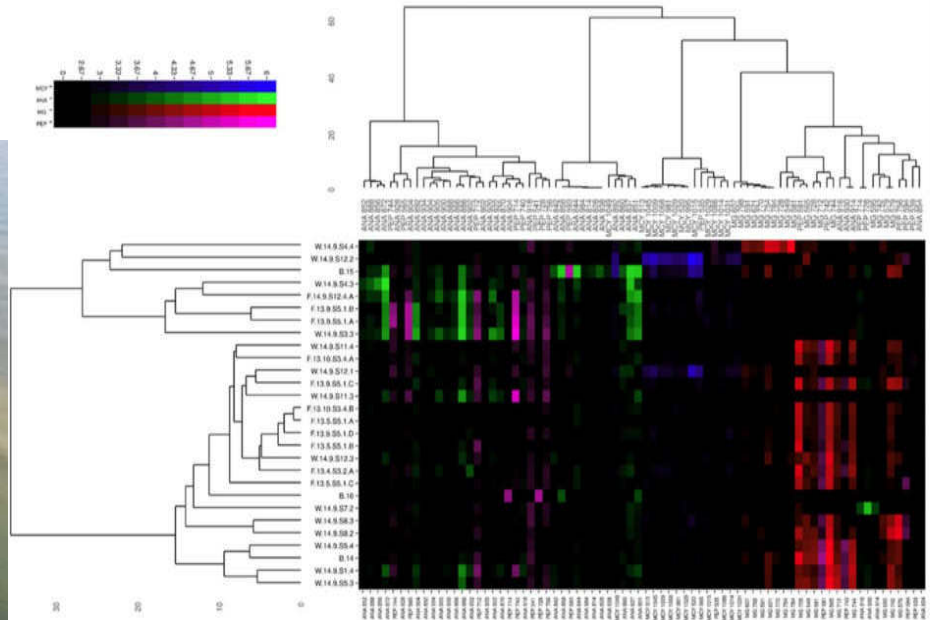
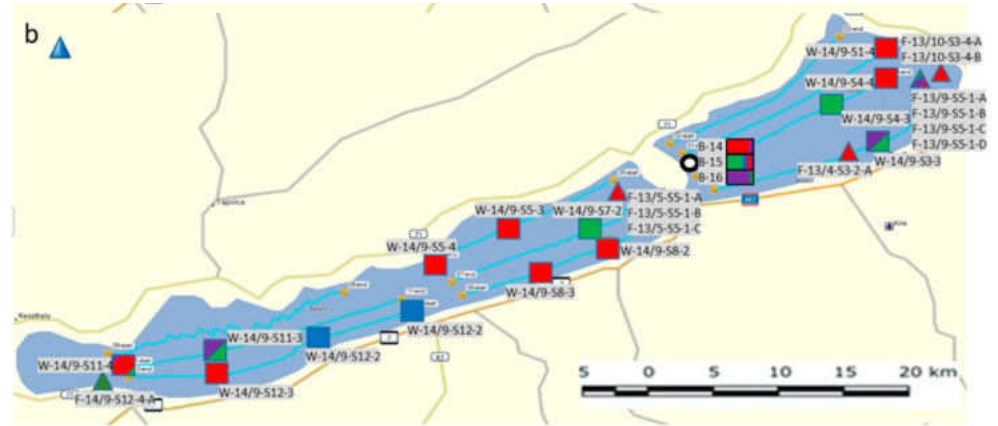


Vasas G, Bacsi I, Surányi G, Hamvas M M, Máthé C, Nagy S A, Borbély G  
Isolation of viable cell mass from frozen *Microcystis viridis* bloom containing microcystin-RR  
**HYDROBIOLOGIA** 639:(1) pp. 147-151. (2010)

## Microcisztinek

- főként a *Microcystis aeruginosa* termeli
- ciklikus heptapeptid
- az 1 és a 2A típusú, szerin-treonin protein foszfatázok specifikus inhibitora



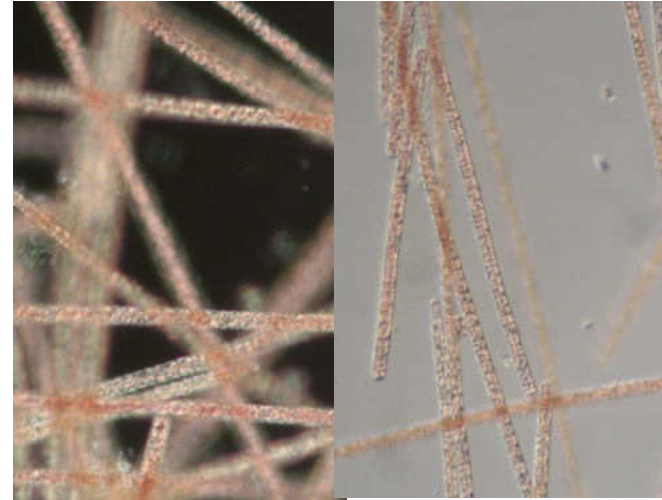


Riba, M., Kiss-Szicszai, A., Gonda, S., Boros, G., Vitál, Z., Borsodi, A. K., ... & Vasas, G. (2019). Microcystis chemotype diversity in the alimentary tract of bigheaded carp. *Toxins*, 11(5), 288.





# *Planktothrix rubescens* virágzás a Kocka tóban

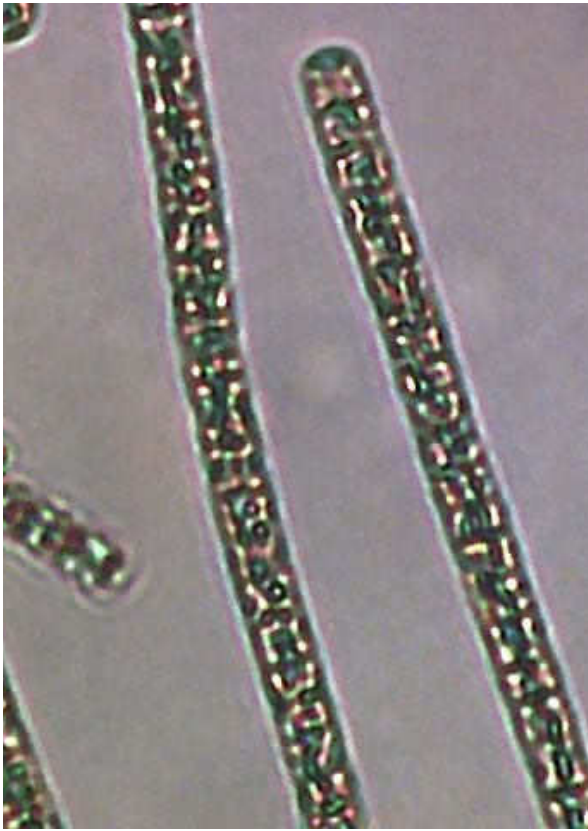




# *Planktothrix agardhii* és tömeges megjelenése

b.

a.

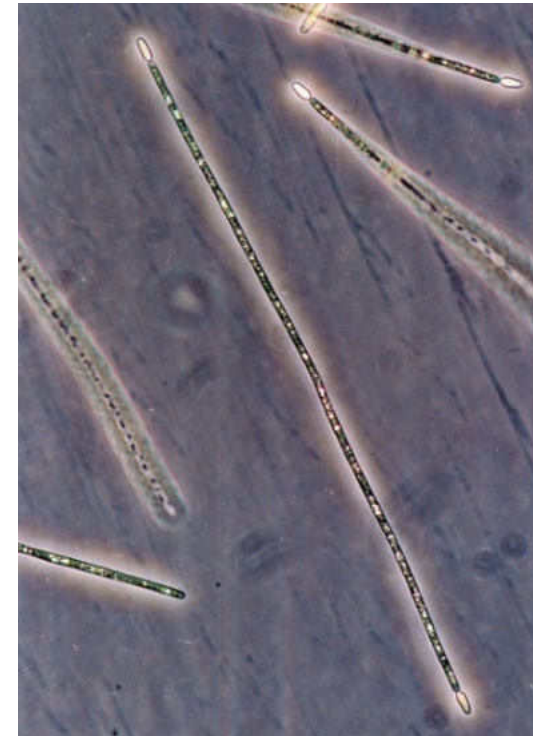


# *Raphidiopsis (Cylindrospermopsis) raciborskii*



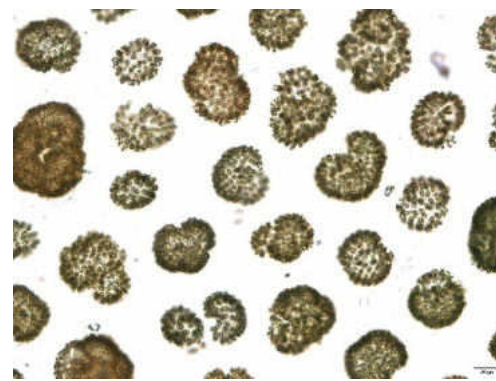
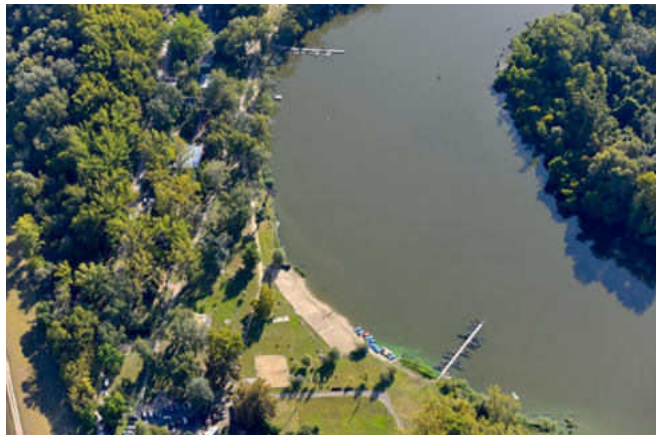
Fig. 2. Map of Hungary with the sampling sites. Symbols ● indicate localities where *C. raciborskii* strains were isolated/collected (1: Kis-Balaton reservoir, 2: Lake Balaton, 3: fish pond, Zamárdi, 4: Lake Szelidi, 5: fish pond, Doboz, 6: backwater, Endrőd, 7: ornamental pond, Debrecen, 8: reservoir Levelek). Symbol ○ indicates the locality where *A. ovalisporum* strain was isolated/collected (Lake Szelidi)

Species	Strain no.	Origin	PSgene/ PKSgene	CYN mg·g <sup>-1</sup>
<i>Cylindrospermopsis raciborskii</i>	BGSD-266*	Lake Balaton, Hungary	-/-	n.d.
<i>Cylindrospermopsis raciborskii</i>	BGSD-2000	Lake Balaton, Hungary	-/-	n.d.
<i>Cylindrospermopsis raciborskii</i>	BGSD-2001	Lake Balaton, Hungary	-/-	n.d.
<i>Cylindrospermopsis raciborskii</i>	BGSD-410	Kis-Balaton reservoir, Hungary	-/-	n.d.
<i>Cylindrospermopsis raciborskii</i>	BGSD-280	Lake Szelidi, Hungary	-/-	n.d.
<i>Cylindrospermopsis raciborskii</i>	AQS**	Australia	+/+	3.94
<i>Cylindrospermopsis raciborskii</i>	phytoplankton samples	fish pond Doboz, Hungary	-/-	n.d.
<i>Cylindrospermopsis raciborskii</i>	phytoplankton samples	backwater, Endrőd, Hungary	-/-	n.d.
<i>Cylindrospermopsis raciborskii</i>	phytoplankton samples	ornamental pond Debrecen, Hungary	-/-	n.d.
<i>Cylindrospermopsis raciborskii</i>	phytoplankton samples	fish pond Zamardi, Hungary	-/-	n.d.
<i>Cylindrospermopsis raciborskii</i>	phytoplankton samples	reservoir Levelek, Hungary	-/-	n.d.
<i>Aphanizomenon ovalisporum</i>	ILC-164***	Israel	+/+	4.78
<i>Aphanizomenon ovalisporum</i>	BGSD-300	Blanes, Spain	+/+	4.52
<i>Aphanizomenon ovalisporum</i>	BGSD-301	Lake Szelidi, Hungary	-/-	n.d.



# 2018. Mártély

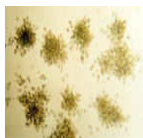
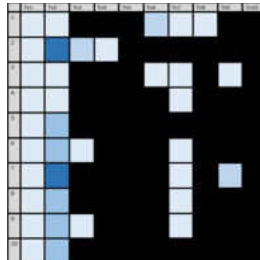
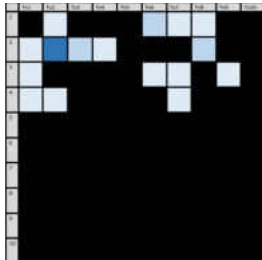
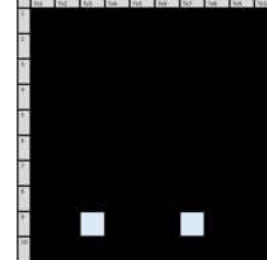
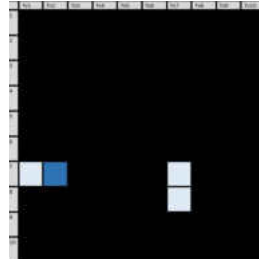
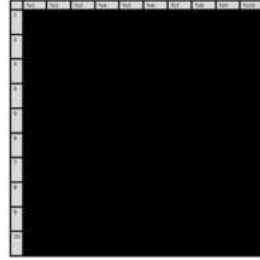
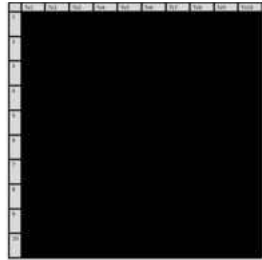
*Woronichinia* sp.



# Balatoni kékalga (cianobaktérium) izolátumok kemotípusai

Toxin(myc) variáns

Izolátum (10 db)



## 2022-es *Microcystis* virágzás

Ø

mikrocisztinek

ID-Asp3]MCY-LR	MCY-LR	MCY-HIR	MCY-FR	ID-Met1,D-Asp3]MC-LR	MCY-YR	MCY-WR	MCY-LW	MCY-RR	MCY-[H4]YR

mikroginek

MG_57	MG_91	MG_71	MG_71	MG_FR	CNST_	MG_73	CNST_	MG_76	MG_79
6	C	2	3B	5	A	9B	B	7	B
1,01E+06	8,27E+05	8,48E+05	7,47E+06	1,73E+06	1,62E+06	5,48E+07	8,73E+07	1,70E+06	

anabaenopeptinek

ANA_D	ANA_B	ANA_B	ANA_A	ANA_E	ANA_B	OSC_Y	ANA_B	ANA_9	ANA_9
		42		/F	52		86	0D	3D
4,14E+05	8,19E+06	9,01E+05	6,92E+06	1,85E+07	2,70E+05	1,73E+07			

- Ivóvíz: **X**
- Öntözővíz: **X**
  
- Dísztavak: **X X X**
- Fürdővíz: **X X X X**
- Halastavak, horgásztavak: **X X X X**



- A mérgező algavirágzások gyakorisága, kiterjedése nő világszerte
- Részben globális részben lokális okokra vezethető vissza
- Gazdasági, egészségügyi kockázat
- Hazai helyzet nem rosszabb/jobb, mint a régióban
- Balatonra és nagyobb vízterekre fokozottabb figyelemre lenne szükség
- Balaton esetében az elmúlt években a lokálisnak mondható tömeges alga megjelenések figyelmeztető jelzések



**KÖSZÖNÖM  
A  
FIGYELMET**

