

THROUGH THE STREETS OF KÖRMEND WITH MAGNIFYING GLASS IN HAND, ALWAYS STOPPING AT A PATCH OF GREENISH COLOUR

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Abstract: A total of 15 taxa of eukaryotic algae and cyanobacteria were identified on different surfaces in various artificial environments in the town of Körmend, W Hungary. The lowest possible taxonomic level was used to identify the organisms. The most common taxon was *Apatococcus lobatus*, which occurred in 6 out of 9 sampling sites. *Gloeocapsa novacekii*, *Gloeocapsopsis dvorakii*, and *Hassallia byssoidea*, which have rarely been mentioned in Hungary, were also common in Körmend. The green basal part of the Körmend Millennium Monument was found to be the most diverse habitat with 8 taxa. Research on terrestrial algae is important from both a scientific and a conservation standpoint, especially given the ongoing global biodiversity crisis. Contributing with new data to the knowledge on microbial diversity would help to better understand and protect terrestrial microbial communities.

Key words: *Apatococcus*, artificial surfaces, *Gloeocapsa*, statue, terrestrial algae

INTRODUCTION

For as long as the world has existed, terrestrial algae have played an important role in fundamental geological processes such as the weathering of rocks. While they are active in the formation and transformation of soil and sediment, we see the positive side of their activities as the focus of human attention. However, when they act on rock art of artistic or historical importance, especially on buildings and monuments (POPOVIĆ *et al.* 2018), we see them as obviously harmful from an aesthetic point of view. There are many examples around the world of how terrestrial algae cause aesthetic damage to cultural heritage, such as Angkor temples, Cambodia (BARTOLI *et al.* 2014); Pompeii, Italy (TRAVERSETTI *et al.* 2018) or the Hieroglyphic Stairway in Copán, Honduras (CANEVA *et al.* 2005).

Various types of substrates such as stone, concrete, tree bark or soil are favourable to different microorganisms. As they grow, they can change the chemical and mineralogical composition of the original rock by altering its stability, permeability, colour, and density (KOVÁČIK 2000).

The susceptibility of stones and rocks to organisms is referred to as bioreceptivity (GUILLITTE 1995). Rather than differences in rock chemistry and mineral composition, it is the high open porosity, capillary water content, surface roughness, and pH of surface erosion that promote the growth of phototrophic biofilms (PINNA 2021). In addition, many factors affect the colonisation of cyanobacteria and algae in terrestrial environments, such as water (humidity), temperature, light, pH, and UV radiation (NOWICKA-KRAWCZYK *et al.* 2022). To survive and thrive in terrestrial environments, terrestrial algae have different cellular adaptations and life mechanisms (NOWICKA-KRAWCZYK *et al.* 2022, TERLOVA *et al.* 2021). In contrast to aquatic habitats, they form biofilms (endo- and epilithic) on terrestrial surfaces, produce various protective biomolecules and extracellular matrices, and alter cell volume in response to desiccation, UV radiation, and high/low temperature fluctuations (KARSTEN *et al.* 2007, LEVIN *et al.* 2023).

There are an increasing number of articles on the extensive, colourful reproduction of subaerial algae species on monuments or other buildings of high architectural value (LIU *et al.* 2020, PURBANI *et al.* 2020). The composition of the emerging biofilm communities depends on the geographical area and climatic zone, mainly consisting of cyanobacteria in warmer regions and eukaryotic microalgae in temperate regions (KARSTEN *et al.* 2007, NOWICKA-KRAWCZYK *et al.* 2022). There is also an increase in the number of articles on how to control them, as they cause aesthetically unacceptable discolouration of buildings, sculptures or monuments (DE LUCA *et al.* 2024, NOWICKA-KRAWCZYK *et al.* 2019). However, in order to defend against them, we must first know what there is.

Despite the appropriate climatic conditions and environmental factors, relatively few articles have been published recently on the distribution of terrestrial algae in Hungary (T-KRASZNAI *et al.* 2023). Therefore, our aim was to contribute to filling this gap. The study of the flora and fauna of the plains of the river Rába in the surroundings of Körmend has been ongoing since the 1990s. Several summary studies have been published on the plants (BALOGH 2023, SZINETÁR 1994a, b) and the insect (NAGY 2021) or spider (KOVÁCS *et al.* 2012) fauna. However, the algal flora of the terrestrial habitats has not been investigated so far. Here, we report on aerial cyanobacteria and algae flora on the surface of buildings and sculptures from different parts of Körmend.

MATERIAL AND METHODS

The samples were collected from 9 different locations in Körmend, Hungary on 24.07.2024 (Fig. 1). Samples were taken with toothbrushes from a variety of artificial environments, such as statues, walls and gates as well as various surfaces, including concrete, limestone, cement walls, plastic, and metal (see Fig. 2, Table 1).

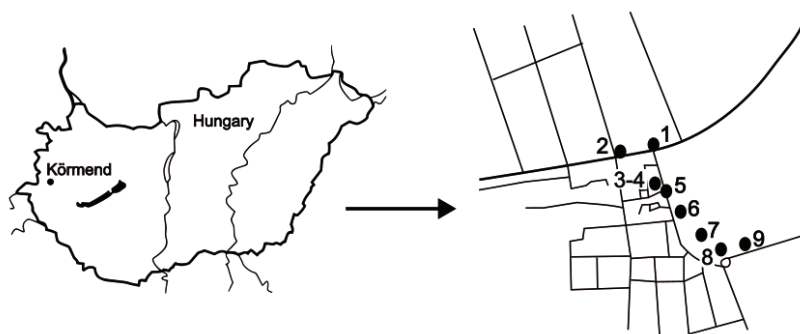


Fig. 1. The map of sampling area in Körmend, Hungary. The numbers indicate the sampling locations (see Table 1 for more details).



Fig. 2. Photos of some sampling points in Körmend. The numbers indicate the sampling locations (see Table 1 for more details).

Table 1. List of sampling sites and the nature of habitat.

No.	Place of collection	Substrata	Colour
1	Rákóczi street, cement wall in front of shop	cement wall	green
2	J. Vida street underpass edge	concrete	green
3	Körmend Millennium Monument, red part	limestone	red
4	Körmend Millennium Monument, base	limestone	green
5	Faludi Ferenc Library in Körmend, northern wall	concrete	red
6	Dr Batthyányi street, utility box	plastic	green
7	The gate of Körmend Castle	metal	green
8	Körmendi Children’s Library, northern wall	cement wall	green
9	Unrestored western wall of the guardhouse of Körmend Castle	concrete	brown

Table 2. List of cyanobacteria and algae identified in the sampling points in Körmend, Hungary.
The numbers indicate the sampling locations (see Table 1 for more details).

Species name	1	2	3	4	5	6	7	8	9
Cyanobacteria									
<i>Hassallia byssoidea</i> Hassall ex Bornet et Flahault				+	+				+
<i>Gloeocapsa novacekii</i> Komárek et Anagnostidis			+	+	+				+
<i>Gloeocapsopsis</i> cf. <i>dvorakii</i> (Nováček) Komárek et Anagnostidis ex Komárek			+	+	+				
cf. <i>Gloeocapsopsis</i> sp.	+								
<i>Microcoleus</i> sp.				+					
<i>Nostoc commune</i> Vaucher ex Bornet et Flahault									+
cf. <i>Nostoc</i> sp.				+					
<i>Phormidium</i> sp.				+					
Chlorophyta									
<i>Apatococcus lobatus</i> (Chodat) J. B. Petersen	+	+		+		+	+	+	
<i>Stichococcus</i> cf. <i>bacillaris</i> Nägeli	+								
cf. <i>Trentepohlia</i> sp.			+		+				
Charophyta									
<i>Klebsormidium</i> sp.				+					
Heterokontophyta									
<i>Achnanthes</i> sp.	+								
<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow									+
cf. <i>Pinnularia</i> cf. <i>borealis</i> Ehrenberg									+
Total species number	4	1	3	8	4	1	1	1	5

The fresh samples were immediately studied with a Zeiss Axio Observer 7 inverted microscope at 100–630× magnification. The species observed were documented using a Canon EOS R6 digital camera. Organisms were identified at the lowest possible taxonomic level. Most recent accepted name of taxa was considered by AlgaeBase (GUIRY and GUIRY 2025). The morphological features of the cells, colonies and thalli were used to identify cyanobacteria and algae.

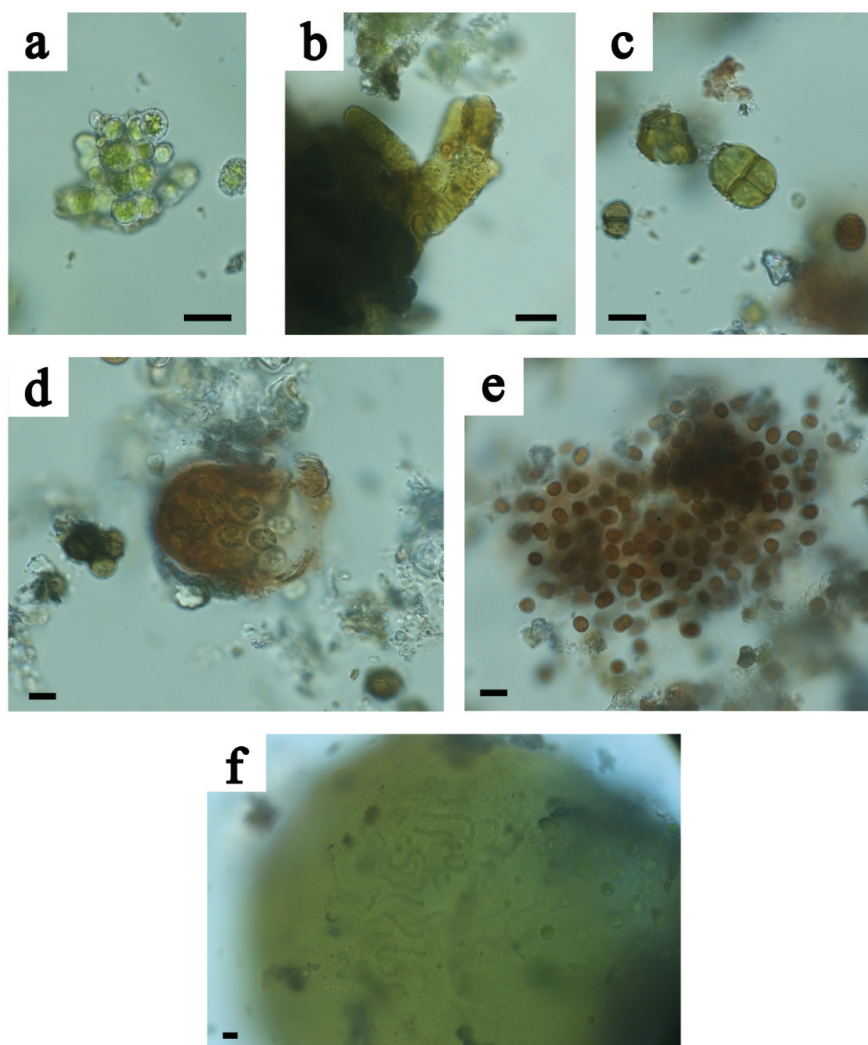


Fig. 3. Photos of the terrestrial species in Körmend – a) *Apatococcus lobatus* (Chodat) J. B. Petersen; b) *Hassallia byssoidea* Hassall ex Bornet et Flahault; c) *Gloeocapsopsis dvorakii* (Nováček) Komárek et Anagnostidis ex Komárek; d–e) *Gloeocapsa novacekii* Komárek et Anagnostidis; f) *Nostoc commune* Vaucher ex Bornet et Flahault. Scale bar 10 µm.

RESULTS

A total of 15 eukaryotic algae and cyanobacteria taxa were identified at genus or species level from the different substrata and localities (Table 2). The Cyanobacteria was the most diverse group with 8 taxa, while 3–3 taxa of Chlorophyta and Heterokontophyta were recorded, respectively. Only one taxon of Charophyta occurred in the samples.

The most abundant taxon, *Apatococcus lobatus* (Chodat) J. B. Petersen, occurred at 6 sampling sites (Fig. 3a). *Gloeocapsa novacekii* Komárek et Anagnostidis (Fig. 3d–e), *Gloeocapsopsis dvorakii* (Nováček) Komárek et Anagnostidis ex Komárek (Fig. 3c), and *Hassallia byssoidea* Hassall ex Bornet et Flahault (Fig. 3b) were also common in two different parts of Körmend (sampling sites 3–5 and 9; Fig. 1). The other species occurred only at 1–1 sampling site.

The base of the Körmend Millennium Monument was the most diverse habitat with 8 taxa. Four of the 9 sampling sites were dominated by only one species (*Apatococcus lobatus*) (Table 2).

The samples taken from the green patches of the cement wall, limestone, plastic, metal, and concrete surfaces (Fig. 2; site 1, 2, 6, 7, 8) were dominated by *Apatococcus lobatus*. The green patches at the base of the Millennium Monument in Körmend were more species-rich than the other green patches.

Species that were previously rarely mentioned in Hungary, such as *Gloeocapsa novacekii* and *Gloeocapsopsis dvorakii* as well as *Hassallia byssoidea* were common in red surface samples.

The taxa *Hantzschia amphioxys* (Ehrenberg) Grunow, *Pinnularia* cf. *borealis* Ehrenberg, and *Nostoc commune* Vaucher ex Bornet et Flahault (Fig. 3f), which were identified in samples from the brownish surface of the unrestored western wall of the guardhouse of Körmend Castle, were not found at other sites (Fig. 2, site 9).

DISCUSSION

Terrestrial algae are a special group within the algae groups that have adapted to desiccation and extreme environments (NOWICKA-KRAWCZYK *et al.* 2022), which can be harsher than those found in aquatic habitats. They are often found in shaded micro-environments that offer some protection from the weather, such as pavements, old buildings, soil surfaces, rocks, and ancient built structures. The species composition and diversity of these habitats are mainly determined by microclimatic factors such as humidity and desiccation as well as surface properties (MACEDO *et al.* 2009; RINDI and GUIRY 2004).

Our results show that the algal assemblage collected in different parts of Körmend is characterised by a generally low diversity. The study identified fifteen

species of algae and cyanobacteria at the lowest possible level of identification. Those species that could not be identified are not mentioned. The taxa occurred on a variety of substrates and in various locations, forming patches of different colours.

The number of species we found (15 taxa) is considered to be average compared to the number of species published in surveys (10 taxa – LJALJEVIĆ-GRBIĆ *et al.* 2010; 18 taxa – POPOVIĆ *et al.* 2018; 17 taxa – RINDI and GUIRY 2004; 25 taxa – UHER 2008). However, in larger surveys, the number of species may exceed 50–100 species (47 taxa – SAMAD and ADHIKARY 2008; 172 taxa – MACEDO *et al.* 2009). In terrestrial environments, it is not unusual for a biofilm to be formed by only a few species, or even just a single species. GARTNER and STOYNEVA (2003) found that the green layers were formed only by *Apatococcus lobatus*. The green microalga *Apatococcus lobatus* is widely distributed in terrestrial habitats. It can be found throughout many climatic zones (GUSTAVS *et al.* 2016). This is supported by our results, there were sites such as surfaces of cement wall, plastic, metal, and concrete, where only *A. lobatus* was present.

Only a few taxa found by us are mentioned in the most recent database of algae and cyanobacteria in Hungary (GÖRGÉNYI *et al.* 2023; NÉMETH and BUCZKÓ 2024; T-KRASZNAI *et al.* 2023). Of the species identified herein, the coccoid cyanobacteria *Gloeocapsa novacekii* was previously mentioned only from Debrecen, Hungary (T-KRASZNAI *et al.* 2023). Its occurrence in Körmend is not only new, but also the second distribution data for Hungary. Two records of the filamentous cyanobacterium *Hassallia byssoidea* were previously published from Hungary: one from Kiskunság (KOMÁROMY and PADISÁK 1999), and one from Debrecen (T-KRASZNAI *et al.* 2023). Its occurrence in Körmend represents a new distribution data set for Hungary. *Gloeocapsopsis dvorakii*, a coccoid cyanobacterium, is also a rare species in Hungary. To the best of our knowledge, it is new to the Hungarian algae flora. It was described as *Gloeocapsa dvorakii* Nováček in 1929. This aerophytic species can be distinguished from other *Gloeocapsopsis* species by its rusty-red or orange-red sheaths.

In the shadow of the global biodiversity crisis and mass extinctions, the importance of biodiversity conservation is becoming increasingly apparent (COWIE *et al.* 2022). Even in aquatic environments, the biodiversity of microorganisms is still a neglected area, thus relatively little is known about the diversity and biogeography of terrestrial algae. Despite systematic research conducted by some countries on these algal groups, they are considered understudied at the global level (HAUER 2007, HAUER *et al.* 2015). However, species-level identification of terrestrial algae is often difficult because of the high morphological similarity of species (RINDI and GUIRY 2004). Although genetic tests (e.g. DNA-based identification) can help to improve identification (JUSKO and JOHANSEN 2024,

NGUYEN *et al.* 2017), these can be costly and adequate financial support is often lacking. A further limitation is that the coverage of databases is not yet complete, so that many sequences appear only as “barcodes” without species names. Nevertheless, there are species that can be identified even by light microscopy at genus or even species level. We believe that these types of experiments, even if incomplete, are more useful than the complete absence of data.

In conclusion, research on terrestrial algae is important both scientifically and for conservation, especially in the current biodiversity crisis. Filling the gap in our knowledge of terrestrial algae could improve our understanding of terrestrial microbial communities and help to conserve them.

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Összefoglaló: Magyarország nyugati részén található Körmend városának különböző mesterséges felületeiről összesen 15 eukarióta alga és cianobaktérium taxont azonosítottunk. Az élőlények azonosítása a lehető legalacsonyabb rendszertani szinten történt. A leggyakoribb taxon az *Apatococcus lobatus* zöldalga faj volt, amely a 9 mintavételi helyből 6 helyen fordult elő. A hazánkban ritkán említett *Gloeocapsa novacekii*, *Gloeocapsopsis dvorakii*, *Hassallia byssoidea* szintén gyakoriak voltak Körmenden. A Körmendi Millenniumi Emlékmű alsó része volt a legváltozatosabb élőhely 8 taxonnal. *Gloeocapsopsis dvorakii* új adat Magyarország flórájára. A szárazföldi algák kutatása mind tudományos, mind természetvédelmi szempontból fontos, különösen a napjainkban is zajló biodiverzitás-válság miatt. A tudáshiány bárminemű csökkentése hozzájárul a szárazföldi mikrobiális közösségek jobb megértéséhez és védelméhez.

REFERENCES

- BALOGH, L. (2023): Overview of the research history of the higher flora of Vas County (Western Hungary). – *Acta Biol. Plant. Agriens.* **11**(1): 158–192. <https://doi.org/10.21406/abpa.2023.11.1.158>
- BARTOLI, F., MUNICCHIA, A. C., FUTAGAMI, Y., KASHIWADANI, H., MOON, K. H. and CANEVA, G. (2014): Biological colonization patterns on the ruins of Angkor temples (Cambodia) in the biodeterioration vs bioprotection debate. – *Int. Biodeterior. Biodegradation* **96**: 157–165.
- CANEVA, G., SALVADORI, O., RICCI, S. and CESCHIN, S. (2005): Ecological analysis and biodeterioration processes over time at the Hieroglyphic Stairway in the Copán (Honduras) archaeological site. – *Plant Biosyst.* **139**(3): 295–310. <https://doi.org/10.1080/11263500500343353>
- COWIE, R. H., BOUCHET, P. and FONTAINE, B. (2022): The sixth mass extinction: fact, fiction or speculation? – *Biol. Rev.* **97**(2): 640–663. <https://doi.org/10.1111/brv.12816>

- DE LUCA, D., PIREDDA, R., SCAMARDELLA, S., MARTELLI CASTALDI, M., TROISI, J., LOMBARDI, M., DE CASTRO, O. and CENNAMO, P. (2024): Taxonomic and metabolic characterisation of biofilms colonising Roman stuccoes at Baia's thermal baths and restoration strategies. – *Sci. Rep.* **14**(1): 26290, <https://doi.org/10.1038/s41598-024-76637-x>
- GARTNER, G. and STOYNEVA, M. P. (2003): First study of aerophytic cryptogams on monuments in Bulgaria. – *Ber. Naturwiss.-med. Ver. Innsb* **90**: 73–82.
- GÖRGÉNYI, J., KRASZNAI, E., ÁCS, É., KISS, K. T., BOTTA-DUKÁT, Z., VÉGVÁRI, Z., LUKÁCS, Á., B-BÉRES, V., KÓKAI, Zs., TÓTHMÉRÉSZ, B. and BORICS, G. (2023): Rarity of microalgae in macro, meso, and microhabitats. – *Inland Waters* **13**(2): 231–246. <https://doi.org/10.1080/20442041.2022.2152247>
- GUILLITTE, O. (1995): Bioreceptivity: a new concept for building ecology studies. – *Sci. Total Environ.* **167**(1–3): 215–220.
- GUIRY, M. D. and GUIRY, G. M. (2025): *AlgaeBase*. – World-wide electronic publication, University of Galway. <https://www.algaebase.org>; searched on 2025. június 17.
- GUSTAVS, L., SCHUMANN, R., KARSTEN, U. and LORENZ, M. (2016): Mixotrophy in the terrestrial green alga *Apatococcus lobatus* (Trebouxiophyceae, Chlorophyta). – *J. Phycol.* **52**(2): 311–314. <https://doi.org/10.1111/jpy.12381>
- HAUER, T. (2007): Rock-inhabiting cyanoprokaryota from South Bohemia (Czech Republic). – *Nova Hedwigia* **85**(3): 379–392. <https://doi.org/10.1127/0029-5035/2007/0085-0379>
- HAUER, T., MÜHLSTEINOVÁ, R., BOHUNICKÁ, M., KAŠTOVSKÝ, J. and MAREŠ, J. (2015): Diversity of cyanobacteria on rock surfaces. – *Biodivers Conserv* **24**: 759–779. <https://doi.org/10.1007/s10531-015-0890-z>
- JUSKO, B. M. and JOHANSEN, J. R. (2024): Description of six new cyanobacterial species from soil biocrusts on San Nicolas Island, California, in three genera previously restricted to Brazil. – *J. Phycol.* **60**(1): 133–151. <https://doi.org/10.1111/jpy.13411>
- KARSTEN, U., SCHUMANN, R. and MOSTAERT, A. (2007): *Aeroterrestrial algae growing on man-made surfaces*. – In: SECKBACH, J. (ed.): *Algae and cyanobacteria in extreme environments. Cellular origin, life in extreme habitats and astrobiology*, vol. 11. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-6112-7_32
- KOMÁROMY, P. Z. and PADISÁK, J. (1999): *The soil algal flora of the Kiskunság National Park and the surrounding regions*. – In: LŐKÖS, L. and RAJCZY, M. (eds): *The Flora of the Kiskunság National Park II. Cryptogams*. Hungarian Natural History Museum, Budapest, pp. 147–165.
- KOVÁČIK, L. (2000): *Cyanobacteria and algae as agents of biodeterioration of stone substrata of historical buildings and other cultural monuments*. – In: CHOI, S. and SUH, M. (eds): *Proceedings of the New Millenium International Forum on Conservation of Cultural Property*, Daejeon, Korea, pp. 44–58.
- KOVÁCS, P., SZINETÁR, Cs. and SZÚTS, T. (2012): A nyugat-magyarországi peremvidék (Győr-Moson-Sopron, Vas és Zala megyék) pókfaunája. – *A Nyme Savaria Egyetemi Központ Tudományos Közleményei XIX. Természettudományok* **14**: 165–229.
- LEVIN, G., YASMIN, M., LIVEANU, V., BURSTEIN, C., HANNA, R., KLEIFELD, O., SIMANOWITZ, M. C., MEIR, A., TADMOR, Y., HIRSCHBERG, J., ADIR, N. and SCHUSTER, G. (2023): A desert *Chlorella* sp. that thrives at extreme high-light intensities using a unique photoinhibition protection mechanism. – *Plant J.* **115**(2): 510–528. <https://doi.org/10.1111/tpj.16241>
- LIU, X., KOESTLER, R. J., WARSCHIED, T., KATAYAMA, Y. and GU, J. D. (2020): Microbial deterioration and sustainable conservation of stone monuments and buildings. – *Nat Sustain* **3**: 991–1004. <https://doi.org/10.1038/s41893-020-00602-5>
- LJALJEVIĆ-GRBIĆ, M., VUKOJEVIĆ, J., SUBAKOV-SIMIĆ, G., KRIZMANIĆ, J. and STUPAR, M. (2010): Biofilm forming cyanobacteria, algae and fungi on two historic monuments in Belgrade, Serbia. – *Arch. Biol. Sci.* **62**(3): 625–631. <https://doi.org/10.2298/ABS1003625L>

- MACEDO, M. F., MILLER, A. Z., DIONÍSIO, A. and SAIZ-JIMENEZ, C. (2009): Biodiversity of cyanobacteria and green algae on monuments in the Mediterranean Basin: an overview. – *Microbiol.* **155**(11): 3476–3490. <https://doi.org/10.1099/mic.0.032508-0>
- NAGY, F. (2021): Vas megye futóbogár faunája, II. (Coleoptera: Carabidae). – *e-Acta Nat. Pannon.* **21**: 1–264.
- NÉMETH, J. and BUCZKÓ, K. (2024): Cyanobacteria of protected areas in Hungary until 2004. – *Studia bot. hung.* **55**(1). <https://doi.org/10.17110/StudBot.2024.55.1.5>
- NGUYEN, X. H., SUMIMOTO, S. and SUDA, S. (2017): Unexpected high diversity of terrestrial cyanobacteria from the campus of the University of the Ryukyus, Okinawa, Japan. – *Microorganisms* **5**(4): 69. <https://doi.org/10.3390/microorganisms5040069>
- NOWICKA-KRAWCZYK, P., ŻELAZNA-WIECZOREK, J., KOZIRÓG, A., OTLEWSKA, A., RAJKOWSKA, K., PIOTROWSKA, M., GUTAROWSKA, B. and BRYCKI, B. (2019): Multistep approach to control microbial fouling of historic building materials by aerial phototrophs. – *Biofouling* **35**(3): 284–298.
- NOWICKA-KRAWCZYK, P., KOMAR, M. and GUTAROWSKA, B. (2022): Towards understanding the link between the deterioration of building materials and the nature of aerophytic green algae. – *Sci. Total Environ.* 802, <https://doi.org/10.1016/j.scitotenv.2021.149856>.
- PINNA, D. (2021): *Microbial growth and its effects on inorganic heritage materials*. – In: JOSEPH, E (ed.): *Microorganisms in the deterioration and preservation of cultural heritage*. Springer Cham, pp. 3–35.
- POPOVIĆ, S., STUPAR, M., UNKOVIĆ, N., SUBAKOV SIMIĆ, G. and LJALJEVIĆ GRBIĆ, M. (2018): Diversity of terrestrial cyanobacteria colonizing selected stone monuments in Serbia. – *Stud. Conserv.* **63**(5): 292–302. <https://doi.org/10.1080/00393630.2018.1438127>
- PURBANI, D. C., PUTRI, A. L. and HABIBI, M. (2020): Epilithic microalgae isolated from biofilm on Borobudur temple stone. – *J. Trop. Biodiv. Biotechnol.* **5**(03): 239–246. [10.22146/jtbb.59216](https://doi.org/10.22146/jtbb.59216)
- RINDI, F. and GUIRY, M. D. (2004): Composition and spatial variability of terrestrial algal assemblages occurring at the bases of urban walls in Europe. – *Phycologia* **43**(3): 225–235. <https://doi.org/10.2216/i0031-8884-43-3-225.1>
- SAMAD, L. K. and ADHIKARY, S. P. (2008): Diversity of micro-algae and cyanobacteria on building facades and monuments in India. – *Algae* **23**(2): 91–114. <https://doi.org/10.4490/ALGAE.2008.23.2.091>
- SZINETÁR, M. (1994a): Körmend élővilága. (Die Naturwelt von Körmend). – *Vasi Szemle* **48**(2): 205–221.
- SZINETÁR, M. (1994b): *Körmend és környékének élővilága*. – Oskar Kiadó, Szombathely, 54 pp.
- TERLOVA, E. F., HOLZINGER, A. and LEWIS, L. A. (2021): Terrestrial green algae show higher tolerance to dehydration than do their aquatic sister-species. – *Microb. Ecol.* **82**(3): 770–782. <https://doi.org/10.1007/s00248-020-01679-3>
- T-KRASZNAI, E., NEMES-KÓKAI, Z., BUCZKÓ, K. and B-BÉRES, V. (2023): Some terrestrial algae on the surface of buildings in Debrecen, Hungary. – *Studia bot. hung.* **54**(2): 113–123. <https://doi.org/10.17110/StudBot.2023.54.2.113>
- TRAVERSETTI, L., BARTOLI, F. and CANEVA, G. (2018): Wind-driven rain as a bioclimatic factor affecting the biological colonization at the archaeological site of Pompeii, Italy. – *Int. Biodeterior. Biodegradation* **134**: 31–38. <https://doi.org/10.1016/j.ibiod.2018.07.016>
- UHER, B. (2008): Spatial distribution of cyanobacteria and algae from the tombstone in a historic cemetery in Bratislava, Slovakia. – *Fottea* **9**(1): 81–92. <https://doi.org/10.5507/for.2009.007>

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