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CYANOPHYTA AND ALGAE AS AN IMPORTANT COMPONENT OF BIOLOGICAL CRUST FROM THE PUSTYNIA BŁĘDOWSKA DESERT (POLAND)

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Abstract: This research on the algae flora of the sandy area of the Pustynia Błędowska desert is the first study of eupsammonic algae in this desert. This paper reports eleven species of algal taxa: six Cyanophyta, one Heterokontophyta and three Chlorophyta found in the Pustynia Błędowska desert. Most of them are reported from soil and sand habitat for the first time, and two species, *Klebsormidium crenulatum* (Kütz.) H. Ettl & G. Gärtner and *Stichococcus chlorelloides* Grintzesco & L. S. Péterfi, are new records for the flora of Poland. Illustrations, taxonomic information and biogeographical data are given for each species.

Key words: Cyanophyta, Heterokontophyta, Chlorophyta, Pustynia Błędowska desert, Poland

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INTRODUCTION

Algae occurring on sands and soils are poorly studied in Poland as in the rest of the world. The present study of algal flora of the sandy area of the Pustynia Błędowska desert is the first research on eupsammonic algae in this desert. Earlier, Rahmonov (1999, 2001) and Szczypek *et al.* (1984) published a few data on the role of algae in succession processes and their influence on the composition of the biological soil crust of the Pustynia Błędowska desert. The authors treated algae as a systematic group of plants, however, and did not give specific identifications, precise descriptions or iconographic documentation.

STUDY AREA

The Pustynia Błędowska desert is a man-made sandy area. Its origin is related to past industrial activity, mainly extensive mining and metallurgy of zinc and lead ore deposits dating back to early medieval times. The desert is located in an area of Vistulian glaciofluvial and fluvial sands in the eastern Silesian Upland (Fig. 1). Since the second half of the nineteenth century this area of drift sands has been characterized by geographers as the largest one of its kind in Poland (up to 30 km^2) and one of the largest in Europe, where sandy hills are not covered with plants (Szczypek *et al.* 1994).

The Pustynia Błędowska desert is a one of the most interesting types of landscape not only in Poland but also in the whole of Europe. Unfortunately, conditions in the desert have been changing in recent years. Vegetation is covering an increasingly greater part of its surface. It is naturally subdivided into northern and southern parts separated by the Biała Przemsza River (Fig. 1). Presently, the sandy part of the study area shows fragmented overgrowth by dry coniferous forest (*Cladonio-Pinetum*), an initially fresh coniferous forest (*Leucobryo-Pinetum*) and a community with *Salix acutifolia* Willd. and *Salix arenaria* L. Psammophilous communities (e.g., *Spergulo morisonii-Corynephoretum canescentis* and *Festuco-Koelerietum glaucae*) have settled the open areas, and loose sands and sinks are occupied by algocoenoses (Rahmonov 2002).

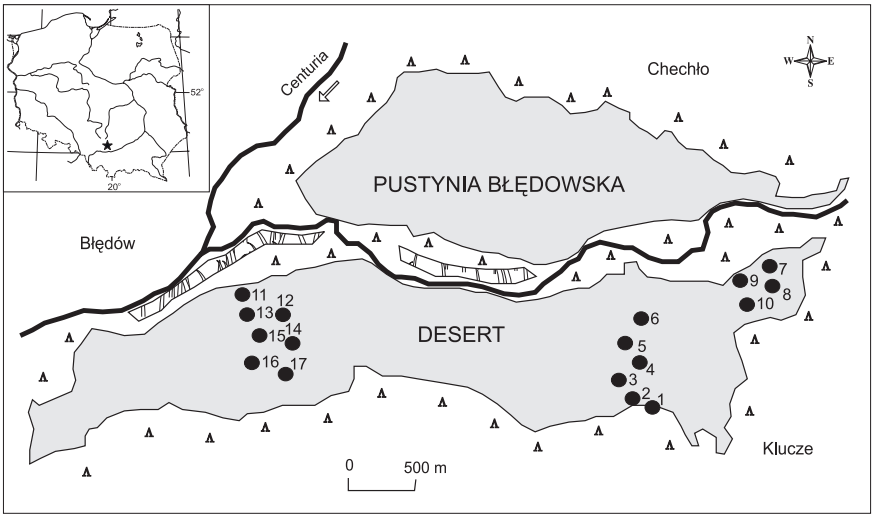


Fig. 1. Location of the study area. 1–17 – collection sites.

Material and methods

The material was collected at 17 localities in the southern part of the Pustynia Błędowska desert (Fig. 1) in June and October 2001 and in April and May 2002, and was taken to the laboratory in Petri dishes. All measurements, descriptions, illustrations, micrographs and observations were made from live material. An Amplival Carl Zeiss Jena light microscope was used for studies. Original drawings were made with the aid of a camera lucida, and micrographs were prepared with a Zeiss automatic photographic system. Data on the distribution of algae were obtained from the Iconotheca of Algae of the Department of Phycology, W. Szafer Institute of Botany, Polish Academy of Sciences in Kraków.

List of taxa

CYANOPHYTA

Chroococcus minor (Kütz.) Nägeli (Fig. 2)

Ref. Starmach 1966 (Figs 140 & 141: 123–125).

Description. Colonies small, gelatinous, with cells in groups of 2–4, mucilage colorless. Cells spherical, 3.3–4.5 μm in diameter.

Habitats. Freshwater environments, especially shallow ponds and slow-flowing streams with submerged macrophytes, wet rocks, trees, walls and plankton. *Chroococcus minor* is reported for the first time from sand as a eupsammonic taxon.

Distribution. A common species all over the world. In Poland known from Silesia (Kirchner 1878), Przywidz (Mariensees) (Lakowitz 1931) and Goczałkowice (Krzyżanek & Krzyżanek 1986).

Chroococcus minutus (Kütz.) Nägeli (Fig. 3)

Ref. John *et al.* 2002 (Fig. 3F: 40)

Description. Colonies small, usually 2–8 celled, cells sometimes solitary, spherical or ovoid in shape, sometimes more irregular. Cells spherical in shape, 4–6 μm in diameter, with a wide (4.1–4.5 μm), colorless sheath.

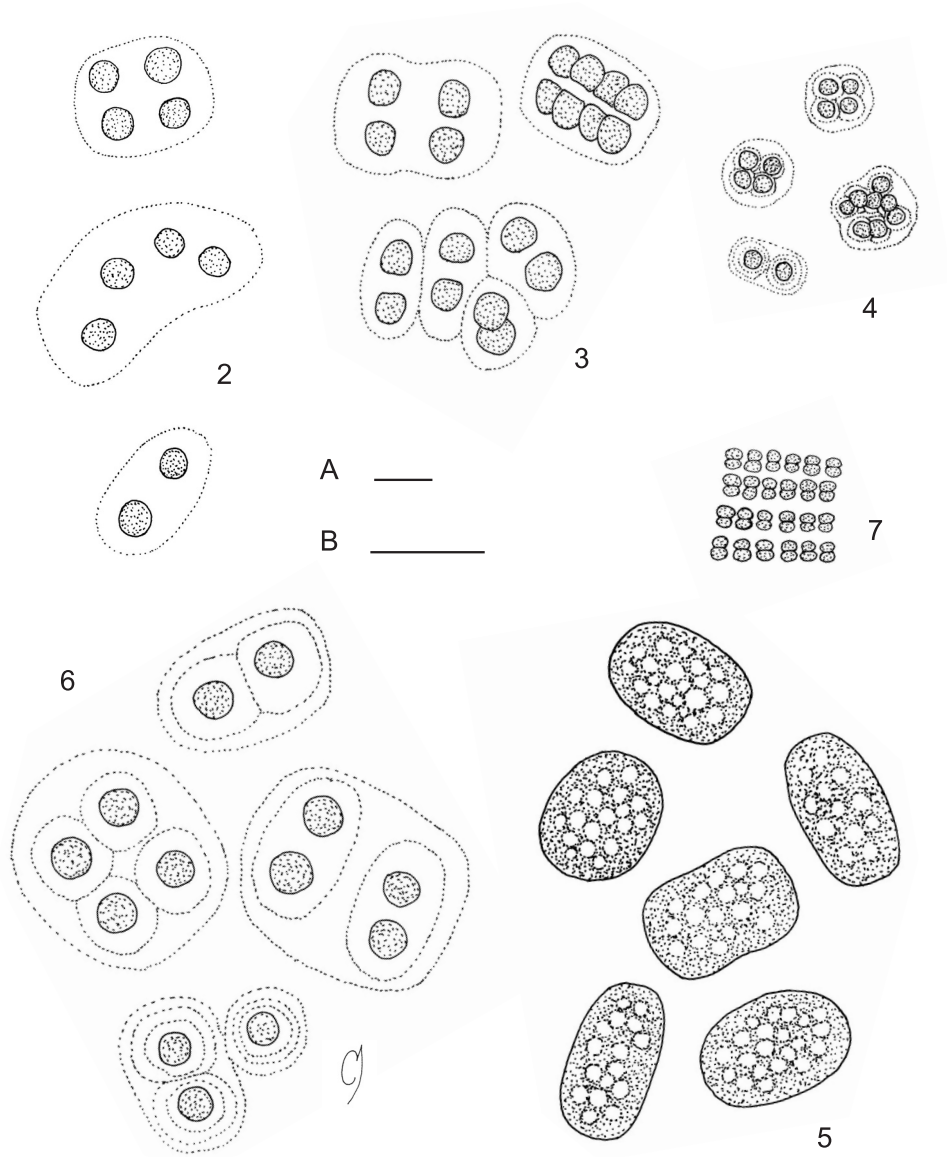
Habitats. Planktonic, tychoplanktonic or metaphytic in oligotrophic up to slightly eutrophic lakes, ponds, swamps, brackish water. It has not been previously reported from sandy habitats.

Distribution. A very common species, reported in Poland from numerous localities.

Chroococcus varius A. Braun (Fig. 4)

Ref. John *et al.* 2002 (Fig. 3C: 42).

Description. Colonies usually microscopic, composite, with 2–4 cells embedded in communal



Figs 2–7. 2 – *Chroococcus minor*; 3 – *Chroococcus minutus*; 4 – *Chroococcus varius*; 5 – *Cyanothece aeruginosa*; 6 – *Gloeocapsa atrata*; 7 – *Merismopedia glauca*. Scale bar A = 15 μm (Fig. 4), 20 μm (Fig. 7); scale bar B = 15 μm (Figs 2, 3, 5, 6).

mucilage. Communal mucilage usually has faint lamellations and ranges from colorless to rich yellow. Cells spherical, 4.0–5.2 μm in diameter.

HABITATS. Aerophytic, epilithic, common on wet rocks and walls, including greenhouses, periphytic in lakes.

DISTRIBUTION. A cosmopolitan species (Komarék & Anagnostidis 1998). In Poland known from Silesia (Schröder 1895), the Dolina Białego valley in the Tatra Mts (Starmach 1981), and the catchment area of Kryniczanka stream (Starmach 1989).

Cyanothece aeruginosa (Nägeli) Komárek (Fig. 5)

Ref. John *et al.* 2002 (Fig. 6E: 57).

DESCRIPTION. Cells single or as a pair during division, short cylindrical with widely rounded ends. Cells 12.5–15.0 μm wide, 18–28 μm long.

HABITATS. Typically shallow waters influenced by human activity, freshwater, free-floating in vicinity of submerged plants, in swamps, on wet rocks, peat-bogs, lakes, ponds, on snow. It has not been earlier reported as a eupsammonic taxon.

DISTRIBUTION. A cosmopolitan species. Known from numerous places also in Poland.

Gloeocapsa atrata Kütz. (Fig. 6)

Ref. Starmach 1966 (Fig. 132: 120–122); Nevo & Wasser 2000 (p. 55).

DESCRIPTION. Colonies small, usually 2–4 celled and 30 μm in diameter, spherical or ovoid in shape. Cells spherical in shape, 4–5 μm in diameter, with a wide (4.2–7.5 μm), striated sheath.

HABITATS. Subaerophytic, on wet rocks, walls, among mosses, on edges of wells, rarely on wet soil.

DISTRIBUTION. The species occurs over the whole temperate zone. In Poland known from Silesia (Kirchner 1878) and the surroundings of Warsaw (Cybulski 1883; Łopott 1884). The present record is the first Polish report in about 120 years.

Merismopedia glauca (Ehrenb.) Nägeli (Figs 7 & 15)

Ref. John *et al.* 2002 (Fig. 3H: 51).

DESCRIPTION. Colonies up to 64-celled, regularly and densely packed. Cells spherical, widely ellipsoidal or hemispherical, 4 μm in diameter.

HABITATS. Typically mesotrophic conditions, fresh and brackish waters, on the surface of silt, among submerged macrophytes, in swamps, stagnant water, littoral of mainly unpolluted ponds and lakes, occasionally in plankton. This species is reported for the first time from sand as a eupsammonic species.

DISTRIBUTION. A cosmopolitan species. In Poland reported many times.

HETEROKONTOPHYTA

Pinnularia borealis Ehrenb. (Fig. 16)

Ref. Krammer 2000 (Figs 6: 5–10, 7: 1–19, 8: 1–14: 24).

DESCRIPTION. Valves linear and linear-elliptical, margins parallel to moderately convex, ends rounded, 24.6–41.4 μm long, 7.9–9.5 μm wide. Raphe filiform to weakly lateral, the fissures curved to one side in the central area. Central pores distinct, rounded, terminal fissures moderately large, sickle-shaped. Axial area narrow, central area large, rounded. Striae broad, distant, 5–6/10 μm.

HABITATS. Large autecological amplitude, benthic in wet habitats, oligohalobious, aerophilic.

DISTRIBUTION. A cosmopolitan species. In Poland found in numerous localities.

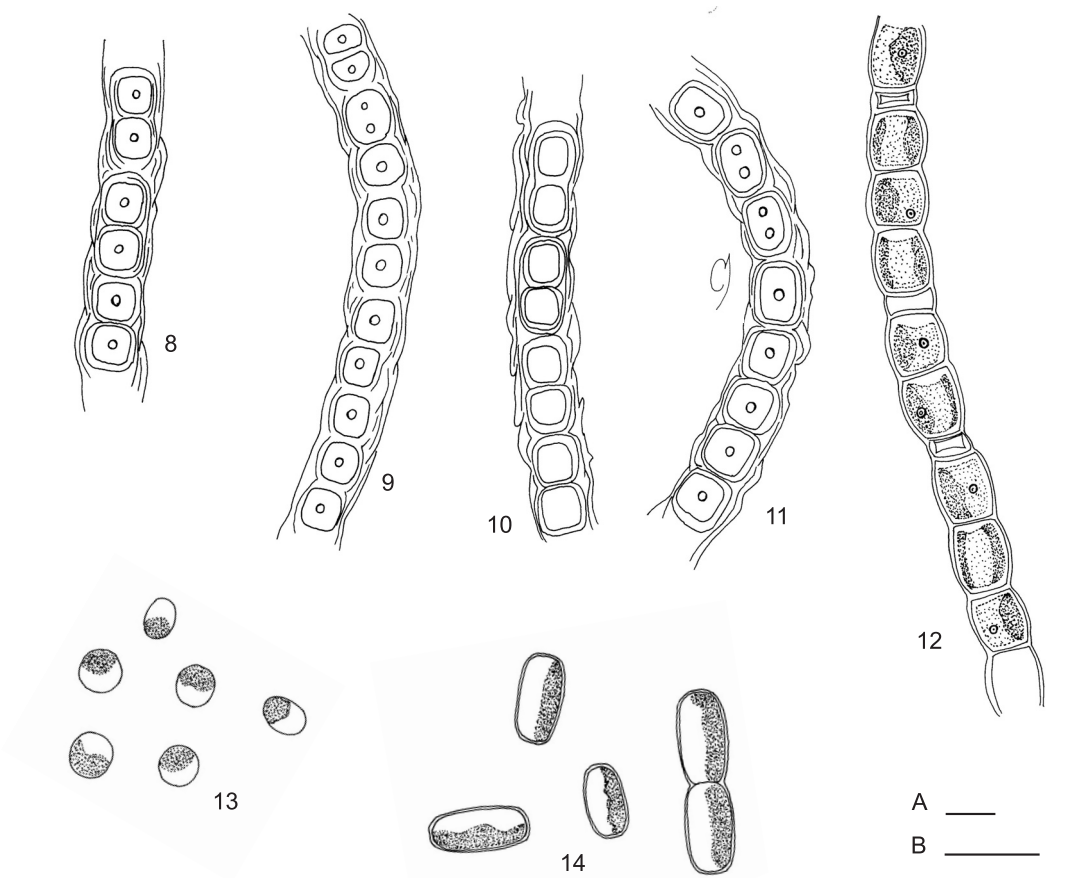
CHLOROPHYTA

Cylindrocapsa sp. (Figs 8–11, 17–19)

DESCRIPTION. Cells 17.5–19.0 μm wide, 15.8–27.5 μm long. Walls very thick (5.0–5.5 μm), irregularly wrinkled, junction between H-shaped sections evident.

HABITAT. On sand.

NOTE. These specimens are similar to *Cylindrocapsopsis* spp. The two genera may be distinguished only on the basis of zoospores. Unfortunately the material collected in the Pustynia Błędowska desert has not formed zoospores and cannot be unequivocally determined. It also resembles *Microspora irregularis* (W. West & G. S. West) Wichmann but has different chloroplasts. This material needs further study in cultures.



Figs 8–14. 8–11 – *Cylindrocapsa* sp.; 12 – *Klebsormidium crenulatum*; 13 – *Stichococcus chlorelloides*; 14 – *Stichococcus* cf. *fragilis*. Scale bars A = 25 μm (Figs 8–11), 10 μm (Fig. 14); scale bar B = 15 μm (Figs 12, 13).

Klebsormidium crenulatum (Kütz.) H. Ettl & G. Gärtner (Figs 12 & 20)

Ref. John *et al.* 2002 (Fig. 115D: 447–449).

DESCRIPTION. Filaments long, cells 10–11 μm wide, 11.0–12.5 μm long, with walls sometimes mucilaginous when moist. H-shaped segments occasionally present. Chloroplast plate- or girdle-shaped, occupies almost 80% of the cell interior, with one pyrenoid.

HABITATS. Soils, pools, swiftly flowing streams.

DISTRIBUTION. A species widely distributed in Europe. This is the first record in Poland.

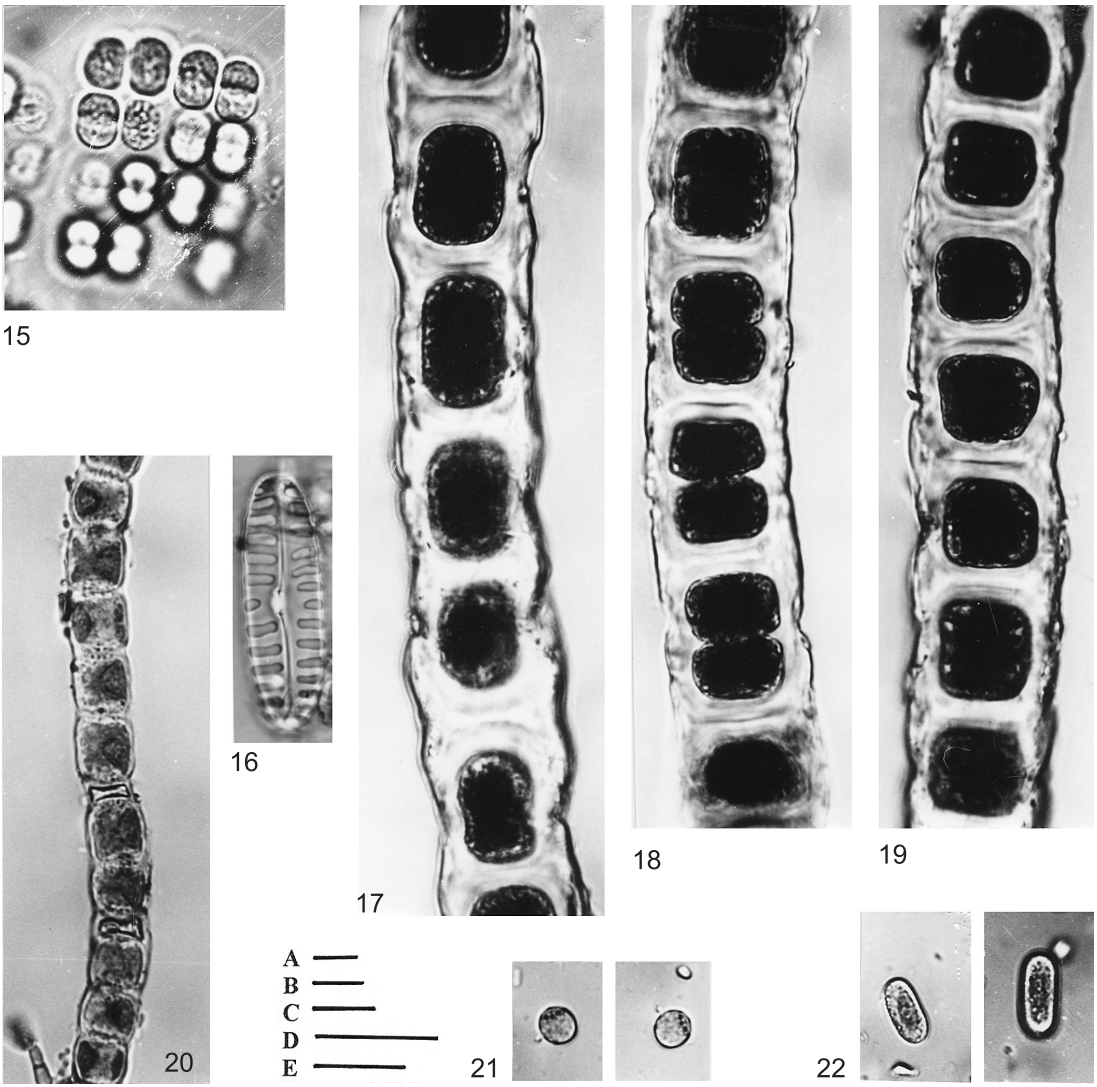
Stichococcus chlorelloides Grintzesco & L. S. Péterfi (Figs 13 & 21)

Ref. Starmach 1972 (Fig. 103: 93).

DESCRIPTION. Cells small, spherical or ovoid in shape, 5.8–7.5(–8.0) μm in diameter. Chloroplast single, occupies only part of cell.

HABITATS. Calcareous rocks, stagnant water, on soil. This species is reported for the first time from sands as a eupsammonic taxon.

DISTRIBUTION. A rare species known so far from Rumania (Grintzesco & Péterfi 1932). This is the first record in Poland.



Figs 15–22. 15 – *Merismopedia glauca*; 16 – *Pinnularia borealis*; 17–19 – *Cylindrocapsa* sp.; 20 – *Klebsormidium crenulatum*; 21 – *Stichococcus chlorelloides*; 22 – *Stichococcus* cf. *fragilis*. Scale bar A = 5 μm (Fig. 16); scale bars B = 10 μm (Figs 17–19, 21); scale bar C = 10 μm (Fig. 20); scale bar D = 30 μm (Fig. 22); scale bar E = 15 μm (Fig. 15).

Stichococcus cf. ***fragilis*** Gay (Figs 14 & 22)

Ref. Starmach 1972 (Fig. 113: 97).

DESCRIPTION. Cells small, usually occurring singly, with widely rounded ends, 9–11 μm wide, 18–22 μm long. Chloroplast single, usually occupies part of cell.

HABITATS. On glass in a greenhouse. The finding of this algae on sand as a eupsammonic taxon expands its ecological amplitude.

DISTRIBUTION. A rare species growing on walls of greenhouses (Printz 1964; Starmach 1972; Hindák 1996), but in these works reported without naming countries where found.

NOTE. These specimens were initially classified as *Stichococcus fragilis* (Starmach 1972: 97, Fig. 113) which, however, has cells about 5 μm wide. As the length of cells in our collection fits the description of this taxon, we tentatively identified it as *Stichococcus* cf. *fragilis*.

DISCUSSION

Eleven algal species have been identified, comprising six species of Cyanophyta, one species of Heterokontophyta and four species of Chlorophyta. Among these are five species that form small gelatinous colonies (*Chroococcus minor*, *C. minutus*, *C. varius*, *Gloeocapsa atrata*, *Merismopedia glauca*), while four other taxa occur as single cells (*Cyanothece aeruginosa*, *Pinnularia borealis*, *Stichococcus chlorelloides*, *S.* cf. *fragilis*) and two compose long filaments (*Cylindrocapsa* sp., *Klebsormidium crenulatum*). *Cylindrocapsa* sp. is the commonest taxon amongst the studied algae. It occurred numerously at localities 9, 10, 12, 13, 14 and 15, where it formed characteristic ravels of long filaments on the surface of the sand, about 0.5–1.0 cm thick. Within the filaments of *Cylindrocapsa* sp. were intermixed single specimens of other algae, mainly *Chroococcus minor*, *C. minutus*, *Cyanothece aeruginosa*, *Gloeocapsa atrata*, *Merismopedia glauca*, *Stichococcus chlorelloides* and *S.* cf. *fragilis*. Together these concentrations of algae formed so-called 'biological soil crust,' being very important in the process of soil cover formation. The diversity and quantity of algae were greater in spring months (April 2002, May 2002) than in summer and autumn (Table 1); this was probably connected with the higher moisture of sands.

Most of the taxa found here are cosmopolitan species occurring commonly worldwide. Only two taxa, *Stichococcus chlorelloides* and *S.* cf. *fragilis*, are considered rare. *Stichococcus chlorelloides* was known so far only from Rumania (Grintzesco & Péterfi1932), and *S.* cf. *fragilis* from walls of greenhouses (Starmach 1972; Hindák 1996).

In her work on algae of Słowiński National Park (N Poland), Picińska-Fałtynowicz (1997) points out that an interesting feature of eupsammonic communities is the large concentration of mobile taxa, mainly flagellates, on the one hand, and species secreting jellies and slimes on the other. These characters result from the habitat conditions of eupsammonic algae, that is, the possibility of active motion and the production of jelly or slime protecting algae from unfavorable strong insolation and changes of sand temperature and moisture. The presence of small gelatinous colonies and long filaments of *Cylindrocapsa* sp. (which has characteristic gelatinous walls) in the Pustynia Błędowska desert seems to confirm this

Table 1. Occurrence of algae at 17 localities (1−17 as an Fig. 1) in Pustynia Błędowska desert. Collecting dates: [a] − 13 June 2001, [b] − 10 October 2001, [c] − 10 April 2002, [d] − 22 May 2002.

Species/ sites	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Chroococcus minor		+[c]															
Chroococcus minutus												+[c]					
Chroococcus varius					+[b, c]												
Cyanothece aeruginosua	+[d]			+[b]								+[a, c]					
Gloeocapsa atrata									+[b]	+[c]	+[b]	+[c]			+[b]		+[d]
Merismopedia glauca						+[b]						+[c]					+[b]
Pinnularia borealis	+[d]	+[d]	+[d]		+[d]	+[d]	+[d]	+[d]							+[c]	+[d]	
Cylindrocapsa sp.	+[b]	+[c]					+[b]	+[b]	+[a, d]	+[c, d]	+[a]	+[c, d]	+[a, d]	+[a, d]	+[c, d]	+[d]	+[d]
Klebsormidium crenulatum	+[c, d]	+[d]					+[d]								+[c]		
Stichococcus chlorelloides			+[c]					+[c]		+[c]			+[c]	+[c]			
Stichococcus cf. *fragilis*			+[a, c]						+[a]	+[c]		+[a, c]	+[c]				

assertion. Unlike Picińska-Fałtynowicz (1997), however, we did not find mobile flagellate taxa here. We found fewer species on the Pustynia Błędowska desert sands than Picińska-Fałtynowicz (1997) found in similar conditions in Słowiński National Park. The present work certainly does not describe the entire algae species composition of the Pustynia Błędowska desert. Long-term investigations should provide further data.

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REFERENCES

CYBULSKI K. 1883. Materiały do flory algologicznej okolic Warszawy. *Pamiętn. Fizjogr*. **3**: 249–273.

GRINTZESCO J. & PETERFI S. 1932. Contribution à l'étude des algues vertes de Roumanie. 1. Sur guelgues espèces appartement an genera *Stichococcus* de Roumanie. *Rev. Algal.* **6**: 159–175.

HINDÁK F. 1996. Key to the unbranched filamentous green algae (Ulotrichineae, Ulotrichales, Chlorophyceae). Bulletin. Slovenská Botanická Spoločnosť pri SAV, Suplement 1, Bratislava (in Slovak with English summary).

JOHN D. M., WITTON B. A. & BROOK A. J. 2002. The Freshwater Algal Flora of the British Isles. Identification Guide to Freshwater and Terrestrial Algae. The Natural History Museum, Cambridge University Press.

KIRCHNER O. 1878. Algen. Kryptogamen-Flora von Schlesien, herausgegeben von F. Cohn, **2**(1): 1–284. J. U. Kern's Verlag, Breslau.

KOMARÉK J. & ANAGNOSTIDIS K. 1998. Cyanoprokaryota 1. Teil Chroococcales. *Süsswasserflora von Mitteleuropa* **19**(1): 1–548. G. Fischer Verlag, Stuttgart.

KRAMMER K. 2000. The genus *Pinnularia*. In: H. LANGE-BERTALOT (ed.), *Diatoms of Europe. Diatoms of the European Waters and Comparable Habitats.* **1**. A. R. G. Gantner Verlag Kommandit Gesellschaft, Ruggel.

KRZYŻANEK E. & KRZYŻANEK M. 1986. Development and structure of the Goczałkowice reservoir ecosystem. XVIII. List of plant and animal species. *Ekol. Pol.* **34**(3): 559–577.

LAKOWITZ K. 1931. VI. Die Algen des Mariensees (Ausschliesslich Diatomeen und Desmidiaceen). *Ber. Westpreuss. Bot.-Zool. Vereins Danzig* **53**: 1–15.

ŁOPOTT W. 1884. Materiały do flory algologicznej okolic Warszawy. *Pamiętn. Fizjogr.* **4**: 243–265.

NEVO E. & WASSER S. P. 2000. Biodiversity of Cyanoprocaryotes, Algae and Fungi of Israel. Cyanoprocaryotes and algae of continental Israel. A. R. G. Gantner Verlag Kommandit Gesellschaft, Ruggell.

PICIŃSKA-FAŁTYNOWICZ J. 1997. Glony. In: H. PIOTROWSKA (ed.), *Przyroda Słowińskiego Parku Narodowego*. Bogucki Wydawnictwo Naukowe, Poznań–Gdańsk.

PRINTZ H. 1964. Die Chaetophoralen der Binnengewässer. Eine systematische übersicht. *Hydrobiologia* **24**: 1–376.

RAHMONOV O. 1999. Processes of overgrowing in the Pustynia Błędowska desert (southern Poland). Wydział Nauk o Ziemi Uniwersytetu Śląskiego, Sosnowiec (in Polish with English and Russian summaries).

RAHMONOV O. 2001. Procesy formowania się pokrywy roślinno-glebowej na piaskach Pustyni Błędowskiej. In: J. PARTYKA (ed.), *XLV lat Ojcowskiego Parku Narodowego. XX lat Zespołu Jurajskich Parków Krajobrazowych Województwa Małopolskiego. Badania Naukowe w Południowej części Wyżyny Krakowsko-Częstochowskiej. Ojców*, pp. 201–205. Ojcowski Park Narodowy, Ojców.

RAHMONOV O. 2002. The evolution and regeneration of ecosystems in Błędów "Desert" (Southern Poland) – undergone of medieval ecological disaster. *Geographia. Studia et Dissertationes* **25**: 61–72.

SCHRÖDER B. 1895. Über die Algenflora schlesischer Bewächshäuser. *Jahres-Ber. Schles. Ges. Vaterl. Cult.* **72**: 26–37.

STARMACH K. 1966. Cyanophyta – sinice. Glaucophyta – glaukofity. In: K. STARMACH (ed.), *Flora Słodkowodna Polski*. **2**. Państwowe Wydawnictwo Naukowe, Warszawa–Kraków.

STARMACH K. 1972. Chlorophyceae III. Zielenice nitkowate. In: K. STARMACH & J. SIEMIŃSKA (eds), *Flora Słodkowodna Polski*. **10**. Państwowe Wydawnictwo Naukowe, Warszawa–Kraków.

STARMACH K. 1981. Algen, besonders *Cyanophyceae* im Tal „Dolina Białego" (Tatragebirge). *Fragm. Flor. Geobot.* **27**(1/2): 275–317.

STARMACH K. 1989. Algae of the catchment area of the Kryniczanka stream. *Studia Ośr. Dokument. Fizjogr.* **17**: 373–400 (in Polish with English summary).

SZCZYPEK T. & WIKA S. 1984. Vlijanie vetra na razmeshchenie rastitelnosti na teritorii Blendovskoj Pustyni. *Acta Fac. Paed. Ostraviensis* **89**: 65–76.

SZCZYPEK T., WACH J. & WIKA S. 1994. Zmiany krajobrazów Pustyni Błędowskiej. Wydział Nauk o Ziemi Uniwersytetu Śląskiego, Sosnowiec.

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