# Contribution to the Knowledge of Soil Algae of Two Abandoned Industrial Sedimentation Basins in Eastern Bohemia

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## Abstract

Sixty three species of soil algae and *Cyanoprocaryota* were recovered from eight investigated sites in the Chvaletice ore-washery basin and the Bukovina ash-slag sedimentation basin. The Chvaletice sites were dominated by green algae, whereas in the Bukovina sites, *Cyanoprocaryota* were more abundant which indicates more alkaline conditions of the last locality. Extremely low algal abundance on the two treeless sites in Chvaletice suggests soil toxicity of these biotopes.

## Keywords

Soil algae, *Chlorophyta*, *Xanthophyceae*, *Cyanoprocaryota*.

## Introduction

Algae and *Cyanoprocaryota* form an important part of soil microbial communities. Due to their primary photosynthetic production, easy dispersion and fast growth, soil algae are very important in the colonisation of pioneer biotopes (Gollerbach, Ština 1969; Evans, Johansen 1999). Species composition of the soil algae in ecosystems reflect environmental conditions, type of vegetation cover, anthropogenic management, etc. (e.g., Petersen 1935; Grondin, Johansen 1995; Lukešová, Hoffmann 1996; Děmčenko *et al.* 1998; Neustupa 2001).

Within the complex ecological investigation of several abandoned industrial fields, soil algal flora of two localities, the Bukovina ash-slag sedimentation basin and the Chvaletice ore-washery basin, were studied. We aimed to determine the soil algal species composition of main successional stages on the two localities and to describe the characteristics of their soil algal flora.

## Study sites and methods

Samples were collected in June 2002. In each site, samples from the 0–3cm layer were taken randomly from physiognomically uniform areas of the size 5–15 $m^2$. The samples were placed into sterile bags and transported to the laboratory for analysis. The soil suspension was spread on Petri dishes with BBM-agar (Bischoff, Bold 1963; Ettl, Gärtner 1995). Algal microcolonies were examined 2–6 weeks after inoculation for species identification. Standard cytological stains (Lugol's solution, cotton blue, methylene blue, acetocarmine, nigrosine) were used. The determination was made using standard authoritative references (Starmach 1972; Ettl 1978; Komárek, Fott 1983; Ettl, Gärtner 1995; Hindák 1996; Lokhorst 1996, etc.).

The quantities of algae on Petri dishes were evaluated as belonging to one of three classes: 1 – single algal colony found, 2 – rare species with several colonies on the dishes, 3 – dominant species in the sample. Statistical analysis was carried out using Canoco 4.5 and Canodraw 4.0. Detrended correspondence analysis (DCA), a non-direct ordination method based on a unimodal response model, was used (for detailed description see Jongman 1995).

Eight physiognomically different sites belonging to different successional stages on the two localities were investigated:

**1** – Chvaletice ore-washery basin, scarce growth of *Populus tremula* and *Calamagrostis epigejos*.

**2** – Chvaletice ore-washery basin, the bottom of a dried-up residual pond, overgrown with *Carex* sp. div. and *Phragmites australis*.

**3** – Chvaletice ore-washery basin, dense growth of *Populus tremula*.

**4** – Chvaletice ore-washery basin overgrown with *Betula pubescens*, *Calamagrostis epigejos* and *Polytrichum formosum*.

**5** – Chvaletice ore-washery basin, treeless saline site with very sparse growth of *C. epigejos* and *Ceratodon purpureus*.

**6** – Chvaletice ore-washery basin, treeless site with *Cladonia* sp. div. and sparse growth of *C. epigejos*.

**7** – Bukovina ash-slag sedimentation basin, the bottom of a dried-up residual pond overgrown with *Funaria hygrometrica*.

**8** – Bukovina ash-slag sedimentation basin with extensive growth of *C. epigejos*.

Table 1: Algal distribution in 8 investigated sites in Chvaletice ore-washery basin and Bukovina ash-slag sedimentation basin.

| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
|---|---|---|---|---|---|---|---|---|---|
| ***Cyanoprocaryota*** | | | | | | | | | |
| ***Chlorogloea*** sp. | CGEA | | | | | | | 1 | |
| ***Leptolyngbya*** cf. ***boryana*** | LPBO | | | 1 | | | | 2 | 2 |
| ***L.*** cf. ***nostocorum*** LPNO | 2 | 2 | | | | | 3 | 3 | |
| ***Leptolyngbya*** sp. | LPSP | | 2 | | | | | | |
| ***Nostoc*** sp. | NSTC | | | | | | | 1 | 2 |
| ***Phormidium*** cf. ***autumnale*** | PHAU | 1 | | | | | | | |
| ***Pleurocapsa*** sp. | PLCP | 1 | | | | | | 3 | 1 |
| ***Bacillariophyceae*** | | | | | | | | | |
| ***Hantzschia amphyoxis*** (Ehrenberg) Grunow | HAAM | 1 | | 1 | 1 | | | | |
| ***Nitzschia palea*** (Kützing) W. Smith | NIPA | | 3 | | | | | | |
| ***Pinnularia borealis*** Ehrenberg | PIBO | | | 1 | | | | | 1 |
| ***Stauroneis obtusa*** Lagerstedt | SAOB | | 1 | | | | | | |
| ***Xanthophyceae*** | | | | | | | | | |
| ***Botrydiopsis intercedens*** Pascher | BOIN | 1 | | | | | | | |
| ***Botryochloris chlorellidiopsis*** Ettl | BTCL | | 1 | | | | | | |
| ***Bumilleriopsis filiformis*** Vischer | BUFI | | 1 | | | | | | |
| ***Tribonema aequale*** Pascher | TRAE | | 3 | | | | | | |
| ***T. viride*** Pascher | TRVI | | 1 | | | | | | |
| ***Xanthonema*** sp. | XNSP | | | | | | | | 1 |
| ***Xanthonema constricta*** (Ettl) Silva | XNCO | | 3 | | | | | | |
| ***X. montanum*** (Vischer) Silva | XNMO | 2 | | | | | | | |
| ***X. stichococcoides*** (Pascher) Silva | XNSC | | | | | | | | 1 |
| ***Euglenophyta*** | | | | | | | | | |
| ***Euglena*** sp. | EUGL | | 1 | | | | | | |
| ***Chlorophyta*** **and** ***Streptophyta*** | | | | | | | | | |
| ***Bracteacoccus*** cf. ***grandis*** | BRGR | | | | | | | | 1 |
| ***B. minutus*** SchwarzBRMI | 2 | | | | | | | | |
| ***B. pseudominor*** Bischoff et Bold | BRPM | 1 | | | | | | | |
| ***Bracteacoccus*** sp. | BRSP | | | | | | | 1 | |
| ***Chlamydomonas*** sp. 1 | CHM1 | 1 | | | | | | | |
| ***Chlamydomonas*** sp. 2 | CHM2 | | 1 | | | | | | |
| ***Chlamydomonas*** sp. 3 | CHM3 | | | 1 | | | | | |
| ***Chlamydomonas*** sp. 4 | CHM4 | | | | | | | 1 | |
| ***Chlorella ellipsoidea*** Gerneck | CLEL | | | 1 | | | | | |
| ***C. kessleri*** Fott et Nováková | CLKS | | 1 | | | | | | |
| ***C. vulgaris*** Beijerinck | CLVG | 1 | | 1 | 3 | 1 | | | |
| ***Chlorella*** sp. 1 | CLS1 | 3 | | | | | | | |
| ***Chlorella*** sp. 2 | CLS2 | | | | | 3 | | | |
| ***Chlorococcum typicum*** Archibald et Bold | CCTY | | 1 | | | | | | |
| ***Chlorosarcinopsis auxotrophica*** Groover et Bold | CSAU | | | | | | | 1 | |
| ***Coccomyxa*** sp. | COCO | 1 | 1 | | | | | | |
| ***Coenochloris bilobata*** (Broady) Hindák | CNBI | | | | | | 1 | | |
| ***Coenocystis*** sp. | COEN | | | | 1 | | | | |

Table 1: Continued

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| ***Cylindrocystis brebissonii*** var. ***minor*** W. West et G. S. West | CYBR | 1 | | | | | | | |
| ***Desmococcus olivaceus*** (Pers. ex Ach.) Laundon | DEOL | | | | | | 2 | | |
| ***Diplosphaera chodatii*** Bialosuknia em. Vischer | DICH | | | 1 | | | | | |
| ***Elliptochloris reniformis*** (S. Watanabe) Ettl et Gärtner | ELRE | | | 1 | | | | | |
| ***E. subsphaerica*** (Reisigl) Ettl et Gärtner | ELSU | | 1 | 1 | | | | | |
| ***Elliptochloris*** sp. | ELSP | | | | | | 1 | | |
| ***Ettlia cohaerens*** (Groover et Bold) Ettl et Gärtner | ETCO | | 1 | | | | | | |
| ***Eutetramorus*** sp. | EUTE | | | | 1 | | | | |
| ***Gloeocystis vesiculosa*** Nägeli | GLVE | | 1 | | | | | | |
| ***Gloeocystis*** sp. | GLSP | | | | | 1 | | | |
| ***Klebsormidium flaccidum*** (Kützing) Silva et al. | KLFL | | 2 | | 2 | | | 1 | 2 |
| ***K. nitens*** (Meneghini in Kützing) Lokhorst | KLNI | 1 | 2 | 2 | 1 | | | | |
| ***Leptosira erumpens*** (Deason et Bold) Lukešová | LEER | 1 | | | | | | | |
| ***Microthamnion kützingianum*** Nägeli | MIKU | | 2 | | | | | | |
| ***Muriella decolor*** Vischer | MUDE | | | | | | | | 2 |
| ***M. terrestris*** J. B. Petersen | MUTE | | | | 1 | | | | |
| ***Mychonastes homosphaera*** (Skuja) Kalina et Punčochářová | MYHO | | 1 | | | | | | |
| ***Neocystis*** sp. 1 | NEO1 | | | 1 | | | | | |
| ***Neocystis*** sp. 2 | NEO2 | | | | | | 1 | | |
| ***Pseudococcomyxa simplex*** (Mainx) Fott | PSSI | 1 | 2 | 3 | | 2 | 3 | 3 | 3 |
| ***Radiococcus bilobatus*** (Broady) Kostikov et al. | RABI | | | | | | | | 1 |
| ***Stichococcus bacillaris*** Nägeli | STBA | 1 | | | | | | 1 | |
| ***S. minor*** Nägeli | STMI | | 2 | | | | 2 | | |
| ***Stichococcus*** sp. | STSP | | | 2 | | | | | |

## Results and discussion

A total of 63 algal and cyanoprocaryotal species representing 38 genera were registered on the sites investigated (Tab. 1). Significant differences were found in algal species composition between the sites (Fig. 1). Green algae and xanthophytes were the dominant groups on all sites in Chvaletice, whereas cyanophytes were abundant in the two investigated sites in Bukovina. *Leptolyngbya* cf. *boryana*, *L.* cf. *nostocorum*, *Pleurocapsa* sp., *Hantzschia amphyoxis*, *Chlorella vulgaris*, *Klebsormidium flaccidum*, *K. nitens* and *Pseudococcomyxa simplex* were the most widespread species occurring on at least three sites out of the eight investigated. Most of the identified taxa were relatively rare, with 49 of the 63 species appearing in only one site.

The treeless sites in Chvaletice were found to be extremely poor in soil algae. There were only four species found on site 5 and six species on site 6, with ubi-

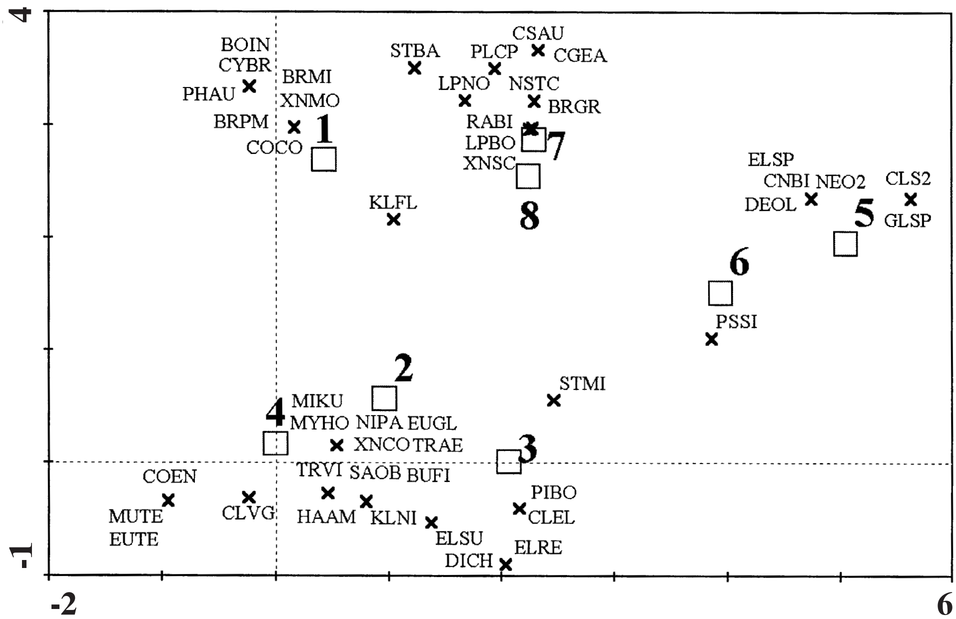


Fig. 1: DCA ordination diagram showing position of localities (symbol □) and species (symbol ×). (For description of abbreviations see Tab. 1.)

quitous *Pseudococcomyxa simplex* and some other *Chlorella*-like coccal green algae being dominant in both of the sites mentioned.

On the other hand, the site from the bottom of a dried-up residual pond in Chvaletice had the most diversified algal flora with 23 species. The occurrence of some interesting xanthophycean species (*Botryochloris chlorellidiopsis*, *Bumilleriopsis filiformis*, *Tribonema aequale*, *T. viride*, *Xanthonema constricta*), monadoid *Euglena* sp. and filamentous green alga *Microthamnion kützingianum* suggest periodic seasonal overflowing of the locality enabling an influx of some hydroterrestrial species.

Both sites in Bukovina were dominated by cyanophytes and shared similar soil algal flora different from that in Chvaletice. The high proportion of cyanophytes compared with green algae indicates higher soil pH (Lukešová, Hoffmann 1996; Neustupa 2001). The green algae dominated soil algal flora in Chvaletice, Sites 1, 3 and 4, characterised by growths of *Populus* and *Calamagrostis*, had a considerable proportion of *Klebsormidium*, *Stichococcus*, *Chlorella* and *Pseudococcomyxa* species. This is the usual pattern of soil algal species composition in temperate forest and meadow ecosystems (Gollerbach, Ština 1969; Děmčenko *et al.* 1998). However, the extremely poor algal representation in both treeless and bare Chvaletice sites indicated possible soil toxicity of these biotopes.

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