

Algae flora of graduation towers in the town of Ciechocinek

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Summary. The research was focused on algae occurring on wooden constructions of three graduation towers, which are the main elements of historical salt production technology, located in the health-resort of Ciechocinek in the region of Kujawy. The research also included algae occurring in reservoirs with brine condensed on graduation towers, as well as algae from puddles and the soil under the graduation towers. 52 algae taxa were recorded in the collected material. Representatives of the following phyla were distinguished: 5 taxa of Cyanoprokaryota, 46 taxa of Heterokontophyta (including 44 taxa of diatoms) and 7 taxa of Chlorophyta. Samples from the sites with brine of the lowest salt concentration (4%) turned out to be the most abundant in species.

Key words: halophilic algae, diatoms Chlorophyta, Dunalulla, brine, saline soils.

1. Introduction

The occurrence of algae in the environment with extreme salinity, such as gradually thickened brine flowing down the graduation towers in Ciechocinek, evoked interest among researchers already since the end of the 19th century. Kozłowski (1890) identified 35 species of halophilic algae in water bodies of Ciechocinek, mainly diatoms. In the paper on the occurrence of algae on salt marshes of the entire area of Kujawy, Namysłowski (1922) listed 19 diatom species. Whereas Liebetanz (1925) reported the occurrence of 29 algae species on salt marshes of the western part of this region, including, after Kącki (2001), 19 species of diatoms. Taking into account the salt marshes from Ciechocinek only, we found that the most comprehensive phycological researches in these ecosystems were carried out by Kącki in the 1980s. He identified 88 algae species in the collected material, including 50 diatoms (Kącki, 1983). Nine years later, Janiak (1992) carried out similar researches, but only in the area of the reserve of halophytes „Ciechocinek”, situated in the vicinity of graduation tow-

ers no. 1 and 3 (Fig. 1). She reported the occurrence of 44 algae species, mainly diatoms.

All the aforementioned studies focused on algae inhabiting puddles and small water bodies with different degrees of salinity, located within salt marshes. Whereas the present paper aims at investigating the algae flora occurring on construction elements of the graduation towers, as well as directly beneath the towers and in their immediate surroundings, i.e. in places where salinity of the substrate is the highest.

2. The study area and methods

Graduation towers in the town of Ciechocinek constitute the study area. They are wooden constructions, unique in Europe, from the 19th century, built in order to condense the brine in the process of salt production. Three graduation towers are altogether ca. 1.63 km long and ca. 15 m high. The construction is based on oak beams, the skeleton of the graduation towers is built of pine, and the whole structure is filled up with blackthorn branches. Brine from

the spring “Grzybek” is pumped to the top of a graduation tower, next through special apertures it falls down between blackthorn branches, and condensed brine, as a result of exposure to sunlight and wind, is collected into special reservoirs. The condensed brine is channelled from graduation tower no. I to graduation tower no. II, where it is exposed to further condensation, and next it is channelled to graduation tower no. III. This way, the concentration of brine changes from few to ca. 25%. From graduation tower no. III, the brine is drained off with a pipeline to the salt-works, which operate to this day (Natura 2000).

Samples to study the algae were collected in spring and in summer 2010 from the area of three graduation towers and from a ditch draining off the rain waters that flow down the graduation towers (Fig. 1). Samples of algae were collected from planks of the graduation towers, from the soil under the graduation towers, from crystallized salt dripstones and from puddles under the graduation towers. Alive algae were examined, shortly after collection, in order to identify flagellate forms. Next, cultures were prepared from some of the samples for further identification, and the remaining samples were preserved with 4% formalin. After roasting, permanent preparations were prepared from diatoms in the resin Naphrax.

3. Results

Altogether 52 algae taxa were identified in 17 samples collected from the substrate around the graduation towers, from planks, which constitute their construction element, from grooves on the graduation towers collecting the brine, from crystallized salt on wooden elements of the graduation towers, from puddles under the graduation towers and from the ditch draining off the storm waters flowing down the graduation towers. Representatives of the following phyla were distinguished: 5 taxa of Cyanoprokaryota, 46 taxa of Heterokontophyta (including 44 taxa of diatoms) and 7 taxa of Chlorophyta. Samples from the sites with brine of the lowest salt concentration (4%) turned out to be the most abundant in species (Figs. 2 and 3). Mainly diatoms characteristic of both saline waters and ubiquitous diatoms were identified there. Filaments of *Leptolyngbya fragilis* (Gomont) Anagnostidis et Komarek occurred in the largest numbers among blue-green algae. They formed algal mats at the site located on the bank of the storm water ditch and at the bottom of puddles.

The species diversity of algae was affected both by the salinity and the substrate. On the wood of graduation tower I, with the lowest concentration of brine (4%), a few species of exclusively halophilous diatoms were identified (Fig. 2) and 1 green alga species classified within the order of Chlorellales – *Chlorosarcinopsis arenicola* Groover et Bold (Fig. 4).

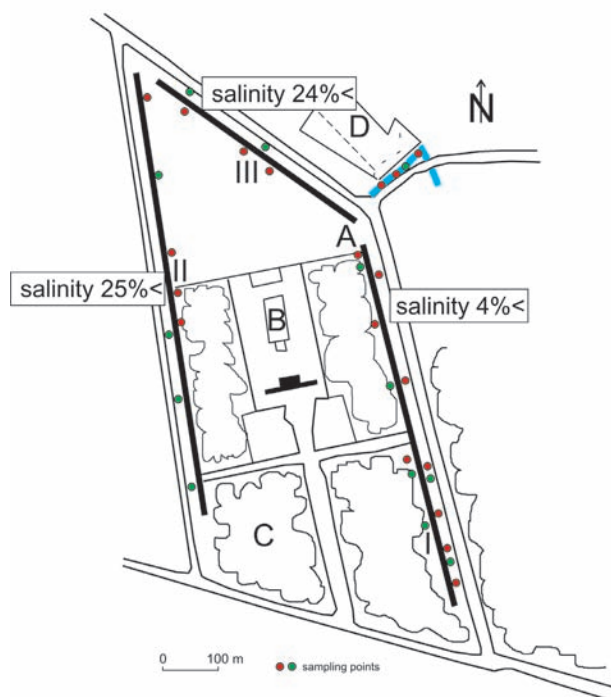


Figure 1. Location of the sampling points in the Spa Park (A – graduation towers No I, II and III, B – brine pool, C – tall greenery, D – the nature reserve of halophytes)

Chlorosarcinopsis arenicola is built of cells with different shape and the length of 6–11 μm ; the width of 4–6 μm ; the diameter of sperical cells of 11–22 μm , the colour from green to orange. The orange colour results from the production of oil by cells, which shields the chlorophyll against excessive solar radiation.

So far this species used to be found in the deserts of Texas and in South Africa. In Europe, *Ch. arenicola* was recorded so far only in Azovo-Syvashsky National Nature Park in Ukraine with the salinity of 5–30% (Vinagrodova & Darienko 2008).

On graduation tower II with salt concentration of 15% and graduation tower III with salt concentration of 25%, in the crystallized green salt, on plaster icicles, probably two species from the genus *Dunaliella* live.

Dunaliella sp. div. is a flagellate with the length of 11–20 μm ; the width of 4.4–11 μm , flagella usually from 1.5 to 2 times longer than a cell; the shape of a cell elongated, elliptical, the top view round. The variable shape depends on the age of a cell and the salinity of the environment in which it occurs (Fig. 5). Cells are usually green.

Dunaliella occurs constantly in crystallized salt dripstones of graduation towers II and III as the only representative of algae. Immobile specimens of *Dunaliel-*

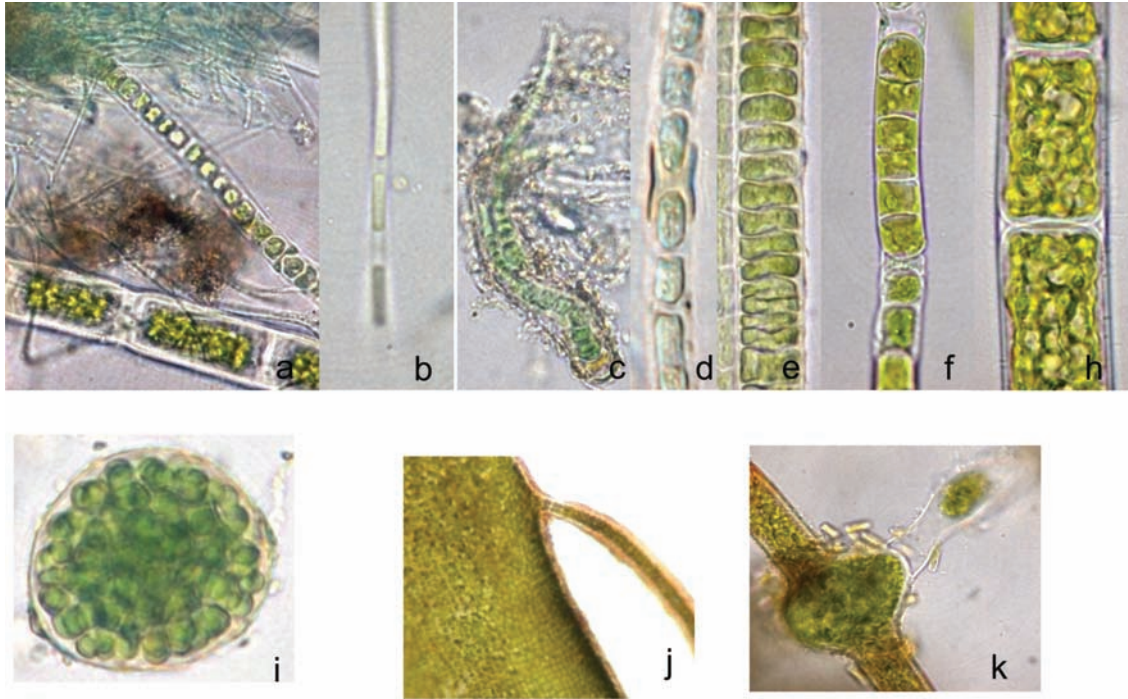


Figure 2. Diatoms on the wood of graduation tower I: a – the graduation tower; b – diatoms; c – *Navicula cinta* (Ehrenberg) Ralfs f. *minuta* Grunov; d – *N. salinarum* Grunov; e – *N. tenelloides* Hustedt; f – *Nitzschia epithemioides* Grunov var. *epithemioides*; g – *Amphora coffaeformis* (Agardh) Kützing; h, i – *Amphora* sp.

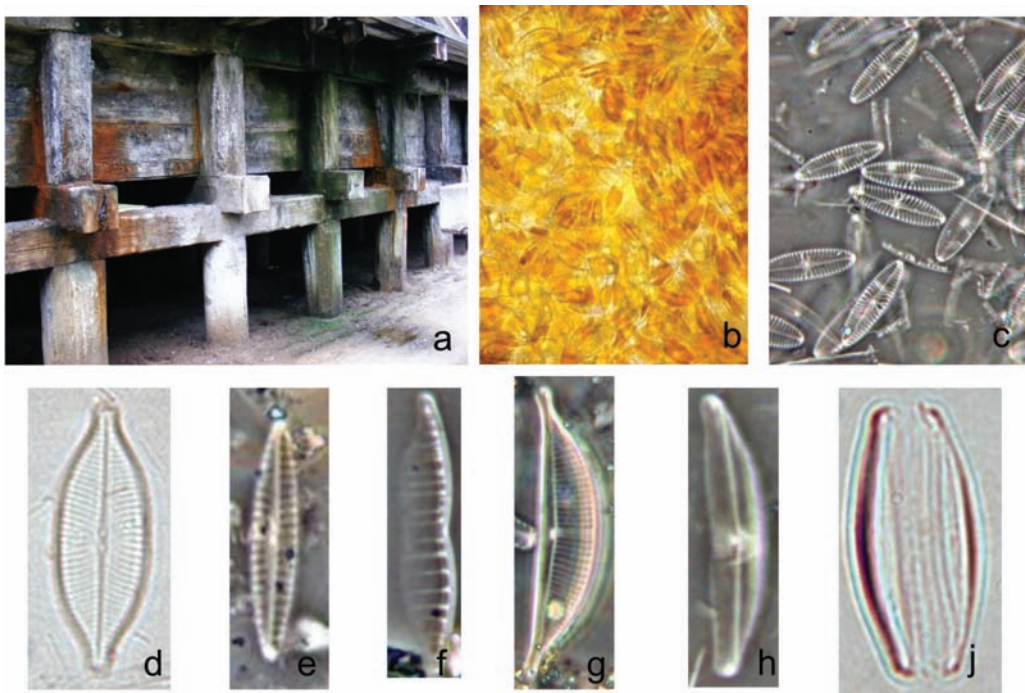


Figure 3. Algae occurring in puddles and on the soil surface under the graduation towers: a – „algal mats”; *Leptolyngbia fragilis* (Gomont) Anagnostidis et Komarek; c – *Calotrix* sp.; d – *Tribonema ulotrichoides* Pascher cf. *T. siderophilum* Ettl; e – *Ulotrix tenuisima* Kützing; f – *U. subflaccida* Wille; g – *Rhizoclonium hieroglyphicum* Kützing; h – *Nostoc edaphicum* Kondratieva cf. *N. microscopicum* Carmichael; j – *Enteromorpha* sp.; k – *Vaucheria* sp.

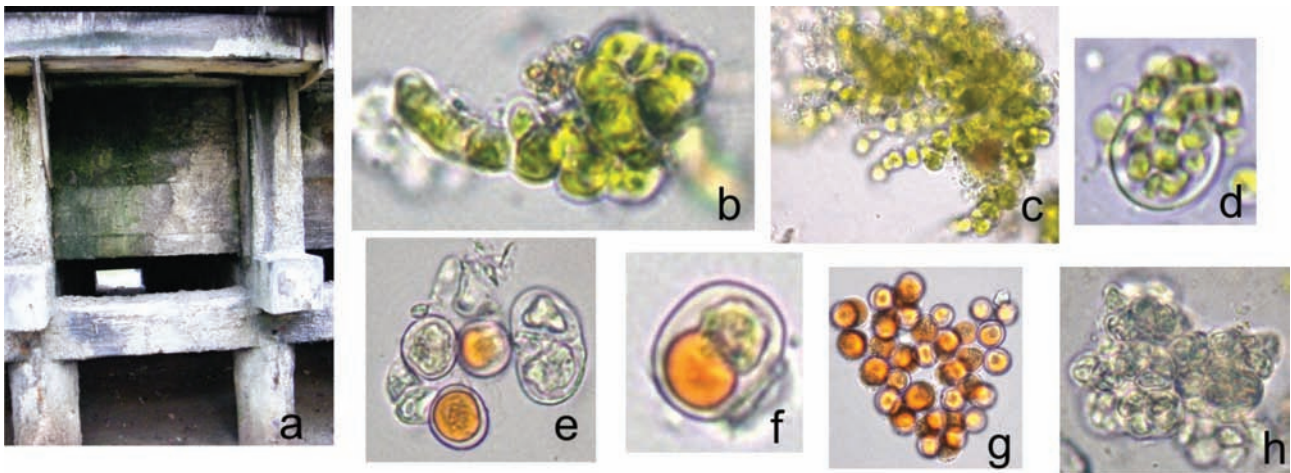


Figure 4. *Chlorosarcinopsis arenicola* Groover et Bold on the wood of graduation tower I: a – the graduation tower; b, c – filaments of a green alga; d – sporangia; e, f, g – oil accumulating in cells; h – ageing colonies

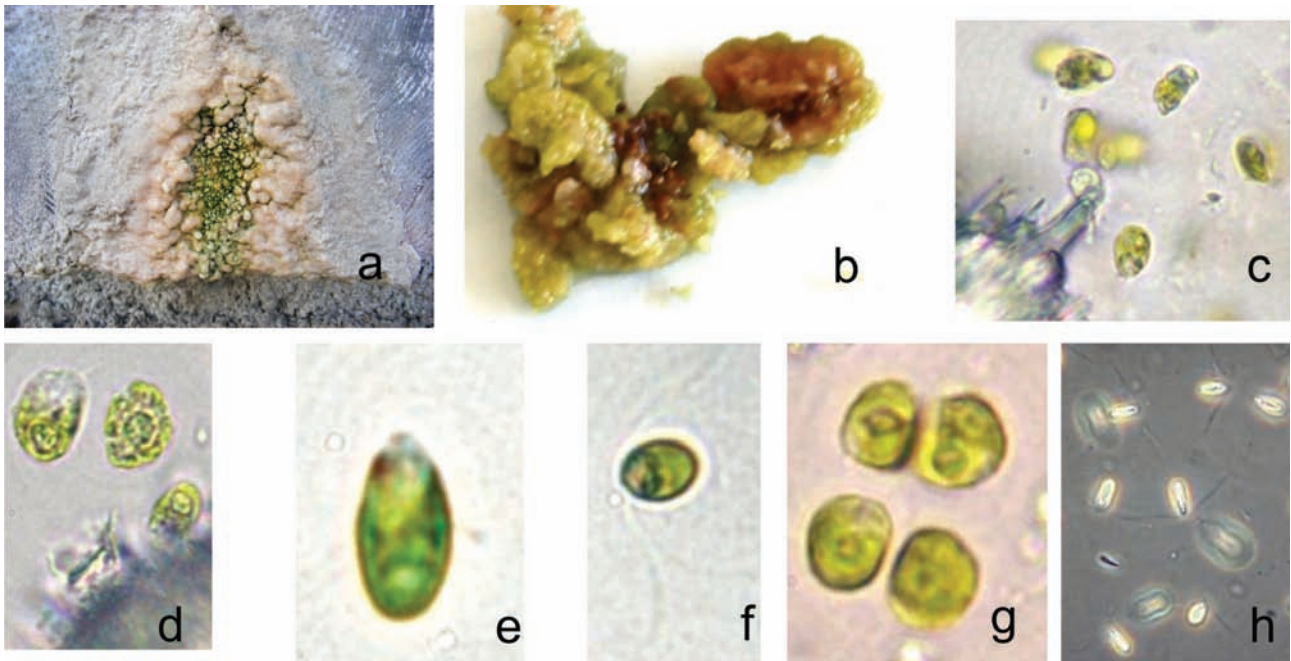


Figure 5. Graduation tower II: a, b – salt dripstones on the graduation tower; c, d – cells of *Dunaliella salina* (Dunal) Teodoresco cf. *D. viridis* Teodoresco flowing out from dissolving small salt crystals; e, f – flagellate forms *Dunaliella*; g – palmella; h – *Dunaliella* cf. *minuta* Lerche

la (akinetes) occurring in small salt crystals, easily and quickly, after adding some water, turn into the flagellate stage (Fig. 5e, f). Also palmelloid stages were observed (Fig. 5g).

Without professional cultures, however, identification of a species is difficult. Species *Dunaliella salina* (Dunal) Teodoresco and *D. viridis* Teodoresco basically morphologically differ only in a considerable concentration of

β -carotene, which gives the orange colour of *D. salina* specimens. Sometimes, however, also not orange specimens of *D. salina* are recorded (Borowitzka M. A. & Siva Ch. J. 2007). Small and elongated specimens are probably *Dunaliella minuta* Lerche (Fig. 4h), which is also well capable of resistance to high salinity.

In the puddles with brine situated under the graduation towers and in the ditch draining off the storm waters from

the graduation towers, numerous diatoms and blue-green algae occur. Due to a lower concentration of salt, not only halophilic algae have a chance to develop there.

4. Conclusions

Apart from the presented data on the algae flora from the aforementioned types of substrate, in the report there are also samples of algae occurring in the ditch draining off the storm waters from the graduation towers. After identification of species, the data will be used for comparisons with the results of the previous researches on algae of salt marshes in Ciechocinek and the entire area of Kujawy.

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