Dissertations

The influence of iron and selected organic compounds on Baltic Sea phytoplankton

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Habilitation thesis in ecophysiology and the biochemistry of marine algae.

Entitled 'The influence of iron and selected organic compounds on the Baltic phytoplankton', this thesis was written by Dr Alicja Kosakowska of the Institute of Oceanology PAS, Sopot (http://www.iopan.gda.pl). It was published as volume 11/1999 of the series Rozprawy i monografie Instytutu Oceanologii PAN, Sopot. It comprises 4 chapters as well as an introduction, summary, conclusions (also in English) and a number of appendices – altogether 160 pages.

The author deals with the biology and chemistry of selected organic compounds complexing iron(III) ions, namely siderophores and polycarboxylic acids (humic acids are also touched upon), and how they affect iron uptake in green and blue-green algae (one species each), carbon dioxide assimilation and chlorophyll *a* synthesis in these algae, and selected aspects of the physiology of these algae in cultures depleted of iron(III).

Since the times when, because of photosynthetic activity, oxygen became a permanent component of the Earth's atmosphere and the marine environment was transformed relatively fast (on the geological time scale) from a reducing to an oxidising one, aquatic organisms have had to cope with the limited availability of iron. This was caused by the oxidation of iron(II) to the thermodynamically more stable iron(III), and by the resulting dramatic decrease in free ferrous and ferric ions, which was due to exceptionally low solubility product of ferric hydroxide in the slightly alkaline environment of seawater. Satisfying the demand for iron is an indispensable requirement for the balanced development of living creatures. Moreover, living organisms are capable of assimilating only dissolved species of iron, hydrated ions for

preference. Therefore, in the face of a potential iron shortage, phytoplankton developed a mechanism of accumulating seemingly unavailable iron(III) ions from colloidal ferric hydroxide. The most important stage of the mechanism is when organic compounds forming stable complexes with iron(III) ions are released from the cells into the water. Both the chemical structure of these compounds and the mechanism of their transport across cell membranes are specific to particular genera or even species of algae. The only element of this mechanism common to these algae is the induction, under iron deficient conditions, of compounds capable of forming stable complexes with iron. Collectively, these compounds are known as siderophores. Obviously, phytoplankton species equipped with an effective mechanism for acquiring iron from seawater will be better able to survive in an iron-deficient environment than those having a less efficient transport mechanism. Algal cells can also make use of siderophores released into the environment by other algae and anthropogenic organic compounds forming complexes with ferric ions.

The aim of the research was to explain the importance of siderophores and policarboxylic acids for iron assimilation by green and blue-green algae, and to define the physiological role of these compounds. The author was thus working on topical, largely unsolved problems, with evident practical applications relating to the carbon dioxide balance in the environment, algal blooms, succession of species, and the persistence of noxious algae as a potential consequence of the modification of iron uptake.

The experimental methods used were far from trivial. While the chlorophyll *a* content is commonly used to measure the intensity of physiological processes, the application of radioisotopes, including the incorporation of radioactive iron, is rather unusual, and the use of specific bacterial tests for the qualitative analysis of siderophores is unprecedented in oceanological research, in Poland or anywhere else in Europe. Furthermore, the identification of siderophores isolated from seawater samples by means of capillary electrophoresis is an original contribution of Dr Kosakowska to siderophore research. The methods she applied enabled her to achieve her objectives with ease.

The results of the research showed that:

- chlorophyll *a* content can be used as an indicator of iron uptake by both green and blue-green algae;
- the extent of the influence of siderophores on carbon dioxide assimilation and chlorophyll *a* production depends both on the type of siderophore and the algal species in question: this can be regarded as a clear indication of the potential influence of siderophores on the succession of species;

- polycarboxylic acids act in a similar way to siderophores; however, the intergenera differences are very much larger than in the case of the naturally-occurring siderophores: thus another case of human interference in natural processes has been demonstrated;
- siderophores of the type usually encountered in bacterial cultures were identified and assessed quantitatively in the abiotic components of the marine environment. This is without doubt a major discovery; well documented as they are, the results of this work have been published in numerous journals.

Dr Kosawkowska's results are a very fair reflection of the complexity of the problems she set out to investigate; she fulfilled her objectives.

The thesis was written according to a logical plan. The discussion of the significance of the results is thorough and supported by well-selected references. Great care was taken with respect to the terminology, a quite remarkable feature considering that the author was dealing with such remotely related subjects as analytical chemistry and oceanology. There are, however, some discrepancies in the chemical nomenclature relating to chelates and some errors in the structural formulas of the siderophores.

The thesis was part of the procedure leading to Dr Kosakowska's habilitation, conducted at the Biology, Geography and Oceanology Faculty of the University of Gdańsk. The procedure was completed in April 2000 when she was awarded her habilitation degree. This decision was confirmed by the Qualification Committee in October 2000. I can but add my own congratulations to Dr hab. Alicja Kosakowska for a job well done.

Janusz Pempkowiak