ECOLOGY OF TOXIC CYANOBACTERIA

Summary

Eutrophication of waters bodies, as a consequence of human activities, results in the loss of biodiversity followed by massive appearance of cyanobacteria. In freshwater ecosystems, the blooms are mostly formed by the genera *Microcystis*, *Planktothrix, Anabaena* and *Cylindrospermopsis*; in brackish and marine waters *Nodularia spumigena*, *Aphanizomenon flos-aquae* and *Trichodesmium* can thrive under favorable conditions.

Species belonging to the order Nostocales and Oscillatoriales live in filaments. The vegetative cells of Nostocales may differentiate into heterocytes and akinets. The order Chroococcales aggregates in colonies of different shape and size; they rarely produce akinets.

Cyanobacteria have developed a wide range of adaptation mechanisms which enable them to inhabit different niches of aquatic ecosystems and outcompete other phytoplankton organisms. Due to N_2 fixation, the filamentous and heterocytes forming species can grow in nitrogen depleted waters; gas vesicles are used to regulate buoyancy and adjust to optimal light intensity, while accessory pigments (phycocyanin, phycorytrin) enable them to absorb light in most efficient way. Growth of cyanobacteria is determined by a number of environmental factors, including water temperature, light intensity, ratio between nitrogen and phosphorus concentrations as well as the dynamics of water masses.

Some species produce secondary metabolites harmful to humans and animals. The compounds show hepatotoxic, neurotoxic, cytotoxic and dermatotoxic activities. Cyclic oligopeptides, termed microcystins, are the most commonly occurring cyanobacterial toxins. Like other non-ribosomal peptides, they are synthesized by thiotemplate mechanism. From one water bloom both microcystin-producing and non-microcystin-producing strains can be isolated. In some studies relationship between microcystin production and the morphology of *Microcystis* has been revealed. It was also proved that microcystin concentration in bloom material mostly depends on the contribution of toxic genotype; it is also affected by environmental factors, but to a lesser extent.

Exposure of aquatic animals to toxin-producing cyanobacteria leads to contamination of their tissues and organs. Microcystins and nodularin may accumulate in the organisms via ingestion, transdermal rout or by taking up directly from water in dissolved form. The toxins were detected in zooplankton, mussels, snails, fish and birds from freshwater and marine environments. In liver and viscera the concentration of the compounds was highest; they were also found in muscles, gonads, kidney, gills and in feather of birds. As polar compounds, cyanobacterial hepatotoxins are probably not biomagnified in aquatic food web. Some authors suggested that detoxication of aquatic organisms proceeds through formation of glutathion conjugates. The process is probably not complete, as microcystin and nodularin were detected in the animal tissues several months after the bloom of toxic cyanobacteria.

Sediments are regarded to be a secondary source of contamination of filter-feeders with the toxins. As many other compounds, microcystin and nodularin are sorbed on sediment particles, especially those with fine-grained structure.

Toxic cyanobacteria blooms pose a serious threat to humans and animals. A variety of methods and techniques, characterized by different sensitivity and selectivity, are used to assess the risk for people exposed to cyanobacterial bloom or dissolved toxin in water. Additionally, some national and international regulations were issued to protect users of drinking and recreational waters. The World Health Organization derived and recommended a provisional guideline value for drinking water of 1 $\mu g\ dm^{-3}$. In the Directive of European Union (2006/7/EC) the importance of cyanobacterial risk in bathing sites has been addressed.

With the view of the fact that cyanotoxins accumulate in edible aquatic organisms, this source of intoxication should not be overlooked.