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Summary

INFLUENCE OF MONOTERPENOID DERIVATIVES ON GROWTH OF CYANOBACTERIA

Every year, in water bodies of temperate zone, cyclic changes in biomass and taxonomic composition of phytoplankton are observed. Depending on the season and the availability of biogenic components cyanobacterial, diatomaceous, dinoflagellatae and chlorophyceae blooms may occur. The influence of blooms on the ecosystem is manifested by a decrease of biodiversity, which is the result of the dominance of one or a few species of phytoplankton. The most dangerous for humans are cyanobacterial blooms which occur in drinking water reservoirs and artificially created inland waters. Blue-green algae develop in response to increased eutrophication, but also as a result of an imbalance of the ecosystem. The massive growth of blue-green algae have a negative impact on water quality, causing a decrease in the oxygen concentration and the emergence of hydrogen sulfide in the bottom waters. The characteristic odor and taste, accompanying blooms of cyanobacteria, worsens the quality and recreational value of water. Cyanobacterial blooms appear both in the seas and in freshwater reservoir. The mass occurrence of cyanobacteria have a negative impact on the functioning of aquatic environments. This phenomenon can also decrease quality of utility water. Blue-green algae are in fact a manufacturer of compounds with a negative effect on the human and animal organisms. These microorganisms produce cyanotoxins which include: microcystin, nodularins, cylindrospermopsins, endotoxin, and anatoxin-a and its derivatives. In case of a living organisms contact with cyanotoxins may occur excessive salivation, muscle cramps, liver damage, skin irritation or paralysis of muscles. The problem of the production of cyanotoxins is still not fully resolved.

The growth and development of cyanobacteria depend on its ability to acquire the necessities of life resources and their skillful use with minimal losses. It is unlikely that any microorganism can adapt to all the changes in environmental conditions. Blue-green algae evolved adaptive mechanisms, which allow them to develop in the temporarily unfavorable conditions. One of the most important mechanism of adaptation of cyanobacteria is the ability to fix nitrogen atmosphere, which exhibits about one-third of all species of cyanobacteria. Additionally, the blue-green algae are capable of collecting and depositing nitrogen and phosphorus in cells. Ability to accumulate polyphosphate allows survival of cyanobacterial cells in the environment with deficit of these compounds. Despite numerous cysts mechanisms, cyanobacterial biomass development is influenced by: light intensity, pH, temperature, turbulence, concentrations of nitrogen and phosphorus. There are two types of blooms: the observed on the surface and that occur in the deeper layers of the water column.

Terpenes are the largest class of plant secondary metabolites. They are the main components of plant extracts and essential oils. Monoterpenes comprise the largest and structurally diverse class of terpenes. About 40 000 different molecules have been discovered to date. In addition to their application as flavour and fragrance compounds, the therapeutic properties of monoterpenes such as anticancer, antispasmodic, antihyperglycemic, antiallergenic, antiinflammatory, immunomodulatory and organoleptic properties make them interesting and desirable molecules for the pharmaceutical,

sanitary, cosmetic, agricultural and food industries. The basic structure of monoterpenes consists of isoprene units $(C_5H_8)_n$. In nature, terpenes occur predominantly as hydrocarbons, alcohols and their glycosides, ethers, aldehydes, ketones, carboxylic acids and esters. This type of compounds possesses chiral carbon atom or atoms; thus, it is possible to obtain the derivatives of spatially defined structure. Some monoterpenes are cheap and readily available. These attributes make them ideal substrates for studies regarding the search for compounds that inhibit growth of cyanobacteria.

The study of influence of monoterpenoids on growth of cyanobacteria was proved that these compounds, in most cases, reduce the growth of blue-green algae. Some experiments like influence of citronellol on growth of *C. minutus*, *N. Moravica* and *S. platensis* or *S*-(+)-carvone on *C. minutus* and *S. platens*is growth led to the death of almost all over the culture in the highest used concentrations. Only experiments with (1*R*)-(–)-fenchon and *S. platensis* and eucalyptol with *N. moravica* caused increased growth of cyanobacteria. These studies also highlighted the most resistance of *Anabaena* sp. on presence of monoterpenoids derivatives.

It has been proven that consortia of fresh-water cyanobacteria increase much better then single species. In the case of monoterpenoids derivatives there was reduced growth of consortia of cyanobacteria. Only eugenol in the slightest reduced the growth of blue-green algae. Interesting results were obtained in the case of (+)-3-carene, it caused better growth of tested consortia. Turpentine was also shown the ability to reduce the development of an investigate consortia.

Mixture of monoterpenoids also reduce the growth of cyanobacteria. The most sensitive species, in this case, was *S. platensis*. Interesting results were obtained in the case of *Anabaena* sp., which in the presence of a mixture of eugenol with *S*-(+)-carvone reduced its development, eugenol mask the effect of *S*-(+)-carvone.

The presented results were shown that selected monoterpenoids, in most cases, limited the growth of cyanobacteria. Only a few experimental systems, there were observed increased growth of blue-green algae. The study showed that each of the applied monoterpenoids otherwise affect on growth of blue-green algae. Develop of cyanobacteria can be reduced by single monoterpenoids derivatives and their mixtures. Each of the tested species characterized by different growth and sensitivity to the presence of tested substances.

Only (+)-linalool, (–)-menthol, *S*- and *R*-carvone with 25 tested compounds were biotransfomated, but with very small yields.