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CELLULAR RESPONSES AND BIOREMOVAL OF NONYLPHENOL BY THE BLOOM-FORMING CYANOBACTERIUM *PLANKTOTHRIX AGARDHII* 1113

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Abstract

Nonylphenol (NP) is extensively used in agricultural, industrial and household applications. Moreover, NP is the major breakdown product of the nonionic surfactants, nonylphenol ethoxylates (NPEOs), the most widely used group of surfactants. Nonylphenol is persistent in the environment, highly toxic to aquatic organisms and is a potential endocrine disruptor. NP and NPEOs have been identified as priority hazardous substances under the Environmental Quality Standards Directive 2013/39/EU and are referred to in the list of substances of particular risk to the Baltic Sea. The toxicity of NP to the bloom-forming cyanobacterium *Planktothrix agardhii* 1113 isolated from the eastern Gulf of Finland, Baltic Sea and the bioremoval of NP by *P. agardhii* were studied. NP in concentrations greater than 0.4 mg L^{-1} suppressed cyanobacterial growth. The median effective concentration of NP for *P. agardhii* after 4 days of treatment (EC_{50}) was 1.5 mg L^{-1}. The removal of NP from the culture medium was primarily due to abiotic processes and biodegradation by the cyanobacterium rather than sorption by the cells. NP significantly increased the photosynthetic pigments, extracellular proteins and soluble exopolysaccharides content. The cyanobacterial growth inhibition was accompanied by the increased synthesis of microcystin dm-RR and of the odorous metabolites, geosmin and 2-methylisoborneol (MIB), by *P. agardhii* 1113. NP also notably increased the microcystin released into the environment. Increased levels of extracellular proteins, soluble exopolysaccharides, microcystins and odorous metabolites may affect the microbial loop in aquatic ecosystems. An increased level of malondialdehyde (MDA) was indicative of the formation of free radicals in *P. agardhii* under NP stress, whereas increased levels of superoxide dismutase (SOD), catalase (CAT), reduced glutathione (GSH) and proline indicated the occurrence of a scavenging mechanism.

Keywords: nonylphenol, bloom-forming cyanobacterium Planktothrix agardhii, extracellular polysaccharides, extracellular proteins, oxidative stress, odorous metabolites, microcystin.

Highlights

1. NP suppressed the growth of the cyanobacterium *Planktothrix agardhii* 1113 at concentrations greater than 0.4 mg L^{-1}.
2. The removal of NP from the culture medium was primarily due to abiotic processes and biodegradation by the cyanobacterium rather than sorption by the cells.
3. NP increased the photosynthetic pigments content in cells of *P. agardhii* and extracellular proteins and soluble exopolysaccharides concentration in medium.

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