Effects of sulfate on microcystin, photosynthesis, and oxidative stress in Microcystis aeruginosa

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Abstract

Increasing sulfate in freshwater systems, caused by human activities and climate change, may have negative effects on aquatic organisms. Microcystis aeruginosa (M. aeruginosa) is both a major primary producer and a common toxic cyanobacterium, playing an important role in the aquatic environment. This study investigated the effects of sulfate on M. aeruginosa. Field study showed that microcystin has positive correlation with sulfate in water. Laboratory study presented here aims at analyzing the effects of sulfate on physiological indices, molecular levels, and its influencing mechanism. The results of our experiment showed that sulfate (at 40, 80, and 300 mg L−1) inhibited M. aeruginosa growth, increased both intracellular and extracellular toxin contents. Sulfate inhibited the photosynthesis of M. aeruginosa, based on the decrease in pigment content and the down-regulation of photosynthesis-related genes after sulfate exposure. Furthermore, sulfate decreased the maximum electron transport rate, causing the cell to accumulate surplus electrons and form reactive oxygen species (ROS). Sulfate also increased the malondialdehyde (MDA) content, which showed that sulfate damaged the cytomembrane. This damage contributed to the release of intracellular toxin to the culture medium. Although sulfate increased superoxide dismutase (SOD) activities, expression of sod, and total antioxidant capacity in M. aeruginosa, it still overwhelmed the antioxidant system since the ROS level simultaneously increased, and finally caused oxidative stress. Our results indicate that sulfate has direct effects on M. aeruginosa, inhibits photosynthesis, causes oxidative stress, increases toxin production, and affects the related genes expression in M. aeruginosa.

Key words: sulfate; Microcystis aeruginosa; microcystin