Water Air Soil Pollut (2021) 232:135
https://doi.org/10.1007/s11270-021-05088-1

Egeria densa Allelopathy on *Microcystis aeruginosa* Under Different Light Intensities and Preliminary Insight into Inter-Parameter Relationships

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Received: 29 December 2020 / Accepted: 18 March 2021

Abstract *Egeria densa* release allelochemicals harmful to other species, including cyanobacteria. Under natural conditions, *E. densa* and *Microcystis aeruginosa* can be found in various aquatic systems with different light levels. The effect that the coexistence of *E. densa* has on *M. aeruginosa* was tested under different photosynthetically active radiation (PAR) intensities. The growth, chlorophyll-a, oxidative stress, and antioxidant activities of *M. aeruginosa* were quantified after 7 days of coexistence with *E. densa*. A control experiment without *E. densa* was conducted for *M. aeruginosa* under the same conditions to distinguish the effect of the PAR intensity from the allelopathic effect. The allelopathy of *E. densa* on *M. aeruginosa* is significantly influenced by the PAR intensity. PAR intensities lower or higher than the favorable range further suppressed *M. aeruginosa* under coexistence. Research has revealed that the allelopathic effect of *E. densa* can be utilized to biologically suppress *M. aeruginosa* under various light conditions. Strong second-order polynomial distributions between the optical density (OD) and cellular H_2O_2 content of *M. aeruginosa* were found for both the control and coexistence conditions. In the practical application of *E. densa* allelopathy, OD can be adopted as a convenient method to obtain an approximate stress status on *M. aeruginosa*.

Keywords Biological control · Cyanobacteria · Coexistence · Environmental management · Macrophytes · Species interactions

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1 Introduction

Nutrients, especially N and P loading through both point and non-point sources, favor cyanobacteria proliferation in freshwater while temperature increments in parallel with global warming augment the former process (Hobbie et al., 2017; Lürling et al., 2018; Wells et al., 2015). Some of these cyanobacteria produce various cyanotoxins, such as 2-MIB and Geosmin. Thus, the quality of aquatic ecosystems deteriorates with the presence of unpleasant odors, clogging, and lack of esthetic value with the massive growth of cyanobacteria. Furthermore, cyanotoxins produced by these organisms, such as microcystins, cause significant health issues, including death (Ferrão-Filho & Kozlowsky-Suzuki, 2011; Howard, 1994; Manganelli et al., 2012; Mowe et al., 2015; Shi et al., 2017). In addition to health issues, the massive growth of cyanobacteria form blooms in aquatic systems, causing abundant environmental damage. For instance, these blooms completely interrupt light penetration, consequently disturbing the integrity of aquatic systems. With the massive growth of cyanobacteria and the

Published online: 30 March 2021