

Changes in pigment composition of phytoplankton in coastal waters and its relationship to copper toxicity.

*Izumi Ishizaki¹, Kuo Hong Wong², Takamura Akihiro¹, Yoshiko Kondo³, Hajime Obata⁴, Asami Mashio², Hiroshi Hasegawa²

1. Graduate School of Natural Science, Kanazawa University, 2. Institute of Science and Engineering, Kanazawa University, 3. Faculty of Fisheries, Nagasaki University, 4. Atmosphere and Ocean Research Institute, The University of Tokyo

Introduction

Phytoplankton are key primary producers in the ocean and exhibit variable rates of primary production depending on the species. However, these marine microorganisms are vulnerable to damage from high concentrations of copper in seawater. Copper uptake by phytoplankton cells leads to the generation of highly toxic reactive oxygen species. As a defense mechanism, phytoplankton may produce specific pigments for detoxification. In this study, we investigated the changes in pigment composition of marine phytoplankton exposed to copper. Additionally, we elucidated the distribution of photosynthetic pigments in the Ariake Sea, in order to understand the response of natural phytoplankton communities to environmental stress.

Methods

Incubation experiments were conducted with a marine cyanobacterium (*Synechococcus* sp.) under laboratory conditions. We utilized f/2 culture medium in our experiments and the phytoplankton were placed within an incubator set to 20°C, 50% humidity, an irradiation of 180 mmol E m⁻² s⁻¹, and a 12 hour –12 hour light-dark cycle. The Cu²⁺ concentrations in the culture medium were set to 0, 10⁻¹¹, and 10⁻¹² M.

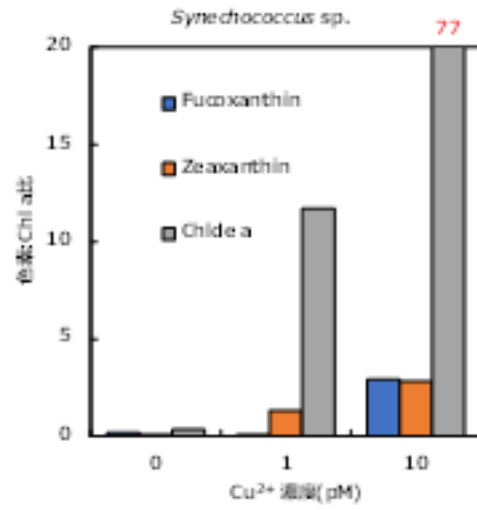
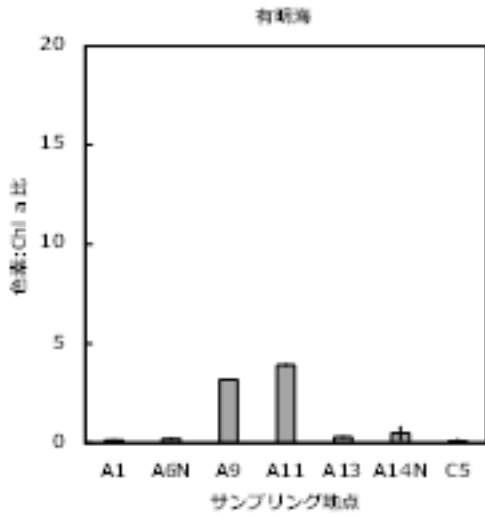
Seawater samples from Ariake Sea were collected using R/V Kakuyo Maru in November 2023. Particulate matter from the samples were isolated using GF/F filters with a 0.7 μm pore size. Pigments were then extracted with an organic solvent and separated into chlorophyll a (Chl a), chlorophyllide a (Chlde a), fucoxanthin, and zeaxanthin using HPLC. These were quantification using either fluorescence or a diode array detector.

Results and Discussion

Chl a concentration in *Synechococcus* sp. were 0.43 μg/L under no copper exposure and decreased to 0.024 μg/L and 0.0042 μg/L under 0 M, 10⁻¹¹ M, and 10⁻¹² M Cu²⁺ conditions, respectively. Conversely, chlde a concentrations were 0.15 μg/L, 0.28 μg/L, and 0.32 μg/L in these conditions. Notably, the ratios of zeaxanthin to chl a and fucoxanthin to chl a remained largely unchanged despite increased Cu²⁺ concentration. However, chlde a to chl a ratios increased substantially, ranging from 6 to 35 fold, under high Cu²⁺ conditions. This suggests a significant alteration in the pigment composition of phytoplankton cells due to copper toxicity. In the Ariake Sea, chlde a to chl a ratios at stations A9 and All were 3.2 and 3.9, respectively, significantly higher than at other stations where the ratios were generally less than 1.0. This suggests that the phytoplankton communities in those areas might be experiencing environmental stress.

Keywords: Ariake sea, Chlorophyll, Cyanobacteria, Toxic assessment

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