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Growth and uptake kinetics of nitrate and phosphate by benthic microalgae for phytoremediation of eutrophic coastal sediments

Hyeong Kyu Kwon, Seok Jin Oh *, Han-Soeb Yang

Department of Oceanography, Pukyong National University, 45 Yongso-ro, Nam-Gu, Busan 608-737, Republic of Korea

HIGHLIGHTS

- We investigated the uptake rates of nitrate and phosphate by 4 benthic microalgae.
- The uptake rate were high in the order of blue, mixed, red, yellow wavelength.
- The *Nitzschia* sp. showed the highest specific uptake rates under all wavelengths.
- The *Nitzschia* sp. may be a useful species for phytoremediation.

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ABSTRACT

In the present study, the effect of monochromatic light (blue, yellow and red) and mixed wavelength on the nutrient uptake and growth kinetics of benthic microalgae *Achnanthes* sp., *Amphora* sp., *Navicula* sp. and *Nitzschia* sp. were investigated. The maximum uptake rate (ρ_{max}) for nitrate and phosphate obtained by short-term experiments were high in the order of blue, mixed, red, yellow wavelength, and among the 4 benthic microalgae, *Nitzschia* sp. was the highest ρ_{max}. The half-saturation constant (*Ks*) was higher than other taxon. The specific maximum growth rate (μ'_{max}) and minimum cell quota (q_0) for the nitrogen and phosphorus-limited condition, *Nitzschia* sp. showed the highest μ'_{max} and q_0 values among the 4 benthic microalgae. These results suggest that the benthic microalgae are adapted to high nutrient concentration. In particular, *Nitzschia* sp., which have a higher capability of storage and uptake, may be a useful species for phytoremediation.

1. Introduction

In the greater part of the bay in South Sea of Korea, domestic sewage and industrial wastewater, as well as self-pollution from aquaculture activity, are increasing organic pollution of the sedimentary environment in the coastal areas. The change in sediment quality of these environments is extremely limited compared with seawater because the material exchange in sediment is only accomplished by means of pore water. In particular, because of the low exchange rates in the semi-closed bay, decomposition of accumulated organic matter leads to anoxic conditions at the sediment–water interface. These conditions, in turn, lead to problems such as a decrease in microbial activity, loss in biodiversity, and the accumulation of toxic gasses (*i.e.* ammonia and hydrogen sulfide). To remediation of the eutrophic coastal sediments, physical methods (dredging and aeration), chemical methods (additional yellow loess, slag and oyster shell) and biological methods (microbial activity) have been used (Murphy and Prepas, 1990; Karim et al., 2003; Yamamoto et al., 2008; Asaoka and Yamamoto, 2010).

In Korea, the dredge is considered to be the most practical method, and it is used throughout the enclosed eutrophic bay. However, it need huge budgets as paid the 42 billion won for a 5 year (1 dollar = *ca.* 1300 won) in Masan Bay, where is one of eutrophic coastal area of Korea. Moreover, the method generated secondary problems such as silt diffusion, prohibition of agricultural work, treatment of contaminated dredged sediment and the huge budget. Therefore, ideal remediation methods should be eco-friendly methods as phytoremediation, which enough leads to self-purification system with natural environment, and is not a surgical operation such as dredging.

Light is the important energy inducing photosynthesis of microalgae. The spectral quality of light is known to affect many aspects of the physiology: pigment composition, photosynthesis, chemical composition, growth rate, and ion transport (Wallen and Geen, 1971; Kowallik, 1987; Oh et al., 2008; Das et al., 2011). Some researchers have investigated the effects of monochromatic light on growth in several microalgae (Sánchez-Saavedra and Voltolina,

* Corresponding author. Tel.: +82 51 629 6576; fax: +82 51 629 6568.
E-mail address: sjoh1972@pknu.ac.kr (S.J. Oh).

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