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Coupled nutrient removal and biomass production with mixed algal culture: Impact of biotic and abiotic factors

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HIGHLIGHTS

- ▶ Compare the performance of individual algae species and mixed algal culture.
- ▶ Cultivate a mixed algal culture consisted of three unicellular microalgae.
- ▶ Investigate the effect of illumination cycle, mixing velocity on nutrient removal.
- ▶ Monitor the effect of nutrient, algal inoculum concentration on removal performance.

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ABSTRACT

The influence of biotic (algal inoculum concentration) and abiotic factors (illumination cycle, mixing velocity and nutrient strength) on the treatment efficiency, biomass generation and settleability were investigated with selected mixed algal culture. Dark condition led to poor nutrient removal efficiency. No significant difference in the N, P removal and biomass settleability between continuous and alternating illumination was observed, but a higher biomass generation capability for the continuous illumination was obtained. Different mixing velocity led to similar phosphorus removal efficiencies (above 98%) with different retention times. The reactor with 300 rpm mixing velocity had the best N removal capability. For the low strength wastewater, the N rates were 5.4 ± 0.2, 9.1 ± 0.3 and 10.8 ± 0.3 mg/l/d and P removal rates were 0.57 ± 0.03, 0.56 ± 0.03 and 0.72 ± 0.05 mg/l/d for reactors with the algal inoculum concentration of 0.2, 0.5 and 0.8 g/l, respectively. Low nutrient removal efficiency and poor biomass settleability were obtained for high strength wastewater.

1. Introduction

Municipal wastewater containing both organic carbon and nutrient could cause eutrophication and deterioration of aquatic ecosystems. These substances need to be removed or captured from wastewater before reuse or return to the environment. A stable and high carbon removal could be easily achieved with many conventional biotechnologies, while nutrient removal is a complex and costly process which involves several steps and technologies (Ahn, 2006; Oehmen et al., 2007; Yeoman et al., 1988). Therefore, optimizing cost effective and efficient technologies for one-step tertiary treatment of wastewater is now given high priority.

Microalgae are an important bioresource that could be further used for biofuels production (Rawat et al., 2011). They are regarded as a potential bioenergy source to face the global threats of fuel shortage. However, cost-effective algae cultivation and harvesting are two obstacles to the exploitation of this technology (Mohn, 1988; Nurdogan and Oswald, 1995). Municipal wastewater is rich in nitrogen, phosphorus and trace metal elements and thus could offer a readily available and cost-effective growth medium for microalgae. The microalgae could assimilate nutrient (NH_4^+, PO_4^{3-}, NO_3^- and NO_2^-) in the wastewater thus integrating of wastewater purification and algal biomass production (Su et al., 2011).

Certain unicellular microalgae such as *Chlorella*, *Scenedesmus*, *Phormidium* and *Chlamydomonas* have been reported as high-potential candidates for domestic wastewater treatment and biofuel production (Gutzeit et al., 2005; Lin and Lin, 2011; Olguin, 2003; Rawat et al., 2010). However, it is difficult to maintain pure culture during the operation because of constant airborne contamination in the open system and impacts from the wastewater (Perez-Garcia et al., 2011). Furthermore, to the best of our knowledge, there are few studies on the mixture of unicellular microalgae for municipal wastewater treatment and whether mixed algal culture could

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