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Immobilization of *Chlorella sorokiniana* GXNN 01 in alginate for removal of N and P from synthetic wastewater

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ABSTRACT

High costs and issues such as a high cell concentrations in effluents are encountered when utilizing microalgae for wastewater treatment. The present study analyzed nitrogen and phosphate removal under autotrophic, heterotrophic, mixotrophic and micro-aerobic conditions by *Chlorella sorokiniana* GXNN 01 immobilized in calcium alginate. The immobilized cells grew as well as free-living cells under micro-aerobic conditions and better than free-living cells under the other conditions. The immobilized cells had a higher ammonium removal rate (21.84%, 43.59% and 41.46%) than free living cells (14.35%, 38.57% and 40.59%) under autotrophic, heterotrophic, and micro-aerobic conditions, and higher phosphate removal rate (87.49%, 88.65% and 84.84%) than free living cells (20.21%, 42.27% and 53.52%) under heterotrophic, mixotrophic and micro-aerobic conditions, respectively. The data indicate that immobilized *Chlorella sorokiniana* GXNN 01 is a suitable species for use in wastewater treatment.

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1. Introduction

Chlorella spp. are a unicellular green microalgae that have a high photosynthetic efficiency (Zelitch, 1971) and absorb nutrients from culture media during rapid growth periods (Qiao et al., 2009). Since *Chlorella* spp. also have a higher capacity than other algae for wastewater nutrient removal, they are regarded as potentially useful as wastewater treatment agents (Gonzalez et al., 1997; Hammouda et al., 1995).

Wastewater treatment by microalgae to remove nitrogen and phosphorus has been studied for almost 50 years (Oswald et al., 1957; Shi et al., 2007), but the presence of free-living microalgae in treated effluents remains a problem (Chevalier and de la Noue, 1985). Recent research has therefore focused on the use of immobilized microalgae (Jimenez-Perez et al., 2004; Tam and Wong, 2000). Alginate has become the most commonly-used polymer in which microalgae are entrapped, because of its high diffusivity, low production hazards, low polymer costs, and a simple and fast immobilization process (Bashan, 1986; De-Bashan and Bashan, 2010).

Not all microalgae can thrive in a matrix (Moreno-Garrido et al., 2005; Moreno-Garrido, 2008) possibly because of diminished light penetration and nutrient diffusion or chemical interactions that cause severe stress (De-Bashan and Bashan, 2010). Some microalgae can damage alginate beads (Moreno-Garrido, 2008). Therefore, it is important to find suitable microalgae species that can survive and grow in alginate beads under relatively low illumination and in micro-aerobic or anaerobic conditions.

Chlorella sorokiniana GXNN 01, isolated from a wastewater treatment pond sample, grows under autotrophic (AA) conditions and has the capability to utilize multiple carbon sources during rapid growth conditions (Qiao et al., 2009). Of particular interest is its ability to assimilate carbon sources under micro-aerobic (MNA) conditions (Qiao et al., 2009). Such conditions are more cost-effective since little or no aeration is required during treatment. The present study investigated the feasibility of using *C. sorokiniana* GXNN 01 in immobilized form for removal of nitrogen and phosphate from a synthetic wastewater under autotrophic (AA), heterotrophic (HA), mixotrophic (MA) and micro-aerobic (MNA) (supplemented with acetate) conditions. The study also compared the growth rate and photosynthetic efficiency of free-living cells.

2. Methods

2.1. Microalgae cultivation and immobilization

C. sorokiniana GXNN 01 (Qiao et al., 2009) was maintained in TAP medium (Harris, 1989) without acetate, and provided with a mean light intensity of 40 μmol m^{-2} s^{-1} under a 12 h:12 h light:dark (L:D) cycle at 20 ± 2 °C. The medium was changed every 2 months.

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