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Effects of Fe^{2+} concentration on biomass accumulation and energy metabolism in photosynthetic bacteria wastewater treatment

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HIGHLIGHTS

- Twenty milligram/L Fe^{2+} enhanced PSB mass production by 50%, and increased the COD removal.
- Twenty milligram/L Fe^{2+} reduced the hydraulic retention time of soybean wastewater by 25%.
- Fe^{2+} could improve the efficiency of biomass recycling in PSB wastewater treatment.
- There was an intracellular Fe^{2+} concentration 16 mg/L that PSB adapted to.
- Different Fe^{2+} concentrations had different impacting mechanisms on PSB biomass.

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ABSTRACT

Photosynthetic bacteria (PSB) wastewater treatment has the advantage of biomass recovery in together with pollutant removal. The effects of different Fe^{2+} concentrations on the biomass accumulation through regulating energy metabolism were investigated in PSB wastewater treatment. Results showed that the optimal Fe^{2+} dosage was 20 mg/L. Optimal Fe^{2+} content could significantly increase the biomass production (4800.9 mg/L) and COD removal (93.4%). Addition of 10–30 mg/L Fe^{2+} could shorten the hydraulic retention time of wastewater. Mechanism analyses revealed that different Fe^{2+} concentrations had different impacting mechanisms on biomass accumulation. Fe^{2+} constituted the dehydrogenase active center, and therefore proper addition of Fe^{2+} could improve energy production by up-regulating dehydrogenase activity, which was beneficial for biomass accumulation. With 20 mg/L Fe^{2+}, the dehydrogenase activity and ATP production of PSB were improved by 48.1% and 42.4%, respectively. However, excessive addition of Fe^{2+} was harmful for biomass accumulation since the ions inhibited the dehydrogenase activity.

1. Introduction

Photosynthetic bacteria (PSB) wastewater treatment has received considerable attentions since it can realize wastewater purification and biomass recycling simultaneously. Since 1960s, scientists have used PSB to treat wastewaters, and the results showed that PSB could effectively treat cadmium wastewater, olive mill wastewater, sulfide containing wastewater, sea food wastewater and palm oil mill effluent (Afsar et al., 2011; Kaewsuk et al., 2010). Moreover, the biomass was valuable resources for high-value biochemical substances such as single cell protein, biopolymers, antimicrobial agents, carotene, pantothenic acid and therapeutic compounds, and was nontoxic and harmless (Kuo et al., 2012; Sabourin-Provost and Hallenbeck, 2009). Therefore, PSB were regarded as suitable renewable raw materials for the production of natural biochemical substances. Furthermore, the PSB biomass has been widely used as feed in the aquaculture industry.

The feasibility of realizing biomass resources recycling in PSB wastewater treatment relies on the maximization of biomass production. However, the biomass production is low in traditional PSB wastewater treatment process, which limits the recycling of biomass resources. Therefore, the improvement of PSB biomass production in wastewater treatment becomes the key in order to promote the biomass resources recycling.

At present, the biochemical engineering is the main way to improve the production of microorganisms' biomass and target products (Dorval Courchesne et al., 2009). The biochemical engineering approach here refers to the strategy of enhancing biomass accumulation by controlling the nutritional or cultivation conditions (e.g., nitrogen and phosphorus) to channel metabolic flux into biomass biosynthesis (Dorval Courchesne et al., 2009). And addition of metal ions is a well established biochemical engineering approach. Among metal ions, Fe^{2+} is the preferred one due to its affordability and importance for biological growth.

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