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審査研究科	生命環境科学研究科
学位論文題目	Study on the Stability and Performance of Algal-bacterial Granular Symbiosis System by Using Sequencing Batch Reactor （回分式反応槽を用いた藻類−細菌共生グラニュールシステムの安定性と処理能力に関する研究）

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論　文　の　要　旨
Abstract of thesis

Low chemical oxygen demand to nitrogen (COD/N) ratio in real wastewater and high energy consumption by aeration units in conventional activated sludge (AS)-based wastewater treatment plants (WWTPs) are the major issues for cost-effective and sustainable management of WWTPs worldwide. On the other hand, algal-bacterial consortia system is regarded as a competitive alterative for conventional AS process owing to its unique features such as less energy demand for organics degradation, enhanced nutrients removal and high resources recovery potential. However, algae harvesting and separation from the treated water is still challenging the current algal-bacterial consortia systems due to the small size of microalgae cells. Previous research works have proven that algal-bacterial aerobic granular sludge (AGS) system possesses compact granular structure and good biomass settleability, demonstrating its more advantages over conventional bacterial AGS and algal-bacterial consortia systems. This doctoral research examined the granular stability and nutrients removal performance during wastewater treatment under two typical conditions, i.e. low COD/N ratio wastewater and no air bubbling which is usually applied for bacterial AGS systems and consumes 40-60% energy of the whole WWTP. In order to shorten the granulation period, algal-bacterial AGS was cultivated from mature bacterial AGS. Results from this research are expected to provide important and scientific data for the design and realization of algal-bacterial AGS application in practice.

The dissertation is divided into 5 chapters. In Chapter 1, the author introduced the research background and significance based on literature review. In this chapter the author specifically addressed the major issues limiting the cost-effective and sustainable management of WWTPs, including low COD/N ratio influent wastewater, high energy consumption by the aeration units in the conventional WWTPs, and some promising alternative like

algal-bacterial consortia system and its challenging aspects, and then arrived at the objectives and framework of the thesis. In Chapter 2, the author investigated the possibility of establishment of algal-bacterial granular system by seeding mature bacterial AGS under light illumination with no algae inoculation. The obtained mature algal-bacterial granules exhibited a compact structure with high stability, large size, and good settling properties with relatively higher total nitrogen (TN) and total phosphorus (TP) removal efficiencies than the bacterial AGS system. More importantly, the algal-bacterial AGS contained higher P content (44.2 mg/g of suspended solids (SS)) with higher P bioavailability (92%), indicating its high potential for P recovery. In Chapter 3, the author researched the impact of low influent COD/N ratio on the algal-bacterial AGS system. Results showed that the integrity coefficient of the tested algal-bacterial AGS reactor stabilized at 0.7-5.4% when the influent COD/N ratio stepwise decreased from 8 to 1. The author also found that the lower influent COD/N ratio (2 and 1) might negatively impact the nitritation process in the algal-bacterial AGS system, while the obtained algal-bacterial AGS biomass contained high P content (28.3 mg/g-SS) with extremely high P bioavailability (up to 98%) under the low influent carbon condition (COD/N = 1). In Chapter 4, the author focused on the stability of algal-bacterial AGS in shaking photoreactors instead of air bubbling usually applied for both algal-bacterial AGS and bacterial AGS systems in previous studies. The preliminary results indicated that the algal-bacterial AGS with good granular integrity (~8.4%) could produce low dissolved organic carbon (DOC, < 14 mg/L) effluent with high TN removal (66.9-76.1%). High P bioavailability (92%) was still maintained in the algal-bacterial AGS biomass while its TP removal greatly varied (15.1-71.6%), attributable to the designed light/dark cycle and hydraulic/sludge retention time. More in-depth research on mechanisms involved in this system is proposed for better design of this kind of no air bubbling system, targeting more nutrients removal with less or no additional energy consumption. Finally, in Chapter 5 the author summarized the major conclusions of the thesis, and also pointed out the future research directions.

審　　査　　の　　要　　旨
Abstract of assessment result

This research explored the influence of two major limiting factors, i.e. low influent COD/N ratio and no air bubbling, on the performance and stability of algal-bacterial AGS systems which was developed from mature bacterial AGS under light illumination. When the influent COD/N stepwise decreased from 8 to 1, the algal-bacterial AGS could maintain its granular stability and highly efficient nutrients removal performance. The granular stability and performance could also be maintained when the algal-bacterial AGS was examined in shaking photoreactors instead of air bubbling applied for conventional bacterial AGS cultivation. High P content and P bioavailability were detected in the algal-bacterial AGS under both tested conditions. Although in-depth research works are demanding with respect to the influence of light/dark cycle and hydraulic/sludge retention times on the stability and performance of the algal-bacterial AGS, results from the current research reflect the great potential of this novel algal-bacterial AGS system in practice, when taking its stable performance and granular stability in coping with low carbon wastewater and low energy consumption into consideration.

The final examination committee conducted a meeting as a final examination on 18 January, 2019. The applicant provided an overview of the dissertation, addressed questions and comments raised during Q & A session. All of the committee members reached a final decision that the applicant has passed the final examination.

Therefore, the final examination committee approved that the applicant is qualified to be awarded the degree of Doctor of Philosophy in Environmental Studies.