氏名	NURAMKHAAN MARJANGUL
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主査	筑波大学准教授	工学博士	雷　中方
副査	筑波大学教授	博士（農学）	張　振亜
副査	筑波大学准教授	博士（農学）	清水　和哉
副査	筑波大学准教授	博士（理学）	内海　真生

論　文　の　要　旨
Abstract of thesis

Algal-bacterial aerobic granular sludge (AGS) is one of the most promising biotechnologies for wastewater treatment, in which algal and microbial cells can aggregate into a dense and compact structure, yielding high biomass content with excellent settling ability and nutrients uptake, and outstanding potential for energy saving to treat various wastewaters. Microalgae in algal-bacterial AGS are regarded to be highly capable of N and P removal from wastewater, and they can convert nutrients into biomass that can be utilized as resources for renewable energy and fuels, thus further reducing greenhouse gasses emission. Previous studies mainly focused on the formation of algal-bacterial AGS by inoculating microalgae with or without bacterial AGS as the seed sludge under different operation conditions. Up to now, however, the mechanisms involved in the formation of algal-bacterial AGS remain unclear, and the contribution of biological factors to the granulation of algal-bacterial symbiosis system hasn’t been addressed yet. This study attempted to figure out the contribution of microalgae to the granulation of algal-bacterial symbiosis system and nutrients removal.

This dissertation is divided into 5 chapters. In Chapter 1, the author introduced the research background and literature review. In this chapter, the author discussed the existing problems of wastewater treatment, especially in developing countries. Then the author provided a brief review on the promising biotechnology, aerobic granular sludge (AGS) and algal-bacterial AGS, and their unsolved issues. At the end of this chapter, the objectives and framework of this research were presented. In Chapter 2, the author investigated the dynamic changes of dominant bacteria or

microalgae during 90 days' operation of two identical sequencing batch reactors(SBRs) after being inoculated with two types of algal-bacterial AGS. Results show that the classes of *Alpha-*, *Beta-*, *Gamma-*, and *Delta*-proteobacteria and *Flavobacteria* dominated both reactors, which remarkably decreased during the later stage of operation. As for algal community, cyanobacteria and unclassified groups were the dominant ones. Some species were found to contribute to the instability of algal-bacterial AGS and its breakage during the long-term operation. In Chapter 3, the author isolated two microalgal strains (A1 and A2) from the algal-bacterial AGS in the above two reactors. Both isolated microalgae belonged to the genus *Chlorella*. The strain A1 always exhibited a faster biomass growth and higher auto-aggregation index (82.4% on day 5) with excellent nutrients (N and P) removal, about 93-96% when treating wastewater containing 50 mg-NH_4-N/L and 5 mg-PO_4-P/L. In addition, the total extracellular polymeric substances (EPS) content of the isolated strains were found to have a strongly positive correlation (r^2=0.95 for A1 and r^2=0.92 for A2) with auto-aggregation capability under the test light/dark (12 h/12 h) condition. In Chapter 4, the author inoculated the two microalgal strains A1 and A2 respectively into two SBRs with seed activated sludge. The inoculated microalgae were observed to help the fluffy activated sludge to transform into a little bit tight structure, initiating the formation of algal-bacterial granules. The dynamic changes of the bacterial and microalgal profiles also shed light on the mechanisms regarding the formation and stable operation of algal-bacterial AGS. Finally, in Chapter 5, the author summarized the major conclusions, and proposed the future research directions.

審　査　の　要　旨
Abstract of assessment result

Algal-bacterial aerobic granular sludge (AGS) process is promising in wastewater treatment due to its great potentials for high efficiency nutrients removal, further reduction in energy consumption and greenhouse gasses emission, and long-term operation stability. All these merits are mainly attributable to the co-existence of algae and bacteria in the AGS. Up to now, however, the real mechanisms and the contributions of biological factors remain unclear. This research for the first time attempted to figure out the contribution of microalgae to the formation of algal-bacterial AGS and nutrients removal. In this study, the author found that the dominant microalgae exhibited some typically similar change in the tested two types of algal-bacterial AGS during 90 days' operation. After two major microalgal strains being isolated from the two algal-bacterial AGS systems, their nutrients removal and aggregation capability were evaluated. Results show that one of the isolated algae (A1) with fast biomass growth rate and high auto-aggregation index (82.5% on day 5) could remove 93-96% of N and P under cultivation at light/dark cycle of 12h/12h. When being further inoculated into two sequencing batch reactors (SBRs), they also exhibited acceleration effect on granulation process of activated sludge. The results from this study suggest that inoculation of some proper algae species into bacterial granulation system may facilitate the formation and stable operation of algal-bacterial AGS system. Further research work is necessary on the isolation of other dominant algae and their contribution, and the interaction between algae and bacteria to the formation of algal-bacterial AGS.

The final examination committee conducted a meeting as a final examination on 14 January, 2020. 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.