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EFFECT OF DIFFERENT LIGHT INTENSITIES ON AMMONIA REMOVAL PERFORMANCE IN A CONSORTIUM OF MICROALGAE AND PARTIAL NITRIFYING GRANULES

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Introduction. Ensuring environmentally-friendly treatment technologies for ammonia-containing wastewater is one of the key challenges for our society. The commonly used process for ammonia removal from wastewaters is biological nitrification-denitrification in which ammonia is oxidized into nitrogen oxides (mainly NO_3^-) during nitrification while nitrogen oxides are converted into N_2 gas during denitrification. However, nitrification needs costly-mechanical aeration and denitrification needs extra carbon additive to proceed their reactions. Thus, a more cost- and energy-effective alternative method is should be developed. A microalgal-nitrifying bacteria consortium is expected as an alternative method because microalgae can supply sufficient oxygen for bacteria to remove biodegradable pollutants through photosynthesis [1]. Ammonia removal through NO_2^- (i.e. partial nitrification followed by denitritation) can save 25% of aeration costs and 40% of carbon additive due to shortening of process [2]. The combination of microalgae with partial nitrification will be one of the best ways for energy-cost-effective treatment of ammonia. The aim of this study is to evaluate ammonia removal activity in a consortium of microalgae and partial nitrifying granules under different light intensities imitating actual fluctuation of sunlight intensity. Bacterial granules were used in this study due to its high sedimentation property and an ability to maintain bacteria in a reaction tank, leading to high treatment capability [3].

Methodologies. Microalgae (*Chlorella sorokiniana*) and the partial nitrifying granules preliminary formed in the laboratory at Soka University were used as inoculums. The identical serum bottles with an effective volume of 100 mL were used as reactors. The microalgae and the granules were added to each reactor, leading to initial suspended solid (SS) concentration of 1.0 g L^{-1} (microalgae: granules = 1:1). The synthetic ammonia-containing wastewater was fed into each reactor to achieve initial NH_4^+-N concentration of 43 mg-N L^{-1}. The reactors were exposed to continuous illumination using LED light devise (custom-ordered, Iida Lighting Co., Japan) for 72 hours. The incident light intensities were adjusted to 0 (dark), 100, 450 and 1600 µmol photons m^{-2} s^{-1}. The variation of dissolved oxygen (DO) and ions (NH_4^+-N, NO_2^--N, NO_3^--N) during the experiments were measured.

Results. During the experimental period, all reactors showed aerobic condition with the relatively high DO values ranging from 6.44 to 8.84 mg L^{-1}. This result represents that sufficient oxygen to proceed nitrification existed in the all reactors. The relatively large amount of NH_4^+ reduction and NO_2^- production was observed in the dark condition (Fig. 1a), leading to NH_4^+ removal activity of 9.35 mg-N g-SS^{-1} day^{-1} and partial nitrifying activity of 8.41 mg-N g-SS^{-1} day^{-1}, respectively. In the lower light irradiation condition (100 µmol photons m^{-2} s^{-1}), the partial decrease in the performances of NH_4^+ reduction and NO_2^- production was observed compared to the dark condition (Fig.1b). In the higher light irradiation conditions (450 and 1600 µmol photons m^{-2} s^{-1}), NH_4^+ reduction and NO_2^- production were observed at the beginning of the experiments, but then the reactions stopped (Fig. 1c, 450 µmol photons m^{-2} s^{-1}) or occurred reverse reactions (Fig. 1d, 1600 µmol photons m^{-2} s^{-1}). These results indicate that strong light irradiation inhibits nitrification performance, especially in the prolonged irradiation period more than a half or one day. This argument is coincident with some previous literatures which mentioned that nitrifying bacteria are sensitive to light exposure [4,5]. As a result, the consortium of microalgae and partial nitrifying granules can be performed effectively under lower light intensity below approximately 100 µmol photons m^{-2} s^{-1} and some strategies to mitigate light irradiation (e.g. use of shading nets) should be conducted when the proposed process is applied under natural sunlight condition.

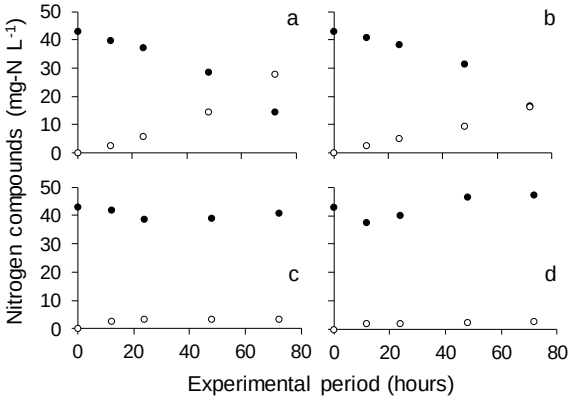

Fig. 1. Variation in nitrogen compounds under different light intensities. a: 0; b: 100; c: 450; d: 1600 µmol photons m^{-2} s^{-1}. ●: NH_4^+-N; ○: NO_2^--N.

Conclusions. Ammonia removal performance of a consortium of microalgae and partial nitrifying granules was evaluated under different light intensities. In the dark condition, the highest NH_4^+ removal and partial nitrifying activities were observed. With an increase in light intensity, the nitrifying activities decreased. Moderate light is suitable to perform the reaction effectively.

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