INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study : Ph.D.

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Ammonium rich wastewater treatment and value addition using microalgae-bacterial consortia in photo-activated systems.

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The conventional activated sludge process (ASP) for ammonium removal relies on mechanical aeration. In addition to very high operating cost due to mechanical aeration, ASP requires addition of external carbon source for nitrification and denitrification. On the other hand, microalgae-bacteria consortia are not only able to grow autotrophically on ammonium but also offer advantages, such as high N affinity, anoxic zone for denitrification, algal photosynthesis, shortcut nitrogen removal, biomass with good settling characteristics and energy production. Hence, this work was aimed at treatment and value addition to ammonium rich wastewater by using microalgae-bacterial consortia. The microalgae-bacterial biomass was initially studied for its ability to remove ammonium at a high concentration of 200 mg/L. Addition of organic carbon source in a photosequencing batch reactor (PSBR) during the dark period enhanced the activity of denitrifying bacteria (DNB) in the microalgae-bacterial consortium, which resulted in nitrogen as the main end product. Detailed bio-kinetics of ammonium removal by the microalgae-bacterial consortium revealed an active role played by microalgae, ammonium oxidizing bacteria (AOB), nitrite oxidizing bacteria (NOB) and DNB for achieving an efficient removal of ammonium. Both the ammonium and nitrogen gas production were best described by using the microalgae-AOB-methanol utilizing denitrifier (MUD) based bio-kinetic models. Also, the profiles of ammonium, nitrite, nitrate and DO in this study were accurately predicted by the microalgae-AOB-MUD bio-kinetic models. Estimated values of the bio-kinetic model parameters further supported the shortcut nitrogen removal without nitrate formation by microalgae, AOB and DNB in the consortium. Light intensity significantly affected the ammonium removal by microalgae-AOB-NOB consortium. Empirical model as mentioned earlier showed that light intensity below 40 µmol photons m^{-2} s^{-1} was ineffective towards nitrification due to oxygen limitation condition. Light intensity in the range 40-160 µmol photons m^{-2} s^{-1} was found suitable for complete nitrification, whereas a light intensity above 100 µmol photons m^{-2} s^{-1} caused inhibition of microalgal-AOB-NOB consortium, thereby resulting in a low nitrification efficiency. The effect of different nitrogen source competition using microalgae-bacterial consortia on ammonium removal was further studied and the NH_4^+ removal rate values were similar at 50 and 100 mg NH_4^+-N/L respectively, indicating enhancement in ammonium removal by both nitrification and microalgae uptake. By comparing the results from this work with a previous study, O_2 supplied by microalgae through NH_4^+ uptake was found to strongly influence the overall NH_4^+ removal by consortium. Finally, ammonium removal by algae-AOB-DNB consortium was integrated in a microbial fuel cell (MFC) and the system was referred as an integrated shortcut nitrogen removal-microbial fuel cell. This study provided direct evidence of shortcut nitrogen removal in membrane photosynthetic microbial fuel cell (MPMFC) by integrating nitritation into the cathodic compartment, which demonstrated a very good ability to overcome issues related to high aeration cost and NOB activity.