INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	BIDHU BHUSAN MAKUT
Roll Number	:	146151006
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"Sustainable biofuel production through effective wastewater treatment using indigenous algae-bacteria consortia"

Name of Thesis Supervisor(s)	:	Prof. Debasish Das
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SHORT ABSTRACT

Microalgal biomass based biofuel has gained impetus as one of the most promising renewable energy source, in recent years. Although microalgal biofuel technology is gaining ground, there are several bottlenecks towards its commercialization and economic feasibility, attributed to high production cost of microalgal biomass, lower biomass productivity and cost intensive downstream processing. Thus, sustainability and economic feasibility of microalgal biofuel production could be achieved by (i) co-cultivating microalgae and bacteria using wastewater as a cheaper source of nutrients and water, and (ii) thermochemical conversion of microbial biomass feedstock into bio-crude oil via hydrothermal liquefaction. Six microalgal and three bacterial strains were isolated from oil refinery wastewater and screened in formulated artificial wastewater (AWW) to check their growth potential. In screening process, the microalgal strains (A1, A2, A4 and A6) and bacterial strains (B1 and B3) showed significant growth which were further characterized in AWW to evaluate their growth potential as well as nutrient removal efficiency. With the aim of evaluating the performance in terms of biomass titer and waste water treatment efficiency, eight primary combinations of microalgae-bacteria consortia (combinations of one microalgal and one bacterial strain chosen from a pool of four microalgal and two bacterial isolates) were characterised in AWW. Among the primary consortia; A2B1 and A4B3 were selected on the basis of total biomass titer (microalgae plus bacteria), nitrate and COD removal efficiency. In the next step, performance evaluation was carried out for four secondary of microalgae-bacteria consortia by considering either one microalgal-two bacterial strains or two microalgal-one bacterial strain, chosen from a pool of the microalgal and bacterial isolates present in the selected better performing primary combination(s). Among other secondary consortia, A2A4B1 and A2A4B3 have showed improved biomass titer as well as nitrate and COD removal efficiency. Finally, characterization was performed for one tertiary combination of microalgae-bacteria consortium which comprised of two microalgal-two bacterial strains chosen from A2A4B1 and A2A4B3. The biomass titer, nitrate removal efficiency and COD removal efficiency of the tertiary consortium was found to be 1.27gL^{-1}, 79.78% and 62.43% respectively. To enhance the biomass titer of the tertiary consortium; biological parameters (inoculum size and inoculum ratio) and physico-chemical parameters (initial pH of the media, initial nitrate concentration, and initial phosphate concentration) were optimised via statistical method. The biomass titer of 1.73 $gL^{-1}$was resulted at optimised parameters having inoculum size of 18%, initial pH of 8.65, initial nitrate concentration

of 1.79 $gL^{-1}$and initial phosphate concentration of 49.5 mgL^{-1} and inoculum ratio of 0.97. In the next step, with the aim of establishing the feasibility of application at industrial scale, performance of this tertiary consortium in terms of biomass titer and wastewater treatment efficiency was evaluated on four different types of wastewater: paper industry wastewater (PWW), textile industry wastewater (TWW), leather industry wastewater (LWW) and municipal wastewater (MWW). The performance of tertiary consortium in terms of biomass titer, nitrate and COD removal efficiency was 2.97 gL^{-1}, 89.3%, and 94.23% in PWW which is quite remarkable as compared to other wastewaters. Therefore, PWW was selected for further batch and fed-batch mode of cultivation in an automated photo-bioreactor. The total microbial biomass titer obtained from fed-batch cultivation is 4.1 gL^{-1} which is 29.33% more than the biomass titer obtained in batch cultivation (3.17 g L^{-1}). The wet microbial biomass thus obtained from fed-batch cultivation was further subjected to HTL. The bio-crude oil yield obtained at un-optimized HTL condition was 15%. To attain maximized bio-crude oil yield, the HTL process parameters such as temperature, reaction time and biomass loading ratio were optimized further via statistical method. 21.73% bio-crude oil yield was resulted at optimized temperature of 299.73 ºC, reaction time of 64.95 min and biomass loading of 16.14 (%, w/v) which is 44.86% higher than the yield at un-optimized conditions. Bio-crude oil with energy recovery of 42.95% and heating value of 33.11 MJ kg^{-1} reflects 81.7% and 73.4% heating value of biodiesel and diesel, respectively indicates its potential as an alternative to conventional fossil fuels. High percentage of hydrocarbon content in bio-crude oil indicates good oil quality; presence of significant esters fraction might offer resemblance to biodiesel. Finally, with the aim to demonstrate large scale cultivation for sustainable production of biomass feedstock coupled with wastewater treatment, the tertiary microalgae-bacteria consortium was grown in 500 litre capacity open pond containing 350 litre of PWW as culture medium in fed-batch mode. The total biomass titer was found to be 3.96 g L^{-1} with COD removal efficiency of 90% during 19 days of cultivation under diurnal condition. The final outcome of the present study was to develop an efficient process with the tertiary consortium that can be industrially scalable for bio-crude oil production as well as effective wastewater treatment.