INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Biomass on its sustainable and economical aspect plays a pivotal role. Among all the available biomasses, microalgae biomass is one of the most vital raw material for biodiesel production. Besides, biodiesel, microalgae can be used to synthesize other forms of biofuel such as bioethanol, biogas, bio–crude etc. Therefore, in–spite of biodiesel application a complete microalgae biorefinery approach is gaining more attention headed for sustainable fuel production.

The advent of the present study is intended to select potent microalgae strains native to Northeast India for biodiesel application. Primarily, the water samples were collected near Gauhati University, serially diluted and plated on BG–11 agar plates for single microalgae colony isolation. The primary identification of isolated microalgae was performed on its morphology and pigmentation system. Successively, the pure cultures were sent for 18S rDNA sequencing. The genome sequences obtained were BLAST using multiple sequence alignment tool and the

corresponding phylogenetic tree was constructed by neighbor end joining method. The sequences were submitted to NCBI and annotated as *Chlorella* CG12 (KR905186) and *Desmodesmus* GS12 (KR905187).

Initially, the growth study, biomass productivity, lipid content and lipid productivity of the microalgae were analyzed under laboratory conditions. Further, to find out the best suitable culture conditions the microalgae strains were grown in a wide range of environmental conditions of light intensity (1–4 Klux), temperature (19–31 °C) and pH (5–9). Based on the initial experiments the statistical and mathematical model of RSM and ANN were applied to enhance the lipid content. The optimized culture conditions obtained for CG12 (light intensity–3.46 Klux; temperature–21.07 °C; and pH–8.74) and GS12 were (light intensity–3.19 Klux; temperature–23.12 °C; and pH–7.53) which showed the maximum lipid content of 13.36 % and 25.85 % in CG12 and GS12 respectively. Furthermore, the sensitivity analysis revealed that light intensity had the most significant impact on lipid accumulation contributing up to 87.78 % and 49.09 % in CG12 and GS12, respectively. The biodiesel properties analysis of microalgae oil showed similar fuel quality with ASTM D6751 standards.

Furthermore, to increase the lipid content salinity induced lipid enrichment was employed with major macronutrients such as NaCl, KCl, $MgCl_2$, and $CaCl_2$ with varying concentrations from 5 mM to 25 mM. It was observed that this induced salt concentration decreases the chlorophyll and biomass concentration in microalgae whereas increases the lipid content. Additionally, $CaCl_2$ showed a tremendous response in lipid accumulation in both the microalgae and attains a high lipid content to up to 40 % and 45 % in CG12 and GS12, respectively.

After attaining the high lipid content in microalgae, the small batch cultures were extended to mass cultivation of up to 100 L. Subsequently, lipid extraction was performed from the harvested biomass and supercritical methanol (SCM) transesterification method was used to convert microalgae oil to FAME. A stepwise hybrid optimization of RSM–ANN–GA were performed for the operating parameters (temperature, time and MeOH: oil) to obtain high conversion efficiency of microalgae oil to biodiesel. The globally optimized reaction conditions for SCM were temp.–285.21 °C, time–25.57 min and MeOH: oil molar ratio–23.47 resulted in 98.12 % conversion of microalgae oil to FAME. The biodiesel properties such as acid value, iodine no., cetane no., calorific value etc., were analyzed and exhibit analogous trend with the standard ASTM D6571 standards.

The high production cost renders the deployment of microalgae biodiesel commercialization. Hence, to reduce the nutrient requirement, microalgae were grown in different waste media formulations such as cow–dung (CD), biogas plant digest sludge (BPW) and vermicompost (VM). Initial growth response and lipid content were recorded in all the media and the best growth supporting media *i.e.*, the BPW was utilized for further optimization studies. Culture conditions optimization were performed considering the three important parameters *viz*., light intensity (2–4 Klux), leachate concentration (10–30 %) and $NaHCO_3$ supplementation (0.5–1.5 %). The optimized culture condition resulted in lipid accumulation of 44.56 % and 41.89 % in CG12 and GS12, respectively.

The residual microalgae biomass remained after lipid extraction was used for biogas production, by co–digesting with rice straw (RS). The co–digestion of microalgae residue with RS yielded 382 mL/g VS of biomethane in CG12 whereas 311 mL/g VS in GS12. The high carbon to nitrogen ratio (C/N) in RS and low C/N ratio in microalgae, balances the typical C/N ratio of the anaerobic digester and provides high bio–methane yield. As studied earlier that BPW is a good source of nutrient for microalgae cultivation hence, combining the production of biodiesel with biogas would definitely be a potent solution to suffice the energy demand, reduces the biodiesel production cost and supportive in bioremediation. This combined approach of microalgae biodiesel and biogas production together presents not only a way to sustainable fuel production, indeed also help in waste stabilization and additional revenue generation.