EFFECT OF CELL WALL WEAKENING ON MICROALGAE (*Chlorella vulgaris*) FOR ENERGY AND COST EFFECTIVE BIOMETHANE PRODUCTION

A THESIS

Submitted by

YUKESH KANNAH R

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

FACULTY OF CIVIL ENGINEERING

ANNA UNIVERSITY

CHENNAI 600 025

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CENTRE FOR RESEARCH

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CERTIFICATE

This is to certify that all corrections and suggestions pointed out by the Indian /Foreign Examiner(s) are incorporated in the Thesis titled " EFFECT OF CELL WALL WEAKENING ON MICROALGAE (*Chlorella vulgaris*) FOR ENERGY AND COST EFFECTIVE BIOMETHANE PRODUCTION " submitted by Mr. Yukesh Kannah.R

9/11/2020

Signature of Research Co-ordinator

J. Rajesh 9/11/2020

Signature of the Supervisor

Place : Thoothukudi

Date : 9/11/2020

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Proceedings of the Ph.D. Viva-Voce Examination of Mr.Yukesh Kannah.R held at 11:00 AM on 09.11.2020 in EDUSAT HALL (First Floor, F-08) Department of Civil Engineering University VOC college of Engineering Thoothukudi Campus

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The Ph.D. Viva-Voce Examination of Mr.Yukesh Kannah.R (Reg. No. 1613189161) on his/her Ph.D. Thesis Entitled " EFFECT OF CELL WALL WEAKENING ON MICROALGAE (*Chlorella vulgaris*) FOR ENERGY AND COST EFFECTIVE BIOMETHANE PRODUCTION " was conducted on **09.11.2020** at 11:00 AM in the EDUSAT HALL (First Floor, F-08) Department of Civil Engineering University VOC college of Engineering Thoothukudi Campus.

The following Members of the Oral Examination Board were present:

1.	Dr. P.Sivagurunathan,Senior Research Officer,Indian Oil Corporation Limited,R & D Center Sec-13,Faridabad - 121007 Haryana	Indian Examiner
2.	Dr. C.Lajapathi Rai,Senior Principal Scientist,Department of Chemical Engineering,CSIR-Central Leather Research Institute,Adyar Chennai - 600020.	Subject Expert
3	Dr. Rajesh Banu.J,Associate Professor, Department of Life Science, Central University of Tamilnadu,Tiruvarur	Supervisor
4	Dr.S Adish Kumar,Assistant Professor,Department of Civil Engineering,University VOC College of Engineering, Anna University - Thoothukudi Campus, Thoothukudi - 628008.	Research Co-ordinator/ Convener

The research scholar, Mr. Yukesh Kannah.R presented the salient features of his/her Ph.D. work. This was followed by questions from the board members. The questions raised by the Foreign and Indian Examiners were also put to the scholar. The scholar answered the questions to the full satisfaction of the board members.

The corrections suggested by the Indian/Foreign examiner have been carried out and incorporated in the Thesis before the Oral examination.

Based on the scholars research work, his/her presentation and also the clarifications and answers by the scholar to the questions, the board recommends that Mr.Yukesh Kannah.R be awarded Ph.D. degree in the **Faculty of Civil Engineering**.

Indian Examiner

09/11/20

Subject Expert

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BONAFIDE CERTIFICATE

The research work embodied in the present Thesis entitled **"EFFECT OF CELL WALL WEAKENING ON MICROALGAE (*Chlorella vulgaris*) FOR ENERGY AND COST EFFECTIVE BIOMETHANE PRODUCTION"** has been carried out in the Department of Civil Engineering, Anna University Regional Campus Tirunelveli. The work reported herein is original and does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion or to any other scholar.

I understand the University's policy on plagiarism and declare that the thesis and publications are my own work, except where specifically acknowledged and has not been copied from other sources or been previously submitted for award or assessment.

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ABSTRACT

In recent years, most of the developed and developing countries step forward to minimize the use of conventional Petroleum Based Fuels (PBF), as continuous burning of PBF cause several negative impacts on the environment. On the other hand, increasing the global population leads to lack of PBF for our day today life. To balance the global energy demand, many developed and developing countries start searching alternative source of bioenergy using renewable waste biomass. In order to overcome this issue, many researchers and policymakers are suggesting Microalgae Biomass (MB) as renewable feedstock for bioenergy production. Deriving bioenergy from microalgae has several benefits than conventional PBF such as eco-friendly nontoxic and pollution free.

Microalgae contains three key biopolymers such as protein, carbohydrate and lipids, which are completely utilized by anaerobic microbes to produces bio-based valuable product. Anaerobic Digestion (AD) is the oldest and profitable technique followed for cost effective biomethane recovery from microalgae. The cell wall of microalgae is complex and rigid in nature, which lowers the anaerobic biodegradability (A_{bio}) of feedstock and Biomethane Yield (BMY). Many researchers have suggested disintegration of microalgae prior to AD, enhances the A_{bio} and BMY. Bearing all these in mind, in the present study a novel two-phase disintegration of MB was employed to improve A_{bio} and BMY. In two-phase disintegration, initially the cell wall of MB was weakened using four different techniques (Ultrasonic – US, Low Thermochemical – LTC, Citric Acid – CA and Titanium Dioxide – TD) followed by Biological Disintegration (BD) using cellulase-secreting bacteria.

At first phase, 101.27 kJ/kg TS of US input energy was employed for cell wall weakening (CWW). The results of two-phase disintegration process (US mediated BD) showed higher algal liquefaction (AL) of about 34.8 % comparatively higher than BD (23.8%) and control (6.9%). A maximal Volatile fatty acids (VFA) production of about 3069 mg/L was achieved in US-BD. The outcomes of biochemical methane potential (BMP) assay reveal that US-BD showed higher BMY of about 0.3035 L/g COD than BD (0.208 L/g COD) and control (0.0682 L/g COD) respectively.

At second phase, 121 kJ/kg TS of LTC input energy was employed for CWW. The results of two-phase disintegration process (LTC mediated BD) showed higher AL of about 32.68 % comparatively higher than BD (23.72%) and control (6.84%). A maximal VFA production of about 2812 mg/L was achieved in LTC-BD. The outcomes of BMP assay reveal that LTC-BD showed higher BMY of about 0.2859 L/g COD than BD (0.2061 L/g COD) and control (0.0680 L/g COD) respectively.

At third phase, 30 mg CA/ g SS dosage was employed for CWW. The results of two-phase disintegration process (CA mediated BD) showed higher AL of about 31.44 % comparatively higher than BD (23.65%) and control (6.74%). A maximal VFA production of about 2646 mg/L was achieved in CA-BD. The outcomes of BMP assay reveal that LTC-BD showed higher BMY of about 0.2745 L/g COD than BD (0.2043 L/g COD) and control (0.0676 L/g COD) respectively.

At fourth phase, 15 mg TD/ g SS dosage was employed for CWW. The results of two-phase disintegration process (TD mediated BD) showed higher AL of about 30.2 % comparatively higher than BD (23.51%) and control (6.54%). A maximal VFA production of about 2468 mg/L was achieved in TD-BD. The outcomes of BMP assay reveal that TD-BD showed

higher biomethane yield of about 0.2641 L/g COD than BD (0.2016 L/g COD) and control (0.0669 L/g COD) respectively.

On comparison, among all the four different two-phase disintegration process, US-BD showed higher AL and BMY of about 34.8% and 0.3035 L/g COD than other three process LTC-BD (32.68% and 0.2859 L/g COD), CA-BD (31.44 % and 0.2745 L/g COD) and TD-BD (30.2 % and 0.2641 L/g COD). In addition to this, energy ratio (ER) and cost benefit ratio (CBR) was found to be higher for US-BD (1.397 & 1.4) than LT-BD (1.225 & 1.22), CA-BD (1.135 & 1.14), TD-BD (1.05 &1.06) and BD (0.563 & 0.6) respectively.