ENHANCEMENT OF ANAEROBIC BIODEGRADABILITY IN MUNICIPAL WASTE ACTIVATED SLUDGE BY IMMOBILIZED BIOLOGICAL DISINTEGRATION

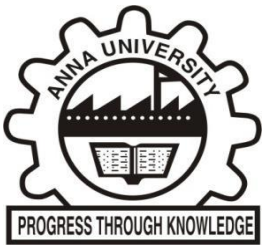
A THESIS

Submitted by

USHANI U

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY



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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 " ENHANCEMENT OF ANAEROBIC BIODEGRADABILITY IN MUNICIPAL WASTE ACTIVATED SLUDGE BY IMMOBILIZED BIOLOGICAL DISINTEGRATION " submitted by Mr./Ms. Ushani.U

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Proceedings of the Ph.D. Viva-Voce Examination of Mr./Ms.Ushani.U held at 11:00 AM on 24.04.2017 in Conference Hall Anna University Regional campus Tirunelveli

The Ph.D. Viva-Voce Examination of Mr./Ms.Ushani.U (Reg. No. 1223729152) on his/her Ph.D. Thesis Entitled " ENHANCEMENT OF ANAEROBIC BIODEGRADABILITY IN MUNICIPAL WASTE ACTIVATED SLUDGE BY IMMOBILIZED BIOLOGICAL DISINTEGRATION " was conducted on **24.04.2017** at 11:00 AM in the Conference Hall Anna University Regional campus Tirunelveli.

The following Members of the Oral Examination Board were present:

1. Dr. P Sivashanmugam,Professor,Department of Chemical Engineering,National Institute of Technology,Tiruchirappalli 620015 — Indian Examiner
2. Dr. R Arthur James ,Associate Professor & Head,Department of Marine Science,Bharathidasan University,Tiruchirappalli 620024 — Subject Expert
3. Dr. Rajesh Banu.J,Assistant Professor, Department of Civil Engineering, Regional Centre of Anna University,Tirunelveli — Supervisor & Convenor

The research scholar, Mr./Ms. Ushani.U 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./Ms.Ushani.U be awarded Ph.D. degree in the **Faculty of Science and Humanities**.

24/4/2017
Indian Examiner

Subject Expert 24/4/17

J. Rajesh 24/4/17
Supervisor & Convenor

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CHENNAI 600 025

CERTIFICATE

The research work embodied in the present Thesis entitled **"ENHANCEMENT OF ANAEROBIC BIODEGRADABILITY IN MUNICIPAL WASTE ACTIVATED SLUDGE BY IMMOBILIZED BIOLOGICAL DISINTEGRATION"** has been carried out in the Department of Civil Engineering, Regional Centre of Anna University, 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

During the last decades, the amount of sludge to be disposed has increased largely due to the higher number of municipal wastewater treatment plants. Surplus waste activated sludge (WAS) generated during biological treatment process from municipal and industrial waste water treatment is an unavoidable problem. Sludge minimization strategies have received more attention recently in research to solve the sludge-related problems, reduce the investment and operational costs, and enhance the performance of the subsequent treatment and final disposal processes. The volume of excess WAS generated in the sewage treatment process is about 0.15–1% of the treated water. A significant increase in WAS production is caused by an increase in the amount of wastewater and the treatment rate. The cost of WAS treatment is very high, accounting for up to 60% of the total operational costs of a plant.

Among the various sludge management methods practiced anaerobic digestion (AD) was proved to be effective in treating excess WAS. Minimization in sludge quantity, stabilization of sludge and production of a biogas are the advantages of AD. The pre-treatment of sludge prior to anaerobic digestion is required because of low biodegradability of the cell walls and extracellular polymers in sludge. Many researchers have suggested that in the sludge, extracellular polymeric substance (EPS) plays a major role in floc formation. In order to hasten the pretreatment process, removal of EPS is a necessary step. Therefore in the present study, it was planned to remove EPS (floc disruption) to increase the surface area for bacterial action and to enhance the solubilization.

The present study affords the consequences attained from laboratory scale experiments of different disintegration methods – Dioctyl sodium sulphosuccinate (DOSS), Magnesium sulfate ($MgSO_4$), and Sodium thio sulphate (STS) induced immobilized bacterial pretreatment methods, evaluation of anaerobic biodegradability of disintegrated sludges. The WAS was collected from municipal waste water treatment plant (MWWTP) at Karakonam, Kerala. Protease secreting bacterial strain was isolated from WAS. The bacterial strain was identified as *Bacillus cereus* (Accession number- KX959688) through 16s rRNA sequencing.

At first phase, effective deflocculation (floc disruption) with negligible cell cleavage was achieved at 0.009 g/g SS DOSS dosage. The outcome of immobilized bacterial pretreatment of sludge biomass reveals that the achieved chemical oxygen demand (COD) solubilization for deflocculated (EPS removed – bacterially pretreated) sludge was observed to be 20% and was higher than that of flocculated (14%) and control (5%). The rate of disintegration was faster in deflocculated sludge with a rate constant of about 0.064 h^{-1}. The biochemical methane potential (BMP) assay resulted in a significant methane yield of about 0.24 (gCOD/gCOD) for deflocculated sludge. The economic assessment showed a net profit of about 1707.7 INR/Ton of sludge.

At second phase, effective deflocculation with negligible cell cleavage was achieved at 0.1 g/g SS $MgSO_4$ dosage. The outcome of immobilized bacterial pretreatment of sludge biomass reveals that the achieved COD solubilization for deflocculated (EPS removed – bacterially pretreated) sludge was observed to be 21% and was higher than that of flocculated (15.2%) and control (4.5%). The rate of disintegration was faster in deflocculated sludge with a rate constant of about 0.006 h^{-1}. The biochemical methane potential (BMP) assay resulted in a significant methane

yield of about 0.26 (gCOD/gCOD) for deflocculated sludge. The economic assessment showed a net profit of about 1802 INR/Ton of sludge.

At third phase, effective deflocculation with negligible cell cleavage was achieved at 0.08 g/g SS STS dosage. The outcome of immobilized bacterial pretreatment of sludge biomass reveals that the achieved chemical oxygen demand (COD) solubilization for deflocculated (EPS removed – bacterially pretreated) sludge was observed to be 22.8% and was higher than that of flocculated (14.2%) and control (4.3%). The rate of disintegration was faster in deflocculated sludge with a rate constant of about 0.0065 h^{-1}. The biochemical methane potential (BMP) assay resulted in a significant methane yield of about 0.32 (gCOD/gCOD) for deflocculated sludge. The economic assessment showed a net profit of about 3801 INR/Ton of sludge.

At last, comparison of three different chemicals used for EPS removal of immobilized bacterial pretreatment was done on the basis of substrate biodegradability and cost analysis. It was concluded that STS mediated immobilized bacterial pretreatment showed enhanced biodegradability with greater net profit.