**INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI**
**SHORT ABSTRACT OF THESIS**

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Thesis Title: ENHANCEMENT OF BIOGAS PRODUCTION FROM RICE STRAW BY CO-DIGESTION AND PRETREATMENT TECHNIQUES

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## SHORT ABSTRACT

Due to rapid economic development over the past few decades, global energy consumption has intensified continuously, causing not only greenhouse gas emissions, but also energy shortage, and in some areas even energy crises. This imminent energy consumption and demand have been the motivation for world scientists to explore alternative energy sources that could replace fossil fuels. Agricultural residues (i.e., wheat straw, rice straw, corn straw, etc.) are the most abundant resource of lignocellulosic wastes, and contribute a major role in producing low-cost and sustainable forms of energy via anaerobic digestion. Anaerobic digestion is a realistic approach to concurrently manage rice straw and harness renewable energy. Inoculum plays a major role in the process of anaerobic digestion; selecting appropriate inoculum is a crucial factor to initiate the anaerobic digestion process. It not only validates the several biochemical and microbial processes, but also enhances the overall methane yield**.** In order to select the appropriate inoculum for rice straw, biochemical methane potential (BMP) assay of anaerobic digestion of rice straw with digested cow dung and fresh cow dung revealed methane yields of 125.77 and 72

mL/g-$VS_{added}$, respectively. The 16S metagenomics sequencing revealed that DCD is enriched with majority of anaerobes.

Initial characterization of rice straw expressed that it has high potential for energy recovery in the form of biogas but biodegradability is restricted by improper nutritional and recalcitrance structure. To balance the improper nutritional structure of rice straw and recompense the nitrogen deficiency of rice straw, rice straw was digested with other nitrogen-rich co-substrates (*Hydrilla verticillata* and food waste) to advance its characteristics in anaerobic co-digestion study (AcoD). A central composite design – response surface methodology (CCD-RSM) was used for defining the experimental design for AcoD of rice straw with *Hydrilla verticillata* and food waste and results of this study showed significant interaction of carbon/nitrogen (C/N) ratio, food/microrganism (F/M) ratio and pH on methane yields (output response). The optimum condition for anaerobic co-digestion of *Hydrilla verticillata* (C/N-29.18, F/M:2.45 and pH 7.37) and food waste (C/N-30, F/M:1.87 and pH 7.32), showed methane yield of 287.6 mL/g-$VS_{added}$ and 323.78 mL/g-$VS_{added}$, 38.9% and 49.55% higher than the mono-digestion of rice straw, respectively.

The recalcitrant behaviour of rice straw marks pretreatment an important step to facilitate the transformation into renewable energy. Therefore, different pretreatment techniques i.e. thermal (hot air oven, microwave, autoclave, water bath), electrohydrolysis and fungal (three fungal strains i.e. *Pleurotus ostreatus, Phanerochaete chrysosposrium, Ganoderma lucidum*) were used for accelerated hydrolysis in anaerobic digestion of rice straw. BMP assay were assessed corresponding to the maximum solubilization rates obtained in pretreatment study and specific methane yields were obtained as 367.68 mL/g-$VS_{added}$ (F/M:2.5) (thermal), 319.03 mL/g-$VS_{added}$ (F/M:2) (electrohydrolysis) and 339.31 mL/g-$VS_{added}$ (F/M:2) (fungal) for different pretreatment. The physicochemical characteristics of pretreated rice straw were investigated by Fourier transform infrared spectroscopy (FTIR) and Field emission scanning electron microscopy (FESEM). FESEM analysis showed the increased porosity of the rice straw, FTIR analysis showed the omission of hemicellulose and lignin from the matrix.

In order to check the feasibility of optimum conditions (maximum methane yields) obtained from batch study in continuous mode, single phase continuous anaerobic reactor (SPCAR) was operated in three phases with untreated, pretreated (microwave) and co-digested (food waste). The results of continuous study suggested that pretreated and co-digested rice straw produced

significantly enhanced methane production as compared to untreated rice straw. The reactor showed superior process performance for pretreatment (microwave) at 8.3 kg-VS/$m^3$/d OLR progressively, with maximum 33.43% VS degradation, co-digested rice straw showed 24.02% VS degradation obtained for an OLR of 6.5 kg-VS/$m^3$/d, whereas, untreated rice straw showed the VS degradation of 9.92% for an OLR of 3.5 kg-VS/$m^3$/d.