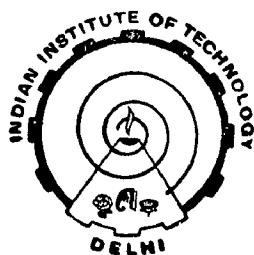


STUDIES ON MESOPHYLIC ANAEROBIC DIGESTION OF WATER HYACINTH FOR BIOGAS PRODUCTION

by
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A Thesis
submitted in fulfilment of
the requirements for the degree of
Doctor of Philosophy in Faculty of Engineering



to the
**INDIAN INSTITUTE OF TECHNOLOGY
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CERTIFICATE

I, the undersigned, certify that the thesis entitled "STUDIES ON MESOPHYLIC ANAEROBIC DIGESTION OF WATERHYACINTHS FOR BIOGAS PRODUCTION", which is being submitted by Mr. K.C. Rathore, in fulfilment of the requirements for the award of the degree of DOCTOR OF PHILOSOPHY in the Faculty of Engineering of the Indian Institute of Technology, New Delhi, is a record of candidate's own bona fide research work carried out under my guidance. The matter embodied in this thesis has not been submitted in part or full, else where for the award of any degree.



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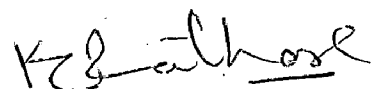
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K.C. RATHORE

ABSTRACT

Amongst the biomass based fuels, biogas is one of the most versatile, cheap and easily producible fuel. It is clean burning and non-polluting fuel which can be easily and continuously produced in biomass digester plants of various capacities and sizes that can generate enough gas to meet lighting and cooking fuel requirements of individual families. It can be used to operate engine pump sets, domestic refrigerators, portable engine generating sets and primemovers used for operating farm machinery.

Biogas can be produced from human and animal wastes as also from waterhyacinth, an aquatic weed plant. Whereas human and animal wastes as feed stock for biogas plants have certain drawbacks and limitations, waterhyacinth gives a better quality gas and does not create unhygienic conditions or odour problem.

Waterhyacinth is a free floating aquatic weed plant. It grows in warm and nutrient rich water. Its growth is very rapid and it tends to block ponds, rivers and estuaries where the polluted water support its growth. It has high potential to generate biogas of good quality. The slurry remaining after digestion is rich in essential crop nutrients which can be used as a fertiliser. Waterhyacinth can be easily and rapidly cultivated in waste water ponds. The cultivated plant can be cut, dried and used as a feed stock into digester plants for biogas production. Thus waterhyacinth

can serve the dual purpose of reducing water pollution and producing biogas for energy.

The following investigations were carried out to assess the suitability of waterhyacinth plant as a raw material for the generation of biogas - an alternate, renewable and clean burning fuel, and performance of anaerobic digester fed with dry waterhyacinth plant material.

In the first phase of this work, various volatile solid loadings of the waterhyacinth plant were digested at 30° and 35°C in batch fed as well as continuous fed digesters for various detention times. The maximum gas production at optimum volatile solids loading and temperature was recorded. The other parameters were also measured viz. total carbon, total nitrogen, total acids, p^H , total alkalinity and volatile solids reduction.

In the second phase of the work the values of the kinetic constants were found out experimentally to be incorporated in the mathematical model for the design of anaerobic digester.

In the third phase of the work, a mathematical model was formulated incorporating the values of kinetic constants found out experimentally. This model was used to predict rate of gas production and volatile solids reduction in a continuous fed, mechanically stirred digester.

In the fourth phase of the work a computer programme was developed and anaerobic digester was designed for various capacities, rate of biogas production, minimum cell retention time and volatile solids reduction.

In the fifth phase of the work, the waterhyacinth plant was subjected to various temperatures under pressure for thermal pretreatment studies prior to feeding it into the digester. The optimum pretreatment temperature and volatile solid loading at highest gas production were found out at the digester temperatures of 30° and 35°C . The waterhyacinth plant was also subjected to alkaline pretreatment. Various quantities of waterhyacinth were soaked in sodium hydroxide solution for 15 days in various concentrations. This pretreated waterhyacinth plant was digested at 30° and 35°C and at a loading of 15 Kg VS/m^3 . The maximum gas production was recorded at optimum loading, temperature and percentage of alkaline treatment.

In the final phase of the work the digester was fed with various quantities of nutrients solution. The maximum gas production was recorded at optimum nutrient concentration, temperature and volatile solids loading.

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