

**FIXED FILM AND OTHER TECHNIQUES FOR
PERFORMANCE ENHANCEMENT OF CATTLE DUNG
BASED ANAEROBIC REACTORS - A PILOT STUDY**

by

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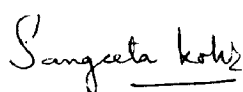
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CERTIFICATE

This is to certify that the thesis entitled, “**Fixed Film and Other Techniques for Performance Enhancement of Cattle Dung based Anaerobic Reactors - A Pilot Study**”, being submitted by Mrs. Yadvika, to the Indian Institute of Technology, Delhi for the award of the degree of Doctor of Philosophy is a record of bonafide research work carried out by her. She has worked under our guidance and supervision, and has fulfilled the requirements for the submission of her thesis, which to our knowledge has reached the requisite standard.

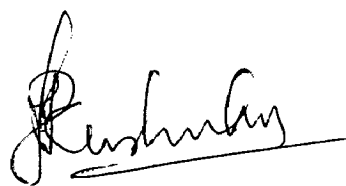
The results contained in this dissertation have not been submitted in part or full to any other university or institute for award of any degree or diploma.



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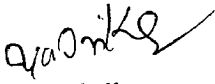
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Abstract

Biogas technology offers a very attractive route for utilization of certain categories of biomass such as cattle dung available in rural areas of developing countries for meeting some of their energy needs. Despite many advantages, the biogas technology continues to suffer from certain limitations. Prime amongst these is the large hydraulic retention period of 30-50 days that needs to be used in the conventional biogas plants. This leads to a large volume of the digester and hence high cost of the system. Therefore, there is a need to either reduce the HRT or enhance biogas production for the same HRT.

The present work, therefore, is aimed at studying the effect of various performance enhancement techniques viz., fixed film matrices, different slurry concentrations, additives in the slurry and recirculation of biogas in the reactor on biogas production rate with cattle dung as the substrate. Experiments have been carried out for over 3 years on pilot size reactors having ~250 litres of cattle dung slurry. An experimental facility with 20 reactors made of 300 litre HDPE tanks was created. The reactors were fed daily with fresh cattle dung slurry and biogas production and the reactor temperature were monitored everyday. Other parameters viz., biogas composition, pH, solids, COD, volatile fatty acids etc. were monitored periodically.

Experiments were carried out in five phases to study the effect of a different factor in each phase. In the first phase, the use of fixed film matrices with 1:1 slurry concentration and 30 days HRT was studied, using six different fixed film materials, viz., nylon rope, clay pipes, asbestos sheet, FRP sheet, ferro-cement angles and iron mesh. In the second phase, experiments were carried out with three different slurry concentrations of 1:1, 1:4 and 1:9 without matrix as well as with clay, asbestos and iron mesh matrices. The third phase comprised of experiments to study the effect of HRT on performance of reactors without matrices and with three slurry concentrations. HRTs of 20d, 30d and 40d were considered. In the fourth phase, effect of additives was studied on

biogas production. Lab scale experiments were carried out with three different additives viz., distillery spent wash (DSW), '*Mailli*' and eosine blue dye. In pilot scale reactors two additives '*Mailli*' and onion storage waste (OSW) were used. In the fifth phase, biogas recirculation in the reactor was attempted for enhancement of biogas generation through agitation.

Experiments showed that fixed film matrices were not suitable for use with 1:1 slurry, since the slurry was too thick. On the other hand, dilution of slurry even without matrix resulted in not only enhanced biogas yield per kg of dung but also higher percentage of methane in biogas. With 1:9 slurry at 30 days HRT, methane production was ~ 3 times higher than that from reactors with 1:1 slurry concentration and 40 days HRT. Even highest biogas yield with 1:9 slurry was found to be 89 l/kg of dung as compared to conventionally used figure of 40 l/kg with 1:1 slurry. Presence of clay matrix was found to enhance biogas production with 1:4 slurry concentration. Additives were also found to be quite effective. At pilot scale 1.5% '*Mailli*' and 1% OSW gave around 50%, and 60% enhancement in biogas production respectively.

A mathematical relation has been fitted to the data on methane production as a function of temperature, HRT and slurry concentration for reactors without matrices or additives. A methodology has been developed to identify optimal parameters for plant design and operation. It has been demonstrated that optimal combination of parameters such as HRT and slurry concentration can result in better gains from a biogas plant than the conventional combination of 30-40 days HRT and 1:1 slurry concentration.

A modified procedure for determining COD of a high solid contents heterogenous substrate like cattle dung was also developed since the standard procedure did not give consistent results with such substrate.

The present study reveals that there is a considerable potential for enhancing the performance of cattle dung based biogas plants through a judicious use of some of the techniques investigated in the present work.

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