Design and Field Testing of a Compact Biogas Plant

A.D. Karve[1], Gandhali Kulkarni[2],
Priyadarshini Karve[1,2]

[1]Appropriate Rural Technology Institute (ARTI), Pune 411 041, India.

[2]Smt. Kashibai Navale College of Engineering (for Girls), Pune 411 041, India.

E-mail: adkarve@vsnl.com

Introduction

- Conventional biogas systems used organic wastes such as human or animal faecaes, distillery effluents, or municipal solid waste.

- These feedstock materials cannot be digested by the bacteria in the system.

- These systems require 40-50 kg of feedstock and have a retention time of about 40 days, to produce daily 1000 lit of biogas.

- Minimum capacity of such systems is 2000 lit.

- The gas is a mixture of CH_4 and CO_2, containing about 40-50% CO_2 by volume.

- They generate daily 80-100 lit of effluent slurry.

- Appropriate Rural Technology Institute (ARTI), developed during 2002-03 an innovative, compact biogas plant, which uses starchy or sugary material as feedstock.

- The new biogas plant has the capacity of just 400 to 500 lit, requires just 2 kg starchy or sugary material to produce about 800 lit of biogas, and the reaction time is only 6 to 8 hours.

Special Features of the Compact Biogas System

- The potential candidate feedstocks, namely rain damaged or insect damaged grain, flour spilled on the floor of a flour mill, oilcake from non-edible oilseeds, seed of various tree species, non-edible rhizomes (banana, arums, dioscoreas), leftover food, spoiled and misshapen fruits, non-edible and wild fruits, spoilt fruit juice, etc. are readily available in rural areas.

- 1 kg of sugar or starch yields about 400 litres of biogas, within a period of 6 to 8 hours. This quantity is enough for cooking one meal for 5 to 6 persons.

- The effluent slurry generated daily by the plant is just a couple of litres. It can be used as manure for plants growing around the house.

- The compact biogas plant, mass produced, would cost about Rs. 3,500 (US$78). The smallest cattle-dung based domestic biogas plant costs about Rs. 12,000 (US$267).

Field Testing

- **Objectives:**
  - To test the quantity and quality of biogas produced from different feedstock materials and their mixtures, under field conditions.
  - To generate data tables of gas yield Vs feedstock used for the convenience of the users.

- **Methodology:**
  - Use an experimental biogas plant producing 25 lit biogas every 24 hours by consuming about 50 g feedstock.
  - Study quantity and quality of biogas produced using a starchy and an oily feedstock separately.
  - Study quantity and quality of biogas produced using mixtures of starchy and oily feedstock.
  - Quantity of biogas estimated from the increase in the height of the floating drum.
  - Quality of biogas deduced from chemical analysis.

Results

- It is not advisable to transport the biogas plant while in operation.

- After installation, the plant requires about 4-5 days to stabilise.

- Once stabilised, the plant routinely produced daily 25 lit biogas using 50 g of a starchy feedstock.

- Chemical analysis indicated that the gas contained < 5% CO_2. This may be due to dissolving of CO_2 in the water in the fermenter.

- Sudden replacement of starchy feedstock by oily feedstock led to stopping of gas production.

- Preliminary experiments involving mixtures of starchy and oily feedstock materials in different proportions indicate that biogas yield may be increased by using a proper combination of feedstock materials.

Conclusions

- There is a need for generating extensive data tables of biogas yield and system stabilisation periods for various feedstock materials used individually and in mixtures.

- An attractive feature of the compact biogas plant is the exceptionally high methane content of the gas. This implies that the gas is useful not only as a clean cooking fuel but also as an excellent transportation fuel.

- Due to simplicity of operation, easy access to feedstock materials, and user-favouring economics, the compact biogas plant has a potential to revolutionise the household energy scenario in India by offering a more accessible alternative to LPG.

- The dream of a 'blue flame revolution' – putting a blue flame in each and every rural kitchen in India - has become more realistic and achievable in the near future with this invention.