Biogas in India

By

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Status

- One of the oldest biogas programmes in the world.
- Full Government backing with generous subsidies on capital expenditure.
- Programme rural, using cattle dung as feedstock. Biogas used primarily for cooking.
- 2 to 3 million plants in working condition. With 160 million rural families in India, hardly 2% rural families use biogas.
- Cannot be considered a success.

Reasons of low penetration

- Dung based biogas technology is wasteful. 1 kg (dry) dung yields 4000 kcal if burned. Only 200 kcal if converted into biogas.
- Dung cakes are saleable at US Cents 3.5/kg. Biogas cannot be sold. No profit in converting dung into biogas.
- Domestic biogas plants use daily 20 kg (dry wt.)dung. It would fetch US Cents 70 if converted into dung cakes.
- Spending daily US Cents 70 on cooking energy is not acceptable when cheaper substitutes are available.

Reasons (Contd.)

- Operating dung based domestic biogas plant needs dung from 5 to 6 heads of cattle. Cattle population has dwindled in recent years due to farm mechanisation and mechanised transport.

- Dung based biogas plant needs daily 40 lit water. Bringing water from a distant source, loading dung into biogas plant and disposal of spent slurry, increase daily workload of women. It is resented by women.

- LPG readily available even in rural areas. A family needs daily about 500g LPG, costing only US Cents 33. LPG has no hassels.

Some Basic Considerations

- Methanogenic Archaea evolved 4×10^9 years ago. No oxygen in atmosphere at that time.

- Photosynthetic organisms, which appeared about 3.5×10^9 years ago, caused increase in atmospheric oxygen content.

- Molecular O_2 (in atmosphere or dissolved in water) is toxic to methanogens.

- Therefore methanogens retreated to regions devoid of oxygen (swamps, guts of animals, etc.).

New light on biogas technology

- All animals represent living biogas plants. Their fecal matter represents effluent slurry. Using slurry from one biogas plant as feedstock in another results into low output of biogas.

- Biogas producing microbes reside in the guts of animals. They eat what the animals eat.

- They are found in dung because they exit the animal body along with dung.

The meaning of volatile solids %

- The term % volatile solids (% biogas yield) is directly correlated with the digestibility of the substance.

- 1 kg of sugar, starch, cellullose, fats and proteins yields 1 kg (800 litres) biogas because they are 100% digestible. Therefore they do not leave behind any slurry.

- Green leaves have only 10% digestible matter. Rest consists of water (80%)and lignin (10%). Therefore, 10 kg fresh green leaves produce 1 kg biogas.

- Only mucus and bacteria in dung are digestible. Therefore, one needs 40 kg fresh dung to produce 1 kg biogas. Almost 90% dung comes out as slurry.

Converting carbohydrates into hydrocarbon

- Even anaerobic organisms need oxygen. Biogas microbes take O_2 from their substrate, converting sulphate into sulphide, nitrate into ammonia and carbohydrates into hydrocarbon (methane).

- Energy loss low if feedstock highly digestible. 1kg cellulose having 4500kcal yields about 370 g methane having 4000 kcal. 1kg (dry weight) dung having 4000 kcal yields only 18.5 g methane having just 200 kcal.

Textbooks carry misconceptions

- Textbooks mention 20 to 25 as the ideal C/N ratio of feedstock, because it is C/N ratio of dung. Sugars, starches, cellulose and fats, having C/N=∞**,** and proteins having C/N=4 or 5, show 100% v.s., whereas dung , with C/N=20 has just 5% v.s.

- Methanogens are primitive organisms. They cannot digest large organic molecules . Large molecules are degraded by other micro-organisms. All organisms normally produce acetic acid under anaerobic conditions. Methanogens attach themselves, like parasites to other bacteria and get the acetic from them. No need for the conveyor belt concept, popularised by textbooks.

Findings from our own research

- Low mineral content of substrate limits microbial activity in a biogas plant. Chemical fertilizers enhance efficiency of a biogas plant.
- A biphasic (aerobic followed by anaerobic) system reduces the volume of the feedstock but its methane output is low.
- Super-methanogens can be bred but they won't survive in commercial biogas plants.
- Pure methane can be obtained from biogas by storing it on water.

Achievements of ARTI

- ARTI biogas plant developed in 2003. 1kg food waste (sugar, starch, cellulose, protein or fat) yields 1 kg biogas in 1d instead of 40 kg dung requiring 40d. Efficiency raised 600 times.

- Dungless urban system uses food waste . Plant fabricated from readily available plastic water tanks. Do-it-yourself.

- Dungless rural system developed in 2012. Uses green leaves, water hyacinth, green agri-waste. 10 kg green leaves yield 1000 litres biogas. Undigested midribs and veins are briquetted.

- Installed about 10,000 plants.

Household Biogas Plants

Terrace Model:

Size: 1 m^3 digester, 0.75 m^3 gas holder
Capacity: up to 2 kg kitchen waste, daily.
Quantity of gas produced: up to 1 kg biogas, capable of replacing 200-300 gm of LPG, daily.

Balcony Model:

Size: 0.5 m^3 digester, 0.35 m^3 gas holder
Capacity: up to 1 kg kitchen waste, daily.
Quantity of gas produced: up to 0.5 kg biogas, capable of replacing 100-150 gm of LPG, daily.

Institutional/Commercial Biogas Plant

Capacity: 10 m^3 Digester (plastic or masonry tank)
7.5 m^3 gas holder (plastic tank)

Pay back period: 3-4 years, for commercial LPG replacement

Operating cost: Electricity for Food Pulper, 1 hp.
Labour 2 hr/day (at actual)

Gas production: 3-5 kg LPG equivalent/day

<u>Requirements</u>:
Area open to sunlight 3m x 3m
Water ~ 100 lit/day (spent slurry can be recycled)
Feedstock: Food waste, any green plant matter, pulped, up to 30 kg

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