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New Compact Biogas Technology

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The current process of biomethanation, which uses feedstocks like cattle dung, human faeces, distillery effluents etc. is highly inefficient, because the nutritionally available calories and nutritive value of these substances is quite low. Common sense tells us that the energy output of a system must be matched by the input. Methane has a calorific value of 11000 kcal/kg. If one wants a high output of methane from this system, it must also receive inputs having a correspondingly high calorific value. Nowadays, municipal solid waste (MSW) is also being used as a source of methane. Food rests in the MSW have a relatively high calorific value. But in the process currently being used (e.g. Kale, 2004) MSW is subjected first to aerobic fermentation. The aerobic process is supposed to digest the material that the anaerobic bacteria find difficult to digest. But the easily digestible components such as sugars, starch, cellulose and proteins are converted in the aerobic phase into carbon dioxide and lost. The predigested material, having very few nutritional calories left in it, is then fed into the anaerobic digester for producing methane. This is called the two-phase fermentation system. As a rule of thumb, one can state that biogas production systems operating on human or animal faeces, distillery effluent, or two phase digestion of municipal solid waste, produce about 10 to 15kg methane per tonne of feedstock. The traditional biogas generating systems require about 40 days to complete the process. The time can be shortened by using thermophilic bacteria and digestion under higher temperature, but the input to output ratio remains unchanged.

Use of catttle dung as the feedstock is the main factor limiting widespread use of methane as household fuel in rural India. The present domestic biogas plant requires daily about 40kg cattle dung (from 6 to 8 heads of cattle). Because dung requires about 40 days to complete its fermentation, the size of such biogas plants is very large (about 4000 litres) and because of the large size, the cost of the biogas plant is also high. Restrictions of space, money and absence of sufficient animals prevent many aspirants, and especially those in the urban areas, from having a biogas plant based on this technology. The servicing of this plant requires daily input of equal quantities of dung and water. In most villages, the water has to be fetched by women from a distant source. Mixing the dung with about 40 litres of water, filling it into the biogas plant and disposal of about 80 to 100 litres of effluent slurry are daily chores, which increase the work load of women and therefore considered by them to be a bother.

The author developed in 2003 a new biogas technology (Karve, 2003), which uses high calorie feedstock, consisting of starchy, sugary or proteinous material. This material is capable of producing about 250 kg of methane per ton of feedstock (on dry weight basis) and the reaction takes only 24 to 72 hours to complete. If sugar is used as feedstock, methane generation starts in just half an hour. The material that can be used as feedstock in the new biogas system consists of waste grain, seed of any plant species, oilcake of non-edible oilseeds, as well as non-marketable or non-edible fruits (wild species of Ficus, mango and banana). Even the flour swept from the floor of a flour mill can be used as feedstock. Slaughterhouse waste, boneless meat, egg yolk, spoilt milk can also be used as feedstock.

Because of the smaller quantity of feedstock and also because of the short reaction time, the digester size and also its price are drastically reduced. The gas holder of the domestic model of the new compact biogas plant has a capacity of just 750 to 1000 litres, which is enough to cook two meals for a family of five. The user applies about 600g feedstock in the morning and 600g in the evening. The total effluent slurry generated daily by this system is hardly 10 litres. Thus, this system does away with the daily drudgery of handling huge quantities of cattle dung and the daily hassle of disposing off about 80 litres of spent slurry. The new biogas plant is available at a cost of about Rs. 9000 (US$200). This technology brings methane within reach of households that do not possess any cattle.

The apparatus itself consists of two plastic water tanks, which are generally available in shops selling sanitary ware and plumbing hardware. The top of each drum is cut open, so that the smaller drum can telescope into the larger one. The outer drum serves as the digester and the inner drum, which is placed upside down into the outer drum, serves as the gas holder. The inlet pipe for the input is a vertical pipe fitted inside the gas holder. It runs along the entire length of the gas holder. The gas outlet is also fitted on the inner drum.

To begin with, the system is loaded with about 20kg cattle dung and water. Then one waits for about 2 weeks, till the gas emanation begins. The gas is tested by burning it. Once it starts producing combustible gas, one can start introducing the high calorie input, as explained above.

As far as economics of the compact biogas system is concerned, it must be pointed out that people generally use feedstock that is available either free of cost, or very cheaply. Examples of the feedstock are vegetable and fruit waste from vendors of these items; waste food from restaurants, from one's own household, and that from neighbours; flour swept daily from the floor of a flour mill; cakes of non-edible oilseeds, etc. When such feedstock is used, the cost of methane is either nil or less than Rs.10 per kg. In calorific value, methane is equivalent to LPG.

So far, about 2500 biogas plants of this type have been in installed, primarily in the state of Maharashtra, but also elsewhere in India. There is great interest all over the world about this biogas generating system. ARTI has sold more than 2000 video CDs that show, step-by-step, how to construct this biogas plant from two plastic water tanks. Users in USA, Tanzania, Austraila and Japan have constructed biogas plants, following instructions in the CD. An exhibition called Miraikan in Tokyo, Japan, is currently exhibiting this system under the theme "Science from Asia".

All those who are using this system were and are LPG users. One cannot expect households using a mud chulha to buy a biogas system costing Rs. 9000. If the family consists of 5 people, our biogas system replaces about half the LPG used by the family. Thus, if the family saves every month LPG costing Rs. 150, the payback period works out to 5 years. But it is not just the payback period that users calculate but also the convenience of being one's own master as far as cooking fuel is concerned.

Another advantage of this biogas system is that it provides users with a means of disposing off their biodegradable waste. Municipal authorities of larger cities like Mumbai, Pune, Thane, etc. no longer accept biodegradable waste as garbage, and the householders have to make their own arrangements for its disposal. The municipal authorities and several NGOs recommend making vermicompost from the biodegradable waste, but disposal of the vermicompost is another problem faced by those who make it. Biomethanation is therefore preferred by many over vermicompost. ARTI recently installed a large biogas plant for Thane Municipal Corporation. It uses waste collected from restaurants in the city and provides methane to Chhatrapati Shivaji Hospital in Thane. Another large biogas system has been established by ARTI at Mahindra & Mahindra factory in Igatpuri (Dist. Nashik, Maharashtra) to convert waste from the industrial canteen into biogas.

Biogas also represents the healthiest way of converting biomass into cooking energy. According to an estimate by the World Health Organisation, about 3 million people in the world die every year as a consequence of exposure to suspended particulate matter in the air, and that 85% of the deaths are due to indoor air pollution (Schwela, 2002). The indoor air pollution is caused mainly by traditional cookstoves, using traditional biomass based fuels. Considering India's share in the world population, the estimated deaths due to indoor air pollution in India come to annually about 500,000. Although acute respiratory infection is the single largest category of deaths in children under 5 years of age (Smith & Mehta, 2000), indoor air pollution remains a neglected topic in India, because the number of persons killed annually by polluted water is much higher than that killed by polluted air. It must however be emphasised, that while polluted water can be made potable by filtration, chlorination, boiling, reverse osmosis, distillation, etc. there is no simple treatment to purify polluted air. It is therefore necessary to reduce the pollutant load in the air at the source itself. Methane as cooking fuel would prevent these deaths. It is non-polluting, renewable, cheap and CO_2-neutral.

In addition to household fuel, methane can also be used as fuel in internal combustion engines.

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