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Biogas production enhancement by soya sludge amendment in cattle dung digesters

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ABSTRACT

Biogas energy production from cattle dung is an economically feasible and eco-friendly in nature. But dependence only on cattle dung is a limiting factor. Rich nitrogen containing substrate addition to extra carbohydrate digester like cattle dung could improve the biogas production. Detailed performance of the digesters at different ratios of cattle dung and soya sludge has been discussed in this paper considering the cold countries climate. Soya sludge substrate not only has high nitrogen content of 4.0–4.8% but it also has high percentage of volatile solids content in the range of 97.8–98.8%. Soya sludge addition also improved the manurial value of the digested slurry and also improved the dewater-ability of the sludge. Results indicated an increment of 27.0% gas production at 25.0% amendment of soya sludge in non-homogenized cattle dung (NCD) digester. The amount of gas production increased to 46.4% in case of homogenized cattle dung (HCD) with respect to NCD feed at the same amendment.

1. Introduction

Increasing industrialization, population and vehicular transport system is exerting enormous pressure on our fossil fuel. This pressure on energy brings forth to attention "biogas" as an alternate energy source i.e. economically feasible and sustainable with unlimited in potential. In rural areas of developing countries, various cellulose biomasses (cattle dung, agricultural residues, etc.) are available in plenty which have good potential to cater to the energy demands especially in the domestic sector. In India alone, there are an estimated over 250 million cattle and if one third of the cattle dung produced is available for biogas generation, more than 12 million biogas plants can be installed [1]. But dependence only on cattle dung would be a limiting factor and hence to look for an alternative biomass/substrate along with cattle dung would be a better solution. This would be achieved by addition of residue of high biogas potential substrate in combination with cattle dung. Various suitable biomass have been identified for their potential as a supplement to the cattle dung digesters for enhancing gas production.

Laboratory investigation on the use of water hyacinth in dry powder, chopped and blended pulp and mixtures of these along with cattle dung showed the feasibility of water hyacinth as a feed supplement to cattle dung biogas plants. Cattle dung and fresh water hyacinth in the ratio of 3:1 and 1:1 at an organic loading of volatile solids of 1.6 kg $m^{-3}d^{-1}$ and detention time of 30 days yielded 30% more gas than with cattle dung alone. Moreover the dewater-ability of the digested sludge also improved manifolds [2].

An enhancement of 40–80% in biogas production has also been observed on addition of 1.0% onion storage waste to

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cattle dung digesters of 400 L capacity having a floating dome [3]. Study on use of burnt coconut shells and burnt bricks in biogas digesters have been reported. Study reveals that the biogas yield of 0.72 $m^3 kg^{-1}$ volatile solids added could be achieved with burnt coconut shell as media while burnt brick made enhanced the biogas production by 40% [4,5]. Likewise addition of wood chips to the biogas digester has also yielded highest biogas of 144.0 L kg^{-1} volatile solids feed [6].

It is very evident from the literature that increased surface area provided increased immobilization of microorganisms and thus resulted in enhanced gas production. But semisolid residue like cattle dung, agricultural residues, plant residue and general solid/semi-solid biomass are not suitable feed materials in fixed film reactors in rural environment, as they lead to frequent choking and clogging of the reactor and also increases the reactor cost due to media with their pretreatment needs. But at rural level simple cost effective digesters would be more suitable option with easily available cheap amendments only. Homogenization increases gas production is well known [7,8] and hence experiments were conducted with non-homogenized and homogenized cattle dung.

Biogas enhancement through organic additive has been reported but the soya sludge as an additive has been tried for the first time. The paper discusses in detail the advantages of soya sludge as an amendment in biogas digesters. Soya sludge with cattle dung in biogas plants has been optimized for optimum efficiency for gas production, particularly in winter season. The studies were carried out on both non-homogenized and homogenized condition of the feed stock to know the performance of the cattle dung digesters. The additive to cattle dung digesters is most suitable for cold countries where cattle dung digesters are not working in peak winter season. In India, there is wide variation in the range of temperature from cold winter (0 °C) to hot summer (45 °C).

2. Selection of soya sludge additive

At rural atmosphere, the gullible rural folk do not understand the scientific details. Hence, it is preferable to use locally available biodegradable organic biomass as an additive to enhance the biogas production. It is more suitable for vulnerable rural community to procure the residue without any extra cost and also fulfill their daily gas requirements. One such locally available substrate is the soya sludge. Soya sludge (SS) is the solid residue generated during soya milk production. This sludge has high volatile solids concentration of 97.80–98.80% and it would be an excellent substrate or additive to biogas digesters to enhance biogas generation particularly in winter season when the gas production decreases in cattle dung digesters. Recent time has seen the emergence of varied soya products due to its high protein content. Soya sludge putrefies faster than other residue in nature when disposed off as it contains 98% volatile solids. Considering the advantage of high volatile solids content and suitability for field application, soya sludge as an additive in the biogas digester has been selected for the present studies.

Table 1 – Physico-chemical characteristics of feed stock materials.

Parameters	Cattle dung	Soya sludge
pH	6.90–7.00	5.50–5.80
Alkalinity, mg L^{-1}	6200–6320	2300–2450
Volatile acid, mg L^{-1}	514–860	462–488
Total ammonia nitrogen, mg L^{-1}	115–220	131–142
Total solids, %	8.50–8.80	8.48–8.60
Total volatile solids, %	6.29–6.82	8.30–8.50
Volatile solids of total solids, %	74.00–77.50	97.80–98.80
Total nitrogen, %	1.20–1.45	4.00–4.80
Total phosphate, %	0.22–0.32	0.35–0.60

3. Methodology adopted

The experiments were carried out at National Environmental Engineering Research Institute (NEERI), Nagpur, India. The four laboratory digesters having total capacity of 10 L were used for the detail experimental studies. Two digesters were used as controls, i.e. one as non-homogenized cattle dung

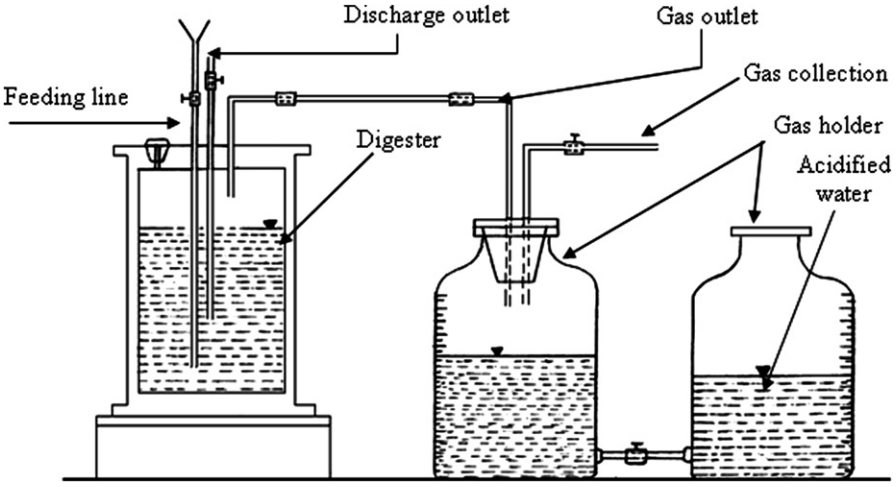

Fig. 1 – Schematic of cattle dung digesters in the laboratory.