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Efficiency of Production of Biogas from Different Non Edible Oil Cakes in Hassan District, Karnataka, India

C. Haleshi[1]*, Bhavishya[2], Sreeram N. Hegde[1], Balakrishna Gowda[1], K. T. Prasanna[1], A. C. Girish[1], Babitha Bora[3] and Navin Sharma[3]

[1]Madenur Department of Studies in Botany, Davangere University, Davanagere, India
[2]Central Plantation Crops Research Institute (CPCRI) Regional Station, Vittal, India
[3]Department of Horticulture, Government of Karnataka, Udupi, India

**Corresponding author*

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A B S T R A C T

Oil seed cakes are the potential source for biogas production and this is the better way to dispose large quantity of oil seed cakes from biofuel industry. This study was conducted in the villages of Hassan district in the farmers houses, it has important role in the future energy supply from biomasses like oil cakes and cow dung and this is the way to saving of fuel wood and reduce the pressure on forests. *Pongamia, Bassia* and *Calophyllum* are three major species growing in Karnataka state and produced lot of oil seed cakes. *Calophyllum, Simarouba, Jatropha, Pongamia* and *Bassia* seed cakes were used in the experiments, all these five species are the best source for biogas production, among five *Calophyllum, Pongamia* and *Bassia* shown good performance. The spent slurry has rich in nutrients as compared to cow dung this can be used as manure.

Introduction

The objective of the United Nations Climate Change Conference held at Paris November, 2015 is to achieve to set a goal of limiting global warming to less than 2 degree Celsius (°C) compared to pre-industrial levels. To meet this new challenge we should increase the use of renewable energy and minimize the use of petroleum products and to address the great concern with the environment problems associated with CO_2, NO_x and SO_x emissions resulting from the rising use of fossil fuels more attention is being paid to renewable energy, especially biomass energy (Mangut *et al.*, 2006 and Goran *et al.*, 2003).

In India the biofuel industry is slowly developing and lot of byproducts from the industry especially oil cakes needs proper utilization. Oil cakes are rich in proteins, carbohydrates, fatty acids, etc. At present biofuels is costlier than petroleum fuels as byproducts are not used properly and are not getting proper price. If byproducts get suitable value, then the biofuel prices will come down

and industry will prosper. Hence research should concentrate on utilization and value addition of byproducts of biofuels (Bertil *et al.,* 2004). During oil extraction from oil seeds the oil cake is produced as byproduct and it is the good source of biogas production and they have good percentage of NPK (Table 2). The farmers produce biogas generally from cow dung slurry and it is the main source, which results in less production of gas compared to cow dung slurry mixed with oil seed cakes which increase the production of biogas (Isci and Demirer, 2007; Deepak Kumar *et al.,* 2013; Chandra *et al.,* 2012; Staubman *et al.,* 1997). It is experimentally proved and still research works are going on different oil cakes throughout the world on different aspects like biotechnological applications of oil cakes (Sumitra *et al.,* 2007), industrial applications of *Jatropha curcas* (Ashwani Kumar *et al.,* 2008), production of methane gas from *Jatropha* and *Pongamia* oil cake (Chandra *et al.,* 2012), enhancement of methane production from sunflower oil cakes by dilute acid pretreatment (Florian *et al.,* 2013) and Methane generation through anaerobic digestion from *Jatropha* and *Pongamia* cake (Vijay *et al.,* 2008). Jasvinder Singh and Sai Gu critically discussed on conversion of biomass to energy in Indian scenario (Jasvinder and Sai, 2010), serial digesters investigated and optimize biogas production from manure (Prasad *et al.,* 2009), quantitative evaluation of biogas production from methanogens (Walker *et al.,* 2009), Jatropha cake with Buffalo dung (Shilpkar *et al.,* 2009), biomethanation process of Jatropha and Pongamia oil cakes and their co-digested substrates (Shilpkar *et al.,* 2009). Still the information is inadequate to understand the biogas production of cakes.

Biomass is abundant in annual production, with a geographically widespread distribution in the world (Kaygusuz, 2004; Matti Parikka, 2004). Biomass is the fourth largest source of energy in the world, accounting for about 15% of the world's primary energy consumption and about 38% of the primary energy consumption in developing countries (Sevgi, 2008).

India is a tropical country blessed with rich biodiversity with favourable climate and soil. There are 287 oil yielding species documented in India (Anonymous, 2007), it includes edible and non edible oil seeds. As per the biofuel policy edible oil cakes should not used for biogas/biofuel production, it should not come in the way of food security. Oil cakes have been in use for feed applications to poultry, fish and swine industry. Being rich in protein, some of these have also been considered for food supplementation (Sumitra *et al.,* 2007). South India particularly Karnataka state has 130 oil yielding species (Jaivika Indana Kannada booklet, 2007). Among 130 species Biofuel Park Hassan has selected ten local species and promoting these species in the farmer's field's viz. bunds, waste lands, ravines, community lands, avenue planting in Hassan district, Karnataka state. The ten non-edible tree species like *Pongamia pinnata, Azadirachta indica, Jatropha curcas, Bassia latifolia, Simarouba glauca, Calophyllum inophyllum, Aphanamixis polystachya, Mesua ferrea, Hevea braziliensis and Alurites moluccana.* In Karnataka state *Pongamia pinnata, Azadirachta indica* and *Bassia latifolia* are the three major oil yielding species and the estimated yield about 2.9 lakh tons/year (Anonymous, 2003). It is a huge source of bioenergy. Generally non edible oil cakes are used as manure, but only small number of farmers are using the oil cakes as manure due to lack of awareness and high prices. Because of this large quantity of oil cakes of *Pongamia pinnata, Azadirachta indica, Bassia latifolia, Simarouba glauca, Jatropha curcas, Calophyllum inophyllum* are available

and can be used for biofuel production in the state (Nagamani and Ramaswamy, 1999). Keeping this point in view and to motivate the farmers to use the oil cakes for production of biogas an experiment was laid at Biofuel park Madenur with the main objective of farmers do practically in their own houses get the experience and understand the utility, importance and efficiency of oil cakes in biogas production.

In this way Biofuel Park, Hassan, University of Agricultural Sciences Bangalore in collaboration with ICRAF (World Agroforestry Center) Nairobi has taken initiation to establish Biogas units at Kinnarahalli, Halenahalli, Malligevalu, Jyothimallapura, Nagenahalli, Talalur, Talaluthore, Bilagunda and Ballekere with the intention of creating smokeless villages in the Hassan district.

Materials and Methods

Hassan district is one among the 30 district of Karnataka state, India and is located between 12^0 31^1 and 13^0 33^1 N latitude and 75^0 33^1 – 76^0 38^1 E longitudes. Following villages of Hassan district were selected and experiments were conducted in Kinnarahalli, Malligevalu, Bilagunda and Ballekere (Map-1), nine farmers were selected who had Gobar gas units (Table 1). These farmers were provided with required quantity of different oil seed cakes, note books and given instruction to them about the uses of oil cakes. First two day's normal cow dung slurry was used and observations on cooking of gas for cooking in minutes was recorded and third day onwards oil cake was used along with cow dung slurry and observations were recorded and proportion of the cake is based on their size of Gobar gas units. Before application the cakes were soaked in water (1:1) for 3-4 hours to mix well with cow dung slurry. Oil seed cakes like *Calophyllum inophyllum, Simarouba glauca, Jatropha curcas, Pongamia pinnata,* and *Bassia latifolia* were produced in Biofuel Park, Hassan. Daily observations were recorded on the basis of cooking time (minutes) the starting and ending time until complete usage and later the minutes were converted into volume (m^3). *Calophyllum* cake was used by four farmers, one farmer *Simarouba* cake, one farmer *Jatropha* cake, two farmers *Pongamia* cake and one farmer used *Bassia* cake (Table 1).

The mixing ratio of Cow dung and water is 1:1 (23) and oil cake water ratio is 1:1. The cow dung and oil cakes were mixed in different ratio for different cakes (Table 3). Treatment details with cake used and name of the farmers are as follows.

Cake treatments

Calophyllum cake treatment details

Girish B.T, Bilagunda, Kattaya Hobli**:** First two days only cow dung was applied and from third day onwards 2 kg of Calophyllum cake was applied along with 15 kg cow dung up to 12^{th} day.

Yogachar, Malligevalu, Kattaya Hobli: First two days only cow dung was applied, from 3^{rd} day onwards up to 13^{th} day 2 kg of *Calophyllum* cake and 8 kg cow dung was applied.

Manjegowda, Malligevalu, Kattaya Hobli: First two days only cow dung was applied, on 3^{rd} day onwards up to 12^{th} days 2 kg of Calophyllum cake and 8 kg of cow dung was applied in the morning.

Shivalingappa, Kinnarahalli, Halekote hobli: First two days only cow dung was applied, on 3^{rd} day onwards up to 7^{th} day daily 2 kg of Calophyllum cake was added with 6 kg cow dung in the morning.

Simarouba cake treatment details

Murthy, Bilagunda, Kattaya hobli, Hassan**:** First two days only cow dung was applied like their regular practice, on 3rd day onwards up to 12th day daily 2 kg of Simarouba cake was added with 6 kg cow dung in the morning.

Jatropha cake treatment details

Devarajegowda, Ballekere, Hassan: First two days only cow dung was applied, from 3rd day onwards up to 7th day daily 2 kg of Jatropha cake was added with 6 kg cow dung in the morning.

Pongamia cake treatment details

Shivanna, Malligevalu, Kattaya hobli: First two days only cow dung was applied, from 3rd day onwards up to 11th day daily 1 kg of Pongamia cake was added with 5 kg cow dung in the morning.

Basavalingappa, Kinnarahalli, Halekote hobli: First two days only cow dung was applied, from 3rd day onwards up to 12 days daily 1 kg of Pongamia cake was added with 5 kg of cow dung in the morning.

Bassia cake treatment details

Puttegowda, Malligevalu, Kattaya hobli: First two days only cow dung was applied, on 3rd day onwards up to 7th day daily 2 kg of Bassia cake was added with 5 kg cow dung in the morning.

Conversion of minutes to volume (m^3)

The volume was calculated by using D^2H, here D is diameter of the biogas unit and H is height (gas accumulated part) of the biogas unit. Measuring the circumference and height of the biogas unit, diameter was calculated by using C/π, C is circumference, and it is divided by π value. Recorded the burning minutes from known volume of the unit and this can be applied to all units and minutes were converted into volume in m^3.

Results and Discussion

Calophyllum cake treatment

The results of cooking hours of oil cakes in farmers units are furnished, it is observed that *Calophyllum* cake and Cow dung (Girish) shows more production of biogas (2.9 m^3) when compared to pure Cow dung (1.82 m^3) (Fig. 1), when cow dung mixed with *Calophyllum* cake increases 1.1 m^3 per day is observed (37%). In First day of application of cake biogas production increases by 16% and gradually reaches to 37% on 5th day. In another experiment (Yogachar) the performance of cow dung was 1.02 m^3 and after application of *Calophyllum* oil cake showed 1.45 m^3 gas production and it increase 27% gas production. Here after application of cake the gas production immediately increases by 12.5% and gradually reaches 27% with time. Manjegowda experiment shown 1m^3 of gas production in Cow dung and 1.34 m^3 gas production when applied *Calophyllum* cake, it increases 25.5% of production.

After application of cake the gas production increases by 12% and gradually it reaches 25.5%. The same experiment of Shivalingappa shown cow dung 0.9 m^3 while after application of *Calophyllum* cake the cooking minutes was 1.15 m^3 (increase of 22.5%). After application of cake the gas production immediately increases by 10% and gradually increases and reaches to 22.5%. Even though biodegradable organic matter (cow dung) is a sole feedstock in anaerobic digestion, the digestion process tends to fail without the addition of external nutrients and buffering agents (oil cake) (24).

Simarouba cake treatment

The cow dung production resulted in 0.91 m^3 gas whereas *Simarouba* cakes with cow dung resulted in 1.12 m^3 (Fig. 2), which shows sudden increase in production of 14% in the next day, when applied eighteen days and gas production is increasing gradually reaches to 23.5%, but in the beginning sudden increase might be due to over activation of Methanogens (Fig. 2).

Jatropha cake treatment

The gas production from cow dung recorded 0.871 m^3 whereas after application of Jatropha cake the gas production increased to 1.211 m^3. After application of cake the production increases by 12% in the beginning days and the application of cake for five days it gradually increases and reaches 28% (Fig. 3).

Table.1 List of farmers using oil cake with cow dung in Gobar gas units

Sl.No.	Cake used	Name of Farmer	Village, Taluk & District
1	*Calophyllum inophyllum* (Surahonne)	Girish	Bilagunda, Hassan, Hassan
2	*Calophyllum inophyllum* (Surahonne)	Yogachar	Malligevalu, Hassan, Hassan
3	*Calophyllum inophyllum* (Surahonne)	Manjegowda	Malligevalu, Hassan, Hassan
4	*Calophyllum inophyllum* (Surahonne)	Shivalingappa	Kinnarahalli, Holenarasipura, Hassan
5	*Simarouba glauca* (Simarouba)	Murthy	Bilagunda, Hassan, Hassan
6	*Jatropha curcas* (Jatropha)	Devarajegowda	Ballekere, Hassan, Hassan
7	*Pongamia pinnata* (Honge)	Shivanna	Malligevalu, Hassan, Hassan
8	*Pongamia pinnata* (Honge)	Basavalingappa	Kinnarahalli, Holenarasipura, Hassan
9	*Bassia latifolia* (Hippe)	Puttegowda	Malligevalu, Hassan, Hassan

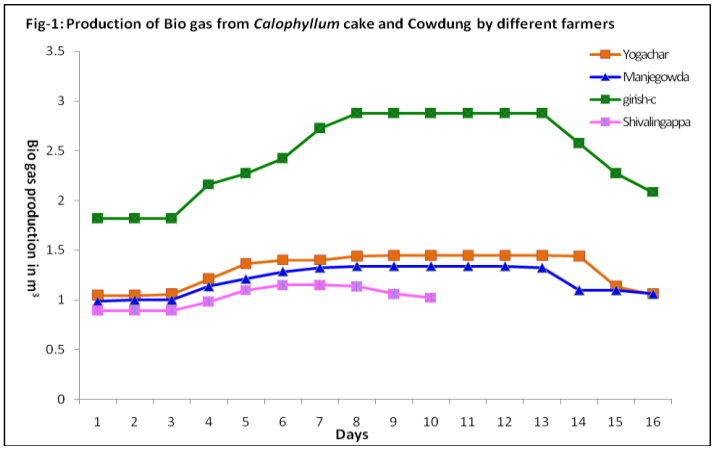
Table.2 Nutrient content of oil cakes

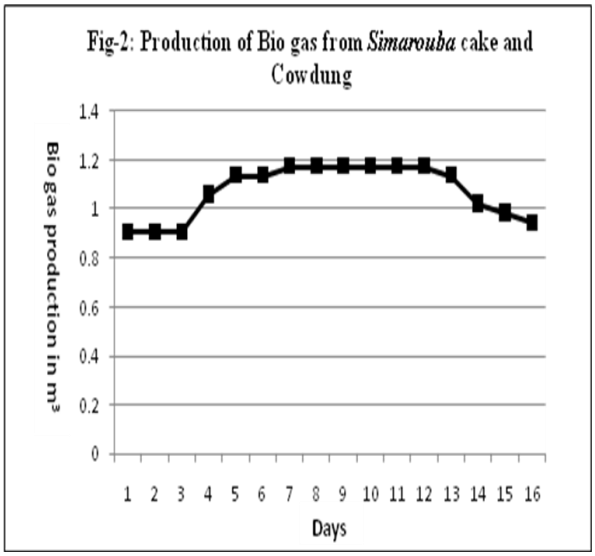
Sl. no	Oil Cakes	pH	EC (ds/m)	OC (%)	Total N (%)	Total P (%)	Total K (%)
1	Pongamia	5.8	1.0	51.5	3.9	0.60	0.88
2	Bassia (Mahua)	4.7	1.6	51.9	1.5	0.29	0.36
3	Simarouba	5.6	0.9	53.9	7.1	0.38	0.5
4	Calophyllum	4.5	1.1	42.4	2.1	0.29	0.11

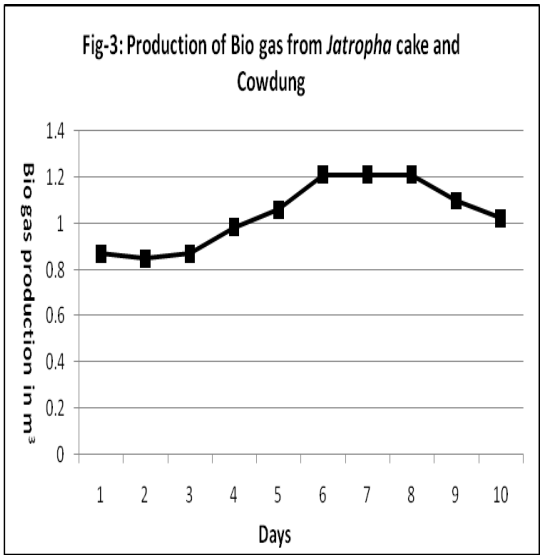
Table.3 Oil cake and cow dung proportion and gas production (maximum)

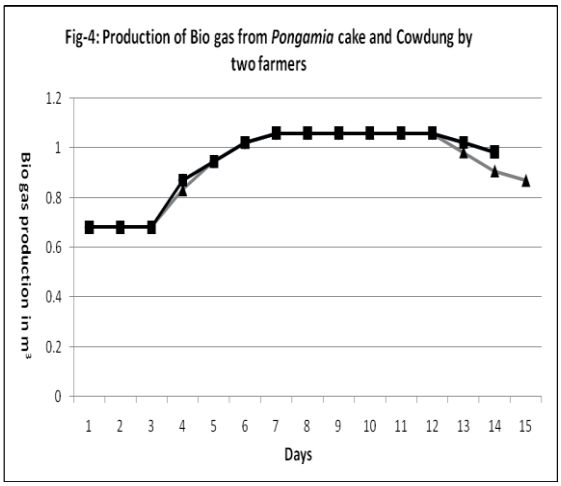
Name of the cake	Qty of CD in Kg	Qty of OC in Kg	Before application of Cake (burned minutes)	After application of Cake (Maxi.Minutes burned)
Calophyllum inophyllum **1)**	15	2	240	380
2)	8	2	135	191
3)	8	2	132	177
4)	6	2	118	152
Simarouba glauca	6	2	120	155
Jatropha curcas	6	2	115	160
Pongamia pinnata **1)**	5	2	90	140
2)	5	2	95	140
Bassia latifolia	5	2	90	141

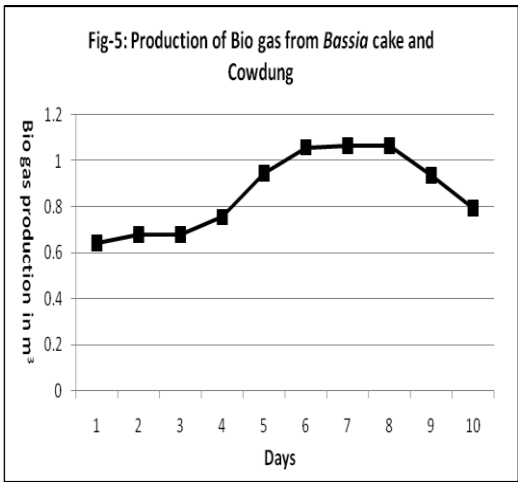
CD= Cow Dung, OC= Oil Cake & Min=Minutes

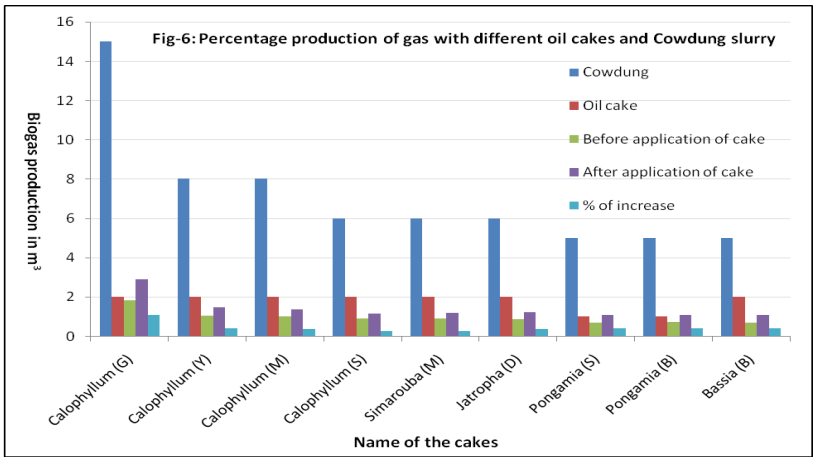




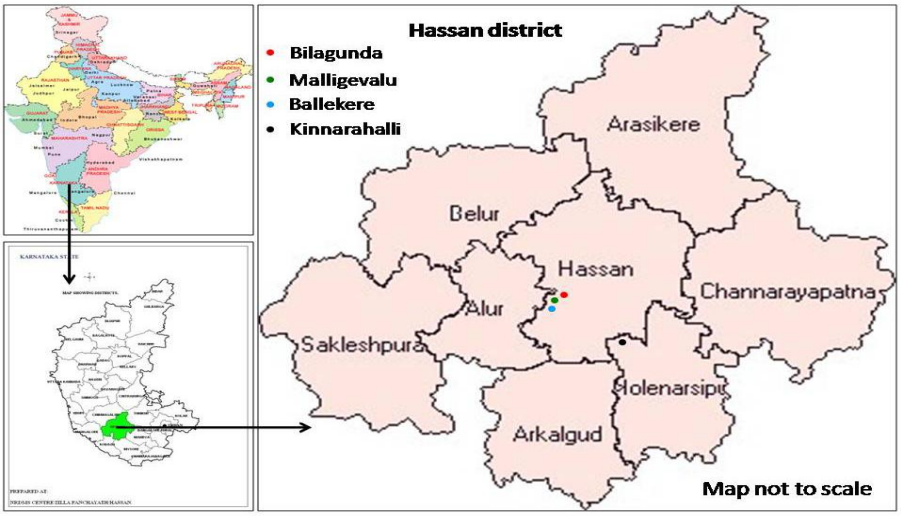








Map.1 Map indicating study villages in the Hassan district, Karnataka, India



Pongamia cake treatment

The cow dung production resulted in 0.681 m^3 and after application of cake in the first day the production is increases 22% (first case Shivanna) during application of cake the gas production gradually increases and reaches to 36% than the cow dung production. After twelve days the gas production slowly reduces. In the second case (Basavalingappa, Kinnarahalli) the gas production in the cow dung resulted in 0.72 m^3 gas and after application of cake it increases by 18% and gradually it increases and reaches maximum to 36% during the cake application. Here initially the gas production is more due to high activation of methanogens. Gas production gradually increases and reaches to 36% (Fig. 4).

Bassia cake treatment

0.682 m^3 of gas was observed during cow dung application, and production increases by 10% after cake application and gradually it increases and reached to 36.2% (1.1 m^3.)

The production of biogas is varying from one unit to another because the usage of cow dung and cake quantity is varying from unit to unit because the units are of different size. The bigger units need more feed and smaller units need less. In case of *Calophyllum* oil cake the production of biogas is 37% in bigger units and lesser production (22%) in smaller units even though used the same quality of cake. The low production of gas compared to above two might be due to light effect (25) and location of the unit. Gas production in *Simarouba* is little low when compared to *Calophyllum, Pongmia* and *Bassia* cakes may be due to hard coat of the seeds in the cake (26 and 27) even though it has high proteins and fats. The hard coat of the seed not encourages the microbial growth. Jatropha produces 28% more biogas after mixing with cow dung, it produces little low when compared to *Calohyllum, Pongamia* and *Bassia* due to undigested matters in the cake (26). *Pongamia* cake produces more biogas when compared to *Simarouba* and *Jatropha* may be due to presence of high proteins, fats, soft tissue and other components in the cake (28), *Pongamia* cake shown instant production of biogas (Fig. 4), when compared to the other cakes due to more activation of methanogens the biogas will produces immediately in the next days. *Bassia* cake also produces more biogas (36.2%) even though it has some undigested matter (hard seed coat) again it might be high proteins and fats encourages the microbial growth and more gas will be produced and *Bassia* cake is the second potential candidate for biogas production after Calophyllum cake.

In conclusion it is evident from this study that oil cakes are the potential source for biogas production. The gas production enhances from 10% - 37% from use of different oil cakes. There is variation in gas production from different cakes, but with any oil cakes more gas is produced than use of normal cow dung. Among the oil cakes *Calophyllum* (37%) shows best performance might be due to presence of high proteins and fats (55-60%) in the cake favorable for microbial activity. It is followed by *Bassia* (36.2%) and *Pongamia* (36%) cakes which have shown good performance again might be due to presence of high proteins and fats. *Jatropha* cake has shown good gas production might be due to its acidic nature and high percentage of Organic Carbon (OC). Low production recorded from *Simarouba* cake compared to others might be due to chemical composition of the cake and hard coat of the seed which cannot be digested by the microorganisms. This study indicated that the use of oil cake is very good source for biogas production and it is the answer for rising fuel crisis in India. After biogas production the spent slurry has

also rich nutrients same as cow dung and oil cakes this can also be used as manure and the anaerobic digestion of oil cakes is the best way to dispose. There is false belief that the spent slurry has less nutrients but lot of studies conducted by Biofuel Park Hassan has proved that the spent slurry has rich in nutrients. If the farmers using more oil cake for their biogas units and produce more gobar gas it automatically reduces the pressure on forests and minimize the uses of LPG's and Kerosene especially in the rural areas it greatly contributes to the savings of foreign exchange, mitigate global warming (29 and 30) by carbon reduction and biodiversity conservation.

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