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Applicability of Biogas Technology In Rural Development And Green House Gas Mitigation

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Abstract: Non-commercial sources like firewood, dung and agricultural waste are major sources of energy in rural India. These sources have a great energy potential and energy production can be enhanced by switching the mode of generation. Cow dung is used as a cooking fuel by drying it into cakes which gives only 11 per cent energy and apart from this causes environmental pollution, indoor air pollution which leads to health disorders. Biomethanation is an excellent option to overcome these harmful effects of traditional cooking fuels. Biogas so produces is less polluting ad can also replace fossil fuels like kerosene and coal in everyday life. A survey was carried out in Bhopal-Sehore region to investigate satisfaction level and benefits actually experienced by the biogas users. This survey includes 22 families which are using biogas for cooking purposes and slurry as fertilizer, 100 per cent families experienced less time consuming and convenient cooking with biogas and all of them noticed health improvement, 96 per cent of them are using digested biogas slurry as fertilizer and all of them stated that it is very helpful in improving soil structure and yield. 90 per cent farmers are able to reduce their use of chemical fertilizer. This paper estimation of green house gas mitigating potential of biogas plants which is up to 262.5 kg CO_2/day and 6.25 kg CH_4/day. If a $2m^3$ Biogas plant is installed in a family of 4 persons it can save up to 2,880 kg wood/year or 6 LPG Cylinders.
Keywords: Biogas; Greenhouse gases; Rural development; Global warming.

Introduction

Industrialization, economic development, modernization of agriculture, population growth and rise in human living standard has created a burgeoning demand for energy in India (1). When it comes to economy and agricultural production villages are acting like a backbone and they also play an important role in conservation of biodiversity. The adequate supply of energy is a matter of great concern when it comes to agricultural output and the source of this energy becomes an important question when it comes to environmental conservation. Traditional cooking fuels like dung cakes, firewood are not only inefficient but also pollute the local and the surrounding environment by adding Greenhouse gases (GHG), which in turn contributes to global warming and

the climate change. At the same time cooking in the traditional cook stoves (*Chulha*) in rural India also contribute to the drudgery of rural women and in terms of time spent in collection of fuel and cooking, Indoor pollution has a pronounced effect on respiratory health and causes eye disorders. This effect can be seen clearly in infant children staying with mother and adolescent girls involved in household activities (2). For many years fuel wood is sharing partnership with cow dung cakes for meeting cooking energy demand in rural India. This not only leads to deforestation but also results in emission of greenhouse gases in the atmosphere. Biogas is very useful as a fuel substitute for firewood, dung cake, agricultural residue, petrol, diesel and electricity having major contribution in supplying energy for cooking and lighting (3). Biogas can also address the problems of scarcity of firewood, respiratory problems due to indoor air pollution and can provide affordable lighting sources. It can save a lot of time and labour for women in activities such as collection of fuel wood and cooking. Economically it can substitute chemical fertilizer, improve soil and boost agricultural production. Environmentally it reduces the use of forest resources for house hold energy purposes and thus slows down deforestation, soil degradation and resulting natural catastrophes like flooding or desertification (4). It provides valuable manure as a byproduct of biogas plants which is useful for improving soil health and crop yield.

There is a great concern about global warming due to increasing concentrations of greenhouse gases in the atmosphere. GHGs *viz*. CO_2, CH_4, N_2O etc are the trace gases in the atmosphere which are relatively transparent to the higher energy sunlight, but trap or reflect the lower energy Infra Red radiation, behaving somewhat like glass in the greenhouse. The warming of the earth atmosphere attribute to the atmospheric trace gases is termed as the greenhouse effect. While the temperature variation in the distant past has been the result of non anthropogenic forces, the recent change in global climate is largely attributed to the human activities. Methane is the most abundant organic gas in the atmosphere and second most important anthropogenic greenhouse gas after CO_2.The contribution of CO_2 and CH_4 to the present global warming is 50 per cent and 20 per cent respectively. At present the atmospheric methane is increasing at the rate of 1.3 per cent per year (4).

Emission from Burning of Cow Dung, Firewood and Traditional Dung Disposal Practices

It has been estimated that methane emission from animal excrement contribute about 7 per cent to the global greenhouse effect, which is similar to 20-30 million tons of methane per year. Global warming potential of methane is 25 times higher than CO_2 (4). Through anaerobic treatment of animal excrement which is a renewable source of energy, biogas is generated which can reduce global warming in the two ways: first by reducing the demand of fossil fuels and at the same time reduce CH_4 emission from openly dumped animal excrement. If fossil fuels and fuel wood is replaced by biogas additional CO_2 emissions can be avoided including a saving of forest resources which are natural CO_2 sink.

Table 1 Emissions from Burning of Different Fuels (5)

Pollutants	**SO_2 kg/TJ**	**NO_X kg/TJ**	**Dust kg/TJ**	**CO_2 g/TJ**	**BaP g/TJ**
Mineral oil	140	90	20	90	1
Gas	3	90	2	70	-
Mineral coal	300	150	20	100	3000
Wood,(industrial combustion)	100	64	100	130	130
Wood, (household burning)	30	60	100	300	-
Straw	170	340	200	300	-
Biogas	3	50	3	50	-

Table 2 Emission from Burning and Traditional Disposal of Cow Dung (2)

Gas	**CO_2**	**CH_4**
Activity		
Burning	2.5kg/kg dry dung	-
Dung disposal (open field)	-	0.009kg/kg dung

Combating Deforestation through Biogas

Apart from direct benefits from biogas systems, there are other perhaps less tangible benefits associated with this renewable technology. By providing an alternative source of fuel, biogas can replace the traditional biomass based fuels, notably wood. Biogas may reduce the dependence on wood from forests. The average fuel wood consumption for cooking purpose in Bhopal Sehore region for a family of 4 members is 240 kg/month. Thus installation of one biogas plant can save fuel wood consumption of 2,880 kg/family/year.

Enhances Agricultural Production and Soil Fertility

Organic manure differs from inorganic fertilizer not only in nutrient content, composition and variance but also in qualitative aspects. Organic fertilizer contributes directly to the humus content of the soil, mineral fertilizer doesn't and lack of humus ultimately results in desertification. A productive soil system needs a balance between accumulation and degradation of humus. Manure, compost or any organic fraction will increase or stabilize the humus level in soil. Humus is one of the most important compounds in the soil since it is responsible for the temperature of soil; the water capacity, structure, pore volume and absorption of nutrients. During the anaerobic process most of the low molecular substances are degraded while lignin substances still contribute to the humus pool of the soil (5). The spent waste material, slurry that emerges out of the biogas plant is a high nutrient organic fertilizer that can be applied directly or in conjugation with composted agricultural residue. If composted properly, the slurry will give higher crop yield and production thereby augmenting income and restoring soil fertility.

Health and Living Conditions

Introduction of biogas technology has a significant impact on health and living conditions of people associated with it. It had created job for masons associated with the construction of biogas plants. Women are overall benefitted with the introduction of this technology, cooking with biogas convenient as it saves time for firewood collection and it is quick and clean. It also reduces time required for cooking of meals and dishwashing. In a survey, almost 100 per cent biogas users in Bhopal-Sehore region which were included in the survey stated that using biogas results in saving of time and convenient cooking. Women can save in average 2-3 hrs daily. Biogas is a clean and particulate free energy source thus results in smoke reduction in the kitchen. A smoke free and ash free kitchen means women and other small girls generally associated with cooking are no longer prone to throat and lung infections. It also reduces the likelihood of chronic diseases that are associated with the indoor combustion of biomass-based fuels, such as respiratory infections, ailments of lungs, bronchitis, asthma, lung cancer and increased severity coronary artery disease. Benefits also scaled up when the potential environment impact are also taken into account; significant reduction in emissions associated with the combustion of biofuels, such as sulphur dioxide (SO_2), nitrogen oxide (NO_2), carbon monoxide (CO), total suspended particles and poly aromatic hydrocarbons are possible with the introduction of biogas technology. All the of biogas users of Bhopal-Sehore region who were surveyed admitted that using biogas stove for cooking reduces lung and throat diseases, eye irritation, cough and cold incidences. 86 per cent of the surveyed biogas users stated that biogas imparted a hygienic environment and it also aids waste disposal thus preventing environmental contamination and spread of pathogens.

Methodology

A survey of biogas users in Bhopal-Sehore district of M.P. was conducted out by a joint team of experts with varied experiences and expertise from Central Institute of Agricultural Engineering (Bhopal). A desk study was carried out for tracing the exact location of biogas plants constructed by CIAE and MP Agro in the selected area. The next step was the preparation of questionnaire followed by site visit. The survey was designed to verify data available in the literature, regarding possible benefits of household biogas plants which stressed on health benefits, income generation and fuel saving etc.
Literature was reviewed for calculating GHGs mitigating potential of biogas plants**.**

Results

Benefits of Biogas Technology: User's Perception

Biogas technology offers several benefits such as health, environmental, agricultural and economic through reduced deforestation and carbon trading that increase the adaptive capacity against climate change (6). Biogas has been proved to be viable and emerged as a promising technology (7). Results of the survey which was carried out in Bhopal-Sehore region to investigate satisfaction level and benefits actually experienced by the biogas users. This survey includes 22 families which are using biogas for cooking purposes and slurry as fertilizer. The questionnaire was based on benefits like health improvement, indoor air pollution control, savings in fuel and fertilizer expenditure, increase in crop yield and time saving.

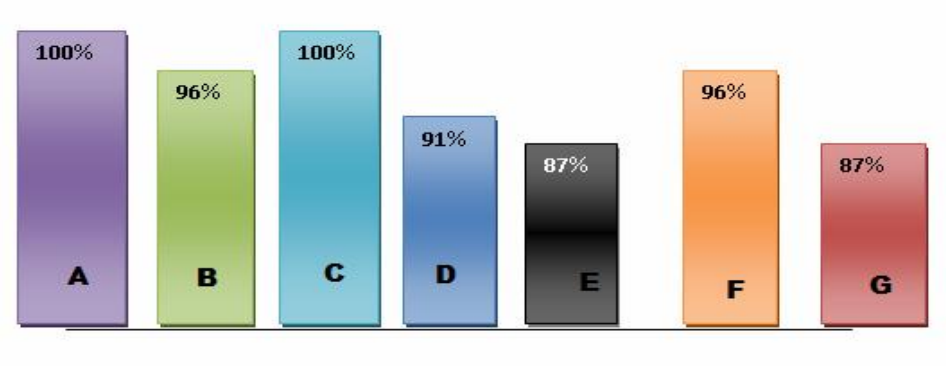

Fig.1 Different Benefits of Biogas as Stated by Biogas Users (Per Cent)

A. Supports saving of time and convenient cooking
B. Use biogas slurry
C. Improvement in health by using biogas for cooking
D. Saves expenditure on fertilizer by using biogas slurry
E. Saves expenditure on fuel after using biogas
F. Hygienic environment after installation of biogas plant
G. Improvement in soil structure and Increased crop yield by using biogas slurry.

Green House Gas Mitigating Potential

Energy is an essential need for human existence and therefore, its sources are always over exploited without keeping an eye on problems associated with it. Increased demand of energy not only led us to a fast depletion of fossil fuels, but also creates imbalance in atmospheric gaseous composition by enriching it with greenhouse gases. All this creates an urgent need to develop efficient measure for utilization of energy through available renewable energy sources which are less polluting and can replace the use of fossil fuels in everyday life (8).Emission reducing potential of different capacity biogas plants is calculated on the basis of literature reviewed which comes out to be as indicated in Table 3.

Table 3 Estimated Reductions of CO_2 Emission And CH_4 Emission

S.No.	Plant Capacity	Dung required (kg)		Emission reduction (kg CO_2)	Emission reduction (kg CH_4)	CO_2 equivalent of methane emission
		Wet	Dry			
1.	$2m^3$	50	10	25	0.5	9.5
2.	$3m^3$	70	15	37.5	0.75	14.25
3.	$4m^3$	100	20	50	1	19
4.	$6m^3$	180	36	90	1.8	34.2
5.	$10m^3$	250	50	125	2.5	47.5
6.	$25m^3$	625	105	262.5	6.25	118.75

Economic Benefits and Bio-fertilizer

Installation of biogas plant can save Rs. 17,280 annually by replacing 2,880 kg wood as the present cost of wood in Bhopal-Sehore region is Rs 6/kg. Moreover it can replace chemical fertilizer; the slurry saves the money previously spent on chemical fertilizers (9). Biogas stoves results in easy and convenient cooking and can save upto 3 hours/ day and this spare time can be utilized in income generating activities.
The spent waste material that emerges out at the end of the biogas plant, the slurry, is a high nutrient organic fertilizer that surpasses raw manure, and can be applied either directly or in conjunction with composted agricultural residue. If composted properly, the slurry will give higher fertilizer yields and increase overall crop yield and production, thereby augmenting income and restoring soil fertility in areas where soil degradation is prevalent. This can impart economic benefits in two ways firstly by selling the slurry ans secondly by using it in their own fields. A detailed account of expected monthly income from sale of slurry obtained from different capacity biogas plants is shown in Table-4.

Table 4 Expected Earnings through Sale of Slurry from Different Capacity Biogas Plants

S.No.	Plant Capacity	Dung required (kg)	Dried manure obtained	Income/day from sale of manure (Rs.)	Monthly Income from sale of manure (Rs.)
1.	$2m^3$	50	2	10	300
2.	$3m^3$	70	3	15	450
3.	$4m^3$	100	4	20	600
4.	$6m^3$	180	6	30	900
5.	$10m^3$	250	10	50	1,500
6.	$25m^3$	625	25	125	3,750

Time saving

Rural women expend a substantial portion of each day gathering fuel wood and cooking meals. In addition to this, they also have farming, household management and childcare responsibilities and as a result work up to 16 hours each day (9). We found in the survey that average time required for different household activities is approximately 5.5 hours and this time can be reduced to 2.5 hours by using biogas technology. This time can be utilized in other social and educational activities, details are shown below in Table-5.

Table 5 Time Required in Different Cooking Activities with Chulha and Biogas Stove

S.No.	Activity	Time required (Hours)	
1.	Firewood collection	2	-
2.	Preparation of cowdund cakes	1	-
3.	Cooking	2	1.5
4.	Cleaning of utensils	0.5	0.5
5.	Feeding in biogas plant (2 m^3)	-	0.5
Total		5.5	2.5

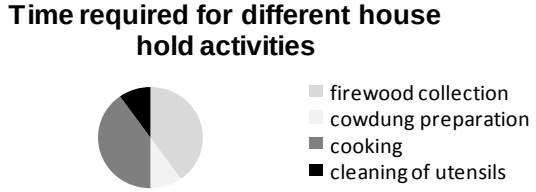

Fig.2

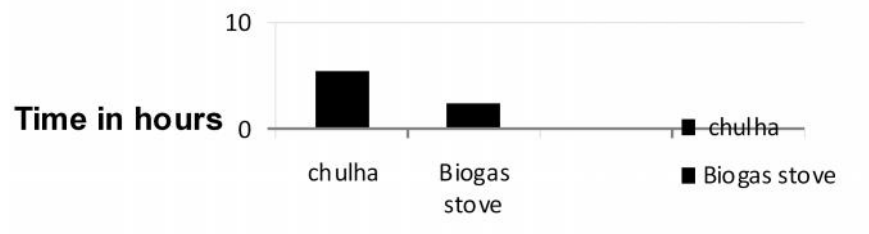

Fig.3 Comparison of Time Required while Cooking with Chulha and Biogas Stoves

Conclusion

Biogas technology contributes in a wide range of aspects to the environment, this has been proved in the present survey. Moreover use of biogas is imparting economic strength to rural India by saving fuel, sale of biogas manure, increased crop yield etc. Thus, there is a large potential of reducing emission of greenhouse gases to the atmosphere by building house hold biogas plants in rural India. It can also reduce emissions due to burning of fuel wood and dung cake; secondly it can arrest emission of methane by open dumping of cow dung, arrestation of fuel wood consumption results in increasing plant population which enhance conversion of atmospheric CO_2 to carbohydrates through Calvin cycle. Biogas stoves fueled by anaerobic digesters of animal, human and crop waste have been shown in laboratory studies to reduce health damaging air pollution by up to 90% (10). Biogas being an eco friendly energy production systems are serving local beneficiary, by improving health, sanitation and economic conditions. It is also proving itself a milestone in fighting against global warming by its potential of reducing CO_2 and CH_4.

References

1. Murugan M., An analysis of rural household energy consumption in kanyakumari district- Tamil Nadu. International Journal of Multidisciplinary Research.,2011, 130-138.
2. Myles R., Environmental, Socio-economic, Health and other positive impacts of building household biogas plants in rural India. Paper presented at the joint NDYMCA-INSEDA-INFORSE-South Asia regional seminar on renewable energy, September 6, 2004 at New Delhi, 6-8.
3. Nasery V., Biogas for rural communities. Study report submitted to the centre for technology alternatives for rural areas, IIT Bombay., 2011,6.
4. Khoiyangbam R.S., Environmental Implications of Biomethanation in Conventional Biogas Plants. *Iranica Journal of Energy and Environment.* **2** (2).,2011, 181-187.
5. Klingler B.,Environmental aspects of biogas technology. Results from GTZ-Project (promotion of anaerobic technologies). TBW GmbH. Frankfurt.,1998, 1-12.
6. Mohan B. Chand., Bidur P. Upadhyay., Maskey R., Biogas Option for Mitigation And Adaptation of Climate Change. Rentech Symposium Compendium, Volume 1, March 2012, 5-9.
7. Katuwal H. & Bohara A.L., Biogas: A Promising Renewable Technology and its Impact on Rural Household in Nepal.
8. Sharma S., Nema B.P., Environmental Implications and other Positive Impacts of Building Biogas Plants in Rural India. Abstract. Volume 2012, National Research Seminar on Environmental Conservation & Management, 2012, pp 8.
9. Anonymous., Biogas for a Better Life: An African Initiative. Summary report on the findings of the Feasibility of a National Household Biogas Commercialization and Promotion Programme in Zambia., 2007, 3-5.
10. Smith K. Green House Gases from Small Scale Combustion in Developing Countries: an analysis for India. Annual Review of energy and the environment, 2000, 25: 741-763.

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