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FAMILY AND COMMUNITY SIZE BIOGAS PLANTS IN KHULNA: PRESENT SITUATION AND FUTURE RECOMMENDATION

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ABSTRACT

The main purpose of this study was to explore the present status of family size plus community size biogas plant and to make recommendation for future. The study was conducted for Fultala Upazilla of Khulna district. Data was collected on 31 biogas plants through survey method using a systematic questioner during 2003 to 2004.Out of 31 plants, 27 are of family type and 4 are of community type. The results show that, (i) Significant reduction in fuel utilization is observed in most of the cases during their operation period, which certainly has a positive impact; (ii) In most of the cases the main reason of closing of the family size plants is lacking of cow dung due to reduction of number of cows. The operational problems are leakage in gas dome, clogging of gas pipe and inactive key of the burner, which can be designated as minor problem; and (iii) Most of the community size plants were in running condition as they do not depend on cow dung rather they use human excreta. They also do not have much complains. In this case the situation is completely opposite and encouraging as compared to family size plants. Specific recommendations to restart the present biogas plants and guidelines for future plants are also presented in the paper.

Keywords: *Biogas, Fuel, Energy, Solid waste, Operation, Maintenance*

1. INTRODUCTION

The energy demand is increasing in urban and rural areas of the developing countries. This demand constitutes a major fraction of energy consumption in cooking. In rural areas the cooking demand is largely met with bio-fuels such as fuel wood, charcoal, crop residues and dung cakes. The utilization of these bio-fuels may have several direct and indirect environmental problems including generation of smoke and these conventional sources of energy in Bangladesh are depleting in course of time. The fuel wood needs for domestic cooking is about 500kg/capita/annum and this result in deforestation (Singh *et al.,* 1997). Biogas technology is one of the options to overcome the problems and to improve the rural economy and enabling the best use of organic solid waste (such as cattle dung) to supply smoke free cooking fuel. In this process the waste mixture (feedstock) is put into a Biogas Plant and after anaerobic fermentation of the same, biogas or methane is produced (Metcalf and Eddy, 2003). Anaerobic fermentation (or oxygen deficient fermentation) of biodegradable organic wastes produces combustible gas called biogas, which contains 50–60% methane, 30–40% carbon dioxide, 1–5% hydrogen and traces of nitrogen, hydrogen sulfide, oxygen, water vapors etc (Singh and Sooch, 2004). As feedstock different kinds of cellulose containing biodegradable organic wastes including cattle dung, poultry droppings, human excreta, crop residues etc. can be used. This produced biogas can meet the growing energy demand of rural areas in developing countries. In addition to replacing fossil fuels this process also contributes to the reduction of a powerful greenhouse gas, methane (Maeng *et al.,* 1999).

The remaining slurry containing about 2.10% nitrogen, 0.046% phosphorous and 2.20% potassium is used as manure for crop production. Banik & Nandi (2004) reported that biogas residual slurry manures are rich in mineral nutrients and are very effective for increasing yield of oyster mushroom. The slurry can also be applied to organic deficient lands to supplement organic matter.

Inspite of all these benefits, the wide application and expected gain of this technology was not possible. For that, this research was undertaken to identify the practical problems in wide application of biogas technology through a systematic field survey in Fultala Upazilla of Khulna. Specific recommendations to restart the present biogas plants in the rural area of Bangladesh and guidelines for future plants are also presented in the paper.

2. METHODOLOGY

The study was confined at rural areas of Fultala Upazila of Khulna district. Data were collected from 31 biogas plant holders (27 family size plus community size plants) during 2003-04. Data were collected from the respondents through personal interview/field survey using an interview schedule with a pre-tested questionnaire.

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The biogas plants under study were constructed during 1998 to 2001 with technological and financial assistance provided by Local Government Engineering Department (LGED). Drawing and details of 4-family type and one community type biogas plants are available in the manual prepared by LGED. For 4-family type plants 40, 60, 80, and 100 kg cow-dung per day is need respectively while 175 human excreta is considered as raw material per day for one community type plants. To comprehend about the present status of family and community size biogas plants data were collected on the following parameters:

In case of family size biogas plants, parameters were: Family size, number of cows (provide cow-dung for the plants), other excreta, present demand of fuel (in %), Deshudge/week, utilization of sludge as fertilizer, fish food, fuel boray. In case of community size biogas plants similar parameter were selected except community size (in persons) instead of the family size. The collected data were analyzed for interpretation.

3. RESULTS & DISCUSSION

Usually two basic types of biogas plants are popular in Asia. These are: (i) floating dome type; and (ii) fixed dome type. The family size of the 26 families ranged from 3-18 with a mean of 7.65 and standard deviation of 3.55 (Table 1).

Table 1: Basic information on utility of family size bio-gas plants

Plant	F. Size	Nos. of Cow	Other Excreta	Present demand of fuel in %	De-Sludge /Wk	Utilization of Sludge as		
						Fertilizer	Fish Food	Fuel, Boray
D-1	8	3 (1)		20	1			Y
D-2	6	4	Poultry	33	2	Y	Y	Y
D-3	3	1		NI	1			Y
D-4	7			NI	2	Y	Y	
D-5	5	3		NI	Other			Y
D-6	5	4 (2)		Less	1			Y
D-7	8	7 (2)		NI	Other			Y
D-8	7	6 (2)		NI	Other			Y
D-9	18	3 (1)	Poultry	NI	0.25	Y		
D-10	8	6		No Need	Other	Y		Y
D-11	6	4		NI	Auto		Y	Y
M-1	8	6		23	Auto			Y
S-2	8	8		No need		Y		
S-3	16	10	Poultry	13	1	Y	Y	
G-1	5	3		NI	1	Y		
F-2	7	5		43	2	Y		Y
P-1	6	3 (2)		35	1	Y		
P-2	7	5 (3)		NI				Y
P-3	5	10 (0)		No need	1			Y
P-4	6							
J-1								
J-2	7	3		Less	1		Y	Y
J-3	16	4						
J-4	6	3 (1)		NI				
R-1	6	3 (2)		NI	1	Y		
R-2	7	3		NI				Y
T-1	8	6 (4)			Auto/0.5	Y	Y	

F. Size = Family size; () = nos. of cow at present; NI = No idea;
The blank cells in table have no available data or not responded by the owner of the plants.
Name of the village are: D = Damodar; M = Mashiahli; S = Shiromoni; G = Gariardanga; F = Fultala; P = Poigram; J = Jamira; R = Raripara; T = Taligati.

Cow dung is used as feedstock for all family size plants. Jointly with cow dung the poultry droppings and other wastes are also used in three family size plants. It was observed that, the number of cows at initial stage of this plant ranged from 3-10 with a mean and standard deviation of 4.65 and 2.33, respectively. However, after few months of initiation the number of cows decreased in case of most of the families due to several reasons and it ranged from 1-4 with a mean and standard deviation of 1.6 and 0.84, respectively. The decrease in number of cows consequently affected the closing of this family type biogas plants. To keep running the family plant, it seems to be essential that, there should be continuous supply of the feedstock. In case of shortage of cow dung other wastes could be used. It could be suggested that, the installation of plant is more feasible for them, who have multiple sources to get the feedstock. Remarkable decrease in fuel consumption was observed during the running period of the plant. Among 27 family responded for survey, six owner now needed only 20 to 50% of fuel used in past. About 14 number of owners could not accurately measure the amount needed for cooking in the past and present. Some families do not need any fuel at all after installation of the biogas plant.

Basic information of four communities is shown in Table 2. The size of community ranged from 45 to 150 persons with a mean and standard deviation of 86.25 and 49.22, respectively. Human excreta are mostly used in the community size plant with little problem in availability of raw waste. Overall, more than 50% fuel demand is reduced after start of those community plants.

The sludge is usually removed manually once in a week or in some cases is removed automatically as indicated in Table 1. The sludge is used as organic fertilizer, as fish food and as fuel. Among responded families eleven were using the sludge as fertilizer, and six were using as fish food. About fifteen families reported as using sludge as fuel.

Table 2: Basic information on utility of community size bio-gas plants

Plant	C. Size, persons	Nos. of Cow	Other Excreta	Present demand of fuel in %	De-Sludge /Wk	Utilization of Sludge as		
						Fertilizer	Fish Food	Fuel, Boray
S-1	150		Human	50				
Ja-1	45		Human					
F-1	50		Human					
B-1	100	4	Human	No need		Y	Y	

C. Size = Family size,
The blank cells in table have no available data or not responded by the owner of the plants.
Name of the village are: S = Shiromoni; Ja = Jagnipasha; F = Fultala; B = Begerdanga.

Different operational and overall problems recognized by the owner/operator of the bio-plants and their management are presented in Table 3 and 4. Among responder families, fourteen complained about some particular operational problems as mention in Table 3. Among them, two, five, and two attributed about key problem in the burner, clogging of gas pipe and leakage in digester, respectively. Other identified problems are, formation of crack on digester, lack of raw materials, and irregularity in gas supply. The operational problems are self-manageable as reported by eight families among the fourteen responded families. Only three have complained regarding bad odor emissions and fly problems. Among 27 family size plants 9 were running and 18 were closed during survey period (Table 3). It means that two third of the family size plants were closed. In most of the cases, the main reason of closing of the plants was lack of raw materials (cow dung) due to decrease in number of cows (Table 1). Among other causes of closing, poor maintenance and fault in construction were remarkable.

Among 4 community size plants 3 were running and 1 was closed during survey period (Table 4). It means that 75% of the community size plants were running. In this case the result is almost opposite and encouraging as compared to family size plants. In most of the cases the main reason of running of the community plants is that, they do not depend on cow dung rather they use human excreta. They also do not have much complains as indicated in Table 4. From this finding it could be suggested that the community size plants are feasible and these could be constructed near community like halls, hostel, etc.

4. ENGINEERING SIGNIFICANCE

Family size to large centralized biogas plants are widely installed in developed and developing countries of the world. About 1.75 to 3 million of family size, i.e. from 1 to 6 m^3 capacities, biogas plants have been set up in India (Purohit *et al.,* 2002; Singh and Sooch, 2004; Khoiyangbam *et al.,* 2004). Biogas plants are one of the important elements in the Danish energy-policy of having reduced CO_2 emissions by 20% by 2005. Since 1984, Denmark has approximately 20 large centralized biogas plants of reactor capacity varying from 500 m^3 to 7500 m^3. All Danish biogas plants have increased gas production as a result of admixing industrial organic wastes with manure (Maeng *et al.,* 1999). Although, biogas technology is very efficient, its failure in the field level after installation would create a very negative impact for its acceptance in the society in future. Consequently the energy contribution from this technology will be cut down from the renewable energy sources. This should not be acceptable for a technologically developing society like Bangladesh.

Table 3: Operational and overall problems recognized by the owner of the family size bio-plant and their management

Plant	Operational problem	Overcome	Other problems	Start	Closed on	Cause of closing
D-1	No			2002	2003	Lack
D-2	Key	Self		1997	Run	
D-3	Netports is damaged	Self		1998	2002	Shortage of manpower
D-4	Crack in digester			1999	2001	Fault
D-5	Clogging	Self	Construction cost is high	1998	2001	Shortage of manpower
D-6	Leakage			1999	2001	Fault
D-7				1999	2001	Less
D-8				1999	2001	Less
D-9				2001	2004	Lack
D-10			Bad odor	2000	Run	
D-11				1999	Run	
M-1			Bad odor	1999	Run	
S-2				2002	Run	
S-3	Leakage		Fly, unhygienic		Run	
G-1	Clogging	Self	Insufficient gas	1999	Run	
F-2				1997	1999	Less
P-1				1999	2003	Other Problem
P-2				2001	2003	Fault
P-3	Clogging	Self		1998	2004	Lack
P-4				I		
J-1				I		
J-2	Clogging	Self		2001	Run	
J-3				I		
J-4				2001	2001	Fault
R-1	Lack			1999	2001	Lack
R-2	Irregular gas supply			1999	2001	Fault
T-1	Moisture in gas pipe	Self	None	1997	Run	

Lack = Lack of raw material; Fault = Fault in construction; Less = Less Maintenance.

Table 4: Operational and overall problems recognized by the owner of the family size bio-plant and their management

Plant	Operational problem	Overcome	Other problems	Start	Closed on	Cause of closing
S-1	Key	Self	None	2001	Run	
Ja-1				2002	Run	
F-1				2003	Run	
B-1	Lack of raw material		None	1997	2002	Lack of raw material

The specific operational and maintenance problems are discussed in the previous section. From the findings of this research, the problems could be designated as minor and could easily be managed by the owner/operator as indicated in Table 3 and 4. The important guidelines are also presented for maintenance of present plants and for designing of future plants. Extensive motivation and training of the plant owners/operators (or the responsible person) is needed to re-start the closed plant. Manual published by LGED is worthy for training. On the other hand continuous follow up of all installed plants by proper authority like LGED should be increased to make viable the technology for the rural people. For the installation of the new future plants the following recommendation should be considered.

- Practically successful good example should be created. For that, at least one new community plants should be installed in most of the higher educational institutes (like Universities, Colleges and Madrasas) in the country, which have student hostels. The students (the future citizen) will be motivated from those successful plants and certainly the acceptance of biogas plants will increase in the society.
- The installation of the new plants will only be permitted for such a place where, the supply of raw materials (solid wastes) could be assured.
- Regular motivation for maintenance and inspection is required.
- Policy to construct several large-scale or centralized biogas plants should be adopted in solid waste management plan of the City Corporation and Municipalities.
- Now it is important to take initiatives to construct centralized biogas plants at Upazilla level using organic solid waste.

5. CONCLUSIONS

The following conclusions can be drawn:

- Significant reduction in fuel utilization is observed in most of the cases during their operation period, which certainly has a positive impact.
- In most of the cases the main reason of closing of the family size plants is lacking of cow dung due to decrease in number of cows. The operational problems are leakage in gas dome, clogging of gas pipe and inactive key of the burner, which could be designated as minor problem.
- Most of the community size plants were in running condition as they do not depend on cow dung rather they use human excreta. They also do not have much complains. In this case the situation is completely opposite and encouraging as compared to family size plants.
- Special steps should be taken to re-start all the closed plants and to install the new plants according to the guidelines presented in the previous section.

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