Bangladesh Journal of Extension Education *ISSN 1011-3916*
Volume 29, No. 1&2, 2017: 23-31 *Research Article*
Journal home page: http://www.bjeebd.com
Published by: Bangladesh Agricultural Extension Society (BAES)

Fostering Community Based Waste Management Practice towards Sustainable Environment in Bangladesh

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Abstract

For sustainable livelihood and environment modified shed for cattle rearing was practiced maintaining 10:1 slope for easy drainage and disposal system of cattle urine, dung and feed left-over including flash water generated from cattle directly disposed to anaerobic digestion system for sustainable livestock waste management. About 80-85% waste materials managed automatically by gravitation flow and rest amount inclined manually into the anaerobic digestion system to capture enriched organic manure co-digested with cattle urine and waste can be converted to value. Instead of traditional family based it would be comparatively economic to adopt "community bio-digester" because of its' multi-dimensional benefits of waste management following "Asset Based Community Development (ABCD)" approach. Through which a community could capture an average 90-110 m^3 biogas/day, allowing space 1.72 m^2/ cow, waste collection 14.7 kg/cattle, manure production 4.1 kg/ cattle, milk production 9.8 litters/ cow, respectively. On the other hand in conventional farming system showed significantly lower performances ($p<0.01$) in an average per day biogas production of 3.6 m^3, allowing space 4.76 m^2/ cow, waste collection 5.55 kg/ cattle, manure production 1.48 kg/ cattle, milk production 6.2 litters/ cow, respectively. The cost and benefit analysis indicated that, per day net income from a cow was significantly higher ($p<0.01$) in community farming compare to conventional system and the respective income per day per cow from waste management was Tk. 22.54 and Tk. 4.52, respectively. The present study was also under taken to assess the quality of co-digested bioslurry (CBS) produced from cowdung in-addition with cattle urine, flash water of cattle sheds, cattle feed residues and the nutritional value changes that occur after anaerobic digestion in community farming compare to conventional farming system. According to analysis average concentration of NPK ($p<0.01$) were found significantly higher in community cattle farming compare to that of conventional system with the corresponding values were 1.93, 1.26, 2.25 and 0.54, 0.05, 0.054%, respectively.

Keywords: Community, waste management, sustainable environment, RDA

Introduction

The world-wide intensification of livestock industries poses major challenges for waste disposal. To meet up high population demand of nutrition especially comes from livestock must be raised in environmentally sustainable manner. Yet, as milk and meat production need to be increased, herd size and waste production also increased. This has finely tuned the awareness for waste management. Any livestock operation, regardless of size, that is causing a pollution problem must follow the regulations (World Bank, 2008). One of the lowest land-person ratios (0.12 ha) in the world (FAO, 2001) the country is losing about 1% of cultivable land every year. Bangladesh is an agricultural country and her soil is the most important natural resource. Unfortunately, organic matter content in most of the Bangladesh soils is alarmingly low. It is generally around 1% in most and around 2% in few soils. To make the soils

productive the organic matter content in them should be maintained at least at 3% level (Islam, 2006). Ledgard et al. (1982) mentioned that addition of cow's urine in composting pits led to production of superior quality vermin-compost with higher concentrations of major macro and micro nutrients. Such Vermi-compost was found to be superior in terms of useful micro-flora (fungi, bacteria, and actinomycosis).

The livestock of Bangladesh consists of 26.21 million of large ruminants, 17.59 million of small ruminants and 137.23 million of poultry (Agricultural Census 2008), and annually produce about 317.5 million tons of livestock manure. A huge amount of manure produced by the farmers used as burned fuel and kept in solid storage for selling to others. All these systems caused air pollution emitting Short Lived Climate Pollutants (SLCPs), and methane (CH_4) shares a major part of them. Commercial (having average per household 15 animals) or subsistence (having average per household 1.98 animals, Agricultural Census 2008) livestock farming affects extent of manure CH_4 emission (Huque, 2015).

Dung and litter have a big impact on the environment and cultivable land in Bangladesh, e.g. dumping of poultry litter on low ground near the farms causes significant odor, dust and surface water pollution (Waste Concern, 2005). It is to be mentioned that production of biogas would benefit the community by providing clean fuel in form of biogas from feed-stocks such as large quantities of agricultural residues, municipal wastes and industrial wastes and help to end energy poverty (Parawira, 2009). Nes and Nhete (2007) advocate that biogas technology which converts biological wastes into energy is an excellent tool for improving life, livelihoods and health in the developing world and that biogas is a service that is broader than just energy supply.

The biogas digesters base on community concept was developed by Rural Development Academy (RDA), Bogra in 2002. A combination of batch and semi-continuous digestion is known as "semi-batch fed digestion". It also called Fixed Dome Digester. Such a digestion process is used where the dung/droppings from domestic farm animals is sufficient to operate a plant and the same time organic waste like crop residues, livestock wastes, kitchen waste, weeds etc. are available during the season. But RDA developed Fixed Dome CBP (Community Biogas Plant) use cow dung and flush water as the major substrates. This plant has an inlet pipe connected to Digester for daily feeding of cowdung including urine directly generated from animal's shed. The semi-batch fed digester has much longer digestion cycle and of much gas production with enriched bio-slurry as compared to the batch-fed digester (Sarkar et al., 2017). The batch-fed digester is ideally suitable for traditional family base small and medium farmers having 6-8 cattle's or 20-30 goats to meet the basic cooking requirement and at the end of the cycle it gives organic fertilizer in the form of digested slurry (Mamun et al., 2009).

More than a decade ago, RDA, Bogra conceived and implemented the waste management program in RDA campus, especial emphasis given on demonstration farm with the aim of putting the brakes on environmental pollution mainly caused by livestock wastes. RDA through its action research project working to address these issues on community basis and will discuss the potential of replication to the other regions (Sarkar and Uddin, 2013).

This is why triggered the need for this study and felt that there is a strong demand for alternative energy sources as a means of solving domestic energy as well as waste management problems. This is also spelt out in the government energy policies, but despite the need and efforts directed to promote the available technologies particularly community biogas technology the adoption is still minimal. The present study therefore, emphasizes to scrutinize the root causes for the low level of application of community biogas technology in comparison to promotional efforts so far executed by RDA in northern part of Bangladesh.

Objectives

The broad objective was to capture prospects of community biogas plants for waste management and its' impact in terms of socio-economic and environmental benefits to the rural community of

Bangladesh. The specific objectives of the study were: (i) to asses existing waste management practice and quality of bio-slurry produced through community biogas technology; (ii) to determine potentiality of community and conventional biogas technology towards environmental sustainability; and (iii) to identify ways and means for fostering biogas technology within rural community of Bangladesh.

Challenges

The existing improper waste management system especially in case of livestock sector at rural areas creates environmental hazard in Bangladesh. Though, wastes can be used as resources for community biogas plants to convert energy with enriched organic manure and could save lots of foreign currency for importing LPG, deforestation leads by using fuelwood and conserve soil health deterioration by using organic manure.

Methodology

This research will enable to look at the problem in both descriptive and exploratory manner. The primary data were collected via observation, questionnaire, interview and focus group discussion during July to December 2017. All the demographic population of Community Based Organization (CBO) implicitly or explicitly who were user and non-user of biogas came under the population frame. Under this method sample were selected 10% households out of 1600 households all together a sample size of 160 household was taken for inquiry.

Basically, SPSS version 17.0 used to analyze the data. The interdependence between the variables, their correlation, and variance analysis were employed to draw the inference. It was also chosen to use F-test, and as if needed other statistical tools for the study of relationship.

Materials and Methods Used in Analysis of Organic Fertilizer

The present study aimed at examining the physical and chemical characteristics including heavy metals concentration of organic fertilizers produced in different systems e.g. biogas technology used in community and non-community farming systems hence to determine their quality as a good organic fertilizer. Both primary and secondary data collected from relevant sources, methods and concepts based on triangulation principles were followed. The collected data were summarized and analyzed with the help of tabular forms, using numbers, average, percentage etc. The organic fertilizer samples were analyzed by the help of Bangladesh Council for Scientific and Industrial Research (BCSIR, Dhaka) laboratory. T-test was performed to calculate the mean difference and p value at the significant level <0.05 and <0.01 to know that if there is any significant change in organic fertilizer produced in community farming and conventional farming system.

After collecting necessary samples of organic fertilizer produced in community and conventional farming system from the action research fields of RDA, Bogra, Bangladesh were processed and analyzed in the BCSIR, Dhaka laboratory. Samples were dried in an oven at 60°C, grinded and sieved by 1mm sieve and then analyzed to monitor the changes in physical and chemical properties.

Characterization of Organic Fertilizer

Organic fertilizers samples color and odor were observed. Moisture percentage was determined by using moisture meter and pH was determined by Corning glass electrode pH meter (Jackson, 1973).

The samples were analyzed following suitable methods as mentioned below:

1. Organic Carbon: Tyurin's method
2. Nitrogen: Kjeldahl method
3. P: Vanadomolybdophosphoric yellow color method
4. K: Flame Photometric method
5. S: Turbidimetric method

6. Zn, Cu, Cr, Pb, Cd and Ni: Flame Atomic Absorption Spectrophotometer
7. As: Atomic Absorption Spectrophotometer with HVG
8. Hg: Atomic Absorption Spectrophotometer with MVU
9. pH: pH meter
10. Moisture content: Moisture meter

Setting ABCD as Model for Community Development Projects

Having established the definitions of key terms, the model termed as "Asset Based Community Development (ABCD)" through which community development project implemented (including community biogas project) is to be studied and will now be expanded. At its most basic, community development can be defined as "a process designed to create conditions of economic and social progress for the whole community with its active participation and the fullest possible reliance on the community's initiative" (Rothman, 1974; Sarkar et al., 2011).

On a broader scale, ensuring that community biogas projects can be justified on economic grounds increases the chances of funding for future projects, as the economic successes of the projects can be demonstrated as environment friendly along with the social benefits without compromising present and future generations.

In figure 1 indicated general representation for this study of community development projects. If internal (within the community) and external (out of the community) assets are used by the provider to deliver the community development project, which delivers the project outcomes to the beneficiary levels. In more detailed assessment of how a provider gets access to the community assets used in the community development project can help to arrangement the investigation into what characteristics of a community influence the success of community development projects (Sarkar and Uddin, 2011).

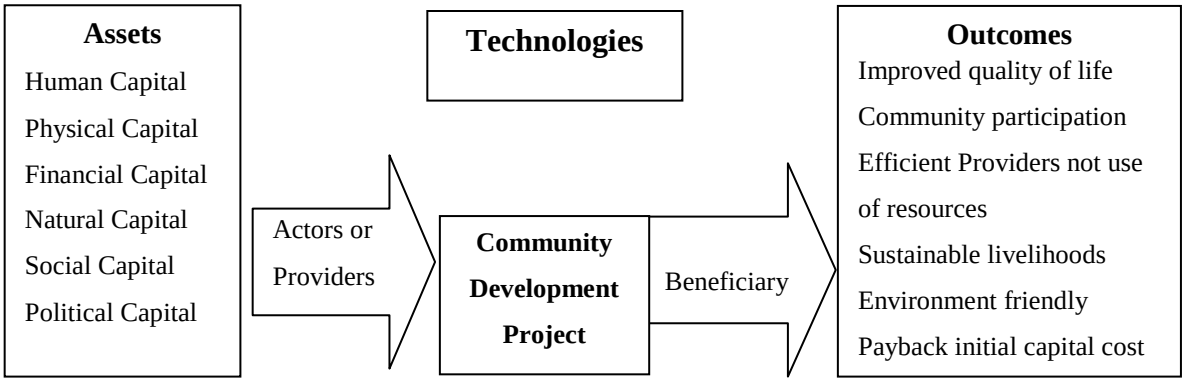

Figure 1: Community development assets and outcomes

Results and Discussion

Socio-economic Characteristics of Biogas Technology Adopters

Table 1 summarized the socio-economic characteristics of sampled population in the study area. Six important characteristics are considered due to their influence and relationship with biogas technology adoption. These characteristics include; sex, age, education level of household head, household size and household income. These characteristics are further subjected to descriptive analysis in order to study their influence to the adoption of biogas technology for managing wastes.

The results in table 1 indicate that the majority (76.3%) of households in the study area are male headed as compared to (23.7%) female headed

households. This has an implication on household decision making systems, the decision on whether the household adopts biogas technology or not, mostly depends on the head of household. The results further indicate that a majority of respondents were in the economically active age, that is, 20 – 60 years which relates to labor stipulation for biogas activities, and resource ownership hence affordability of biogas installation costs. Table 1 further indicates that a majority of household heads, 58.1% had attained primary education. This implies that a large part of the sample population can at least read and write, meaning that the individuals are trainable as far as biogas technology awareness is required for successful implementation. The results indicate that a large number of households in the study area have an average of 1-4 and 5–8 family members 47.5% and 45% respectively, a sufficient number to provide adequate labor for smooth of running biogas plant operations. The average income, where 31.2% of respondents earn Tk. <250,000/= per annum but, a majority 68.8% earn Tk. >250,000/= per annum. This has got an implication on affordability of biogas installation costs (Table 1).

Table 1: Socio-Economic Characteristics and Biogas Technology Adopters

Household characteristics	Community Adopter (N=80)	Non-community Adopter (N=80)	Total (N=160)
Sex of respondent			
Male	80.0 (64)	72.5 (58)	76.3 (122)
Female	20.0 (16)	27.5 (22)	23.7 (38)
Total	100.0 (80)	100.0 (80)	100.0 (160)
Age of respondent			
Between 20 – 40 years	45.0 (36)	48.8 (39)	46.9 (75)
Between 41 – 60 years	48.8 (39)	42.5 (34)	45.6 (73)
Above 60 years	6.2 (5)	8.7 (7)	7.5 (12)
Total	100.0 (80)	100.0 (80)	100.0 (160)
Education level			
Uneducated	3.8 (3)	5.0 (4)	4.4 (7)
Primary education	58.7(47)	57.5 (46)	58.1(93)
Secondary education	18.7(15)	18.7(15)	18.8 (30)
College Education	12.5 (10)	12.5 (10)	12.5 (20)
University	6.3 (5)	6.3 (5)	6.3 (10)
Total	100.0 (80)	100.0 (80)	100.0 (160)
Household size			
Between 1 – 4 Members	37.5 (30)	57.5 (46)	47.5 (76)
Between 5 – 8 Members	55.0 (44)	35.0 (28)	45.0 (72)
Above 8 members	7.5 (6)	7.5 (6)	7.5 (12)
Total	100.0 (80)	100.0 (80)	100.0 (160)
Household Average Income p.a.			
Between Tk. 100,000 - 250,000	35.0 (28)	27.5 (22)	31.2 (50)
Between Tk. 251,000 - 500,000	35.0 (28)	47.5 (48)	47.5 (76)
Above Tk. 500,000	30.0 (24)	12.5 (10)	21.3 (34)
Total	100.0 (80)	100.0 (80)	100.0 (160)

Note: The figures are the percentages and those in brackets are the number of the respondents
Source: Field data (2017)

Existing Livestock Waste Management Practice in Study Area

The livestock waste management system of Bangladesh may be categorized into i) Solid storage, ii) Liquid slurry, iii) Burned fuel, iv) Anaerobic digestion, and v) Without litter, the systems defined by the Inter-governmental Panel on Climate Change (IPCC 2007). In the case of livestock waste management four systems are practiced by 22.3%, 8.2%, 66.5% and 3%, respectively (Table 2). Liquid slurry, instead of keeping it in confined systems, is practically lost out of ignorance as stated by respondent farmers, and thus, a very low share (4%) of the system was reported during the survey. However, liquid slurry is considered to be one of the major pollutants of air and water. It may be processed into organic fertilizer/soil conditioner, vermi-compost, and organic pesticides which may be marketed as value added products.

Table 2: Existing Livestock Waste Management Systems

Systems	Percentage of farmers
Solid storage	22.3
Liquid slurry	8.2
Burned as fuel	66.5
Biogas plant	3

Source: Field data (2017)

Importance of Bio-Slurry as Organic Fertilizer in Bangladesh

This study looks at the importance and highly positive impact of bio-slurry on the agriculture in Bangladesh. Bio-slurry is a 100% organic fertilizer produced through community biogas plants anaerobically, using feed-material mainly cow-dung in-addition with cattle urine, flush water, feed residues from cattle shed, poultry droppings and kitchen waste etc. Rural Development Academy (RDA), Bogra has implemented an action research project following asset based community development approach (ABCD) to foster environmentally friendly waste management practice during 2009-2015 aiming to promote the use of bio-slurry as organic fertilizer and biogas for cooking & electricity generation with a package support including installation of deep tube-well (DTW) for ensuring safe drinking water as well as household chores and smooth running of community biogas plant and has started to marketing of bio-slurry/organic manure/organic fertilizers with the brand name of **Palli Jaibo Sar** (Reg. No. M 604, 2011) to conserve the soil health through ACI Ltd. whole over the country under a MoU with RDA, Bogra. This ABCD approach would certainly be one of the best options for managing all sorts of degradable wastes special emphasis on livestock sector at rural areas of Bangladesh to convert waste into wealth by reducing poverty, malnutrition, fuel and fertilizer crisis to support food security with environmentally sustainable manner for the present and future generation.

Characteristics of Organic Fertilizer Produced in Different Systems

In this study, quality of organic fertilizers produced under different systems was assessed by determining concentrations of different nutrients and heavy metals by using most popular and suitable chemical methods (Table 3) in the Bangladesh Council for Scientific and Industrial Research (BCSIR Dhaka) Laboratory.

Chemical characteristics: One of the often used parameters to assess the rate of decomposition in the fermentation process is the C/N ratio, since it can be a sign of the complete fermentation of the organic fertilizer (Jusoh et al., 2013). In this study, C/N ratio in conventional and community farms was found 5.36%, and 21.88, the recommended value being less than or equal to 25 (Shymala and Belagali, 2012). The lower C/N ratio is an indicator that in the conventional farming system for producing organic fertilizer may be remain incomplete in fermenting process due to biogas plant is smaller in size with short retention time. The concentrations of N, P, K, and S were measured as 1.93%, 1.26%, 2.25% and 0.451% respectively, all of which were not only within the recommendation limits (FRG 2012) but also higher in quantity in the case of community farm. Heavy metal present in organic

fertilizer may create health hazards as they may enter into human body through food chain. So, heavy metal contents higher than permissible limit would lead deterioration the quality of fertilizers. These were all found within the recommended limit in both the farming systems.

Statistical Analyses of Organic Fertilizer Produced in Different Systems

The statistical analysis done according to Steel & Torrie (1980) of organic fertilizers produced in conventional and community farms are presented in (Table 3). The average concentration of N ($p<0.01$), P ($p<0.01$), K ($p<0.01$) were found significantly higher in community cattle farming compare to that of conventional system and the corresponding values were 1.93, 1.26, 2.25 and 0.54, 0.05, 0.054%, respectively. Again, the average concentration of pH ($p<0.01$), Hg ($p<0.05$), Ni ($p<0.05$) were found significantly lower in community cattle farming compare to that of conventional system and the corresponding values were 6.7, 6.21 ppm, 9.62 ppm and 8.6, 12.02 ppm and 28.4 ppm, respectively. The addition of cattle urine and collection of manure in community farming for co-digestion compare to conventional system was practiced by the community for cattle rearing, housing with better husbandry practices followed by the farmers' in the study area found to be very effective for producing high quality nutrition rich organic fertilizer.

Table 3: Statistical Analysis of Organic Manure Produced under Different Systems

Parameters	Farming System		Sig	Govt. Standard (2008)
	Community	Conventional		
pH	6.69±0.06	8.62±0.19	**	6-8.5
Moisture (%)	14.04±0.39	36.20±4.55	**	10-25%
OC (%)	21.96±0.25	4.54±0.61	**	0.5-4%
N (%)	1.93±0.54	0.54±0.07	**	Maximum 20:1
C:N	11.50±1.28	8.40±0.51	**	0.5-1.5%
P (%)	1.48±0.25	0.05±0.01	**	1-3%
K (%)	2.64±0.36	0.054±0.005	**	0.1-0.5%
S (%)	0.44±0.15	0.078±0.005	NS	Maximum 0.1%
Zn (%)	0.012±0.001	0.0116±.0004	NS	Maximum 0.05%
Cu (%)	5.37±1.16	5.38±0.22	NS	Maximum 20 ppm
As (ppm)	15.52±0.67	15.53±0.36	NS	Maximum 50 ppm
Cr (ppm)	10.92±1.06	3.66±0.35	**	Maximum 5 ppm
Cd (ppm)	0.20±0.05	3.61±0.22	**	Maximum 30 ppm
Pb (ppm)	4.41±0.98	5.46±0.29	NS	Maximum 0.1 ppm
Hg (ppm)	6.21±1.65	12.02±0.46	*	Maximum 30 ppm
Ni (ppm)	9.62±4.75	28.40±1.45	*	Maximum 1%

*Significant at ($p<0.05$), **Significant at ($p<0.01$), NS= Non-significant

Though concentration of NPK was within standard range in conventional farming, but their concentration were in lower range limit than that of community farm produced organic fertilizer. The organic fertilizer produced in community based biodigester was found to be free from bad odor and higher in nutritional value. Hence, all these properties indicate that the asset based community development approach can be effectively used to produce good quality organic fertilizer by managing all sorts of degradable wastes in the rural areas of Bangladesh in an environmentally sustainable manner for the present and future generations as well.

Conclusion

The process for ABCD model proved as effective for community based sustainable livestock development through managing all sorts of degradable waste in an environmentally friendly manner putting positive impact on their livelihoods. Production and utilization of bio-slurry, biogas for cooking and electricity generation and of nutrient rich organic fertilizer for soil health conservation to extend organic farming should be explored for capturing full potential of this model.

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