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The introduction of low-cost polyethylene tube biodigesters on small scale farms in Vietnam

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Abstract

In order to evaluate polyethylene tubular digester development in Vietnam, interviews were carried out in ThuanAn district and at two extension centres. Data of design parameters, gas production, economic aspects, farmers' participation, technical problems and methodologies of biogas development were collected. The technology was appealing to the rural people because of its low cost, fast payback, simplicity and positive effect on pollution. The findings pointed to the importance of farmers' participation for technical feedback, plant maintenance, plant repair and teaching of other farmers. The dissemination of the technology needs the selection of real farmers with high fuel demands as demonstrators, the support of a credit system for the poor farmers and strengthening farmer-extension-scientist relations. Follow-up research should be focused on on-farm studies, particularly the use of the effluent (slurry).

Key words: Plastic tube biodigester, low cost, farmer impact, women, sustainable development.

Introduction

In recent years, the conversion of biomass to methane for use as an energy source has excited interest throughout the world. Biogas digestion was introduced into developing countries as a low-cost alternative source of energy to partially alleviate the problem of acute energy shortage for households. However, few farmers used biogas in practice. The poor acceptability of the digesters is believed to be due mainly to the high cost of the digesters, difficulty in installing them and difficulty in getting spare parts. The biogas programs developed quickly in some developing countries only under substantial support from governments and aid agencies (Gunnerson 1986; Kristoferson and Bokalders 1991; Marchaim 1992; Karki 1996) . Besides, the replacement of worn-out parts posed another technical problem, in addition to the fact that such spare parts were not always locally available.

Many developing countries, such as Colombia, Ethiopia, Tanzania, Vietnam, Cambodia, Bangladesh promoted the low-cost biodigester technology aiming at reducing the production cost by using local materials and simplifying its installation and operation (Solarte 1995; Chater 1986; Hieu et al 1994; Sarwatt 1995; Soeurn 1994; Khan 1996). To this end it was decided to use a continuous-flow flexible tube biodigester based on the bag digester model as described by Pound et al (1981) and later simplified by

Preston and co-workers first in Ethiopia (Preston T R, unpublished data), Colombia (Botero and Preston 1987) and later in Vietnam (Bui Xuan An et al 1994). Up to now (May 1997), more than 4,000 polyethylene digesters were installed in Vietnam, mainly paid for by farmers (Nguyen Khang, personal communication).

The objectives of this study were to assess the effects of low-cost biodigesters in small farms in Vietnam and to identify experiences, effects, constraints and problems associated with this technology.

Materials and methods

Parameters of digesters

Data of design parameters and cost were collected from 194 biodigesters installed from April 1993 to December 1995 around Ho Chi Minh City.

Influence of biodigesters on the farmers' lives

Open-ended interviews (Casley and Kumar 1988) were carried out on 35 small farms having biodigesters in the Thuan An district, 40 km north of Ho Chi Minh City. In the selected area there were both upland and lowland ecosystems with 1800 mm rainfall, an average temperature of 27^{o}C with small difference between seasons, sugarcane and cassava as the main crops and pigs as the most common animal (Thuan An People's Committee report, 1994; unpublished).

The questionnaire for farmers and their wives contained questions such as:

- Use of the biodigesters: cooking parameters, economics of biogas use, use of effluent for fertilizer and other uses.
- Farmers' participation: where did they get the information, payment of the digester, conditions before and after biogas use, opinions and suggestions.
- Digester life: technical problems, when did problems occur, who fixed them, how was it done, what materials were needed.

Input and output from digesters

- Manure inputs were weighed directly on most of the farms. In cases when weighing was impossible, the amounts were estimated by comparing with other farms with similar numbers and ages of animals. The amounts of water were weighed directly or estimated from multiplying water speed and washing time.
- Gas production: by industrial gas-meter model k-875-1, Yazaki Keiki Co., Japan connected to the gas outlet of digesters.
- pH: by digital pH-meter.
- Dry matter (DM) of the manure was measured by drying at 105^{o}C until constant weight in a forced draught oven.
- COD: Chemical Oxygen Demand (the amount of oxygen consumed for the oxidation of the reductive substances contained in a litre of liquid waste sample), using standard methods (HMSO1986).

Table 1: Mean values for some design parameters and cost of 194 digesters installed around Ho Chi Minh City

	Mean	Range
Length (m)	10.2	4-30
Digester liquid volume (m3)	5.1	2-15
Distance to kitchen (m) 23	8-71	
Material cost (US$)	25.4	14-82
Days to first gas production	17	1-60
Digesters in rural areas(%)	91	
Floating digesters (%)	5	

The data and samples were taken for two consecutive days in the rainy season (from May to October) from 31 biodigesters randomly selected around Ho Chi Minh City. The average temperature in the area was 27.5^{o}C and temperature difference between day and night was 10^{o}C.

Interviews on extension and demonstration farms

The topic-focused interviews (Casley and Kumar 1988) were carried out with two extensionist groups, one at BaVi, HaTay province and the other at Thu Duc, Ho Chi Minh City. The topics concerned selection and status of demonstration farms, list and rank of problems in the biogas development. The data were then verified by farmer's interviews and field observations.

Results and discussion

Design parameters and cost of digesters around Ho Chi Minh City

The data are presented in Table 1. The average length of the digesters was 10.2 m with an estimated digesta volume of approximately 5.1 m^3 (length x 0.5 m^3). The material cost was slightly more than US$25 for a family digester.

Table 2: Economics of biogas introduction in 31 small farms in Thuan An district, Vietnam

	Mean	Range
Cooking time (hours)	4.4	1-9
Fuel saved in cooking (US$/month)	6.5	1.8-13.6
Digester cost (US$/unit)	34.8	18-53
Number of pigs/farm	10.7	0-40
Payback time (months)	5.4	2-19

In most developing countries, when the subsidies from governments are reduced, the number of plants built each year falls dramatically (Ellis and Hanson 1989; Qiu et al 1990; Desai 1992; Karki et al 1994). The most important problem in biogas programs in developing countries has been the price of digester plants. For exemple: the price of a concrete digester plant installed for an average family in Vietnam varied from 180 to 340 US$ (Thong 1989). This size of investment is considered unaffordable by average farm families (Bui Xuan An et al 1994). Chinese designers tried to reduce the cost of red-mud digesters to 25-30 US$/m^3 (Gunnerson and Stuckey 1986) but it was still high in comparison with the polyethylene digesters (5 US$/m^3). This is obviously one important feature which makes the polyethylene digesters attractive and no farmer in the present study complained about the price.

Among the polyethylene digesters installed, 5% of them were floated in ponds adding an innovative feature to the development. According to Khoi et al (1989), in the Mekong Delta where most land is low, the application of concrete digesters was very difficult especially when the water level went up. The floating digesters solved this problem and as they also required little space they very well suited for low-lying areas. More than 90% of the plants were installed in the rural areas indicating the good impact of the technology in the rural areas of Vietnam.

Influence of biogas on small farms in the ThuanAn district

Table 3: Farmers' participation and opinions on plastic biodigesters in ThuanAn district, Vietnam (n=number of farmers)

First information from:	**n**
Neighbours or relatives	32
Mass media	3
Payment of the digester plants:	
Farmers paid totally	33
Partially (demonstration)	2
Using slurry for:	
Plants	3
Ponds	3
Nothing	31
Status of gas production:	
Enough gas	26
Little gas	5
No gas	4
Advantages of biogas:	
Saves money	34
Less pollution	35
Easy cooking	35

The effects of the introduction of digesters in small farms are presented in Tables 2-4. According to the annual report of Thuan An people's committee (1994, unpublished), most of the farms with biodigesters belonged to the medium income group (sufficient food all year around). In this group animal production is a very important component in their farming systems and a sufficient number of animals is important in the dissemination of biodigesters. The expense for the digester plant was paid back within slightly more than 5 months, so most of the farmers found a great benefit from installing digesters.

Among 35 farmers interviewed, four of them were poor (not enough food in certain months) The most important thing for them is food and they could not afford a sufficient number of animals for feeding manure to the digester. They wanted to borrow money to be able to raise animals. Four farmers had no gas when the interview was carried out. Three of them did not have animals because they found raising animals unprofitable if they had to borrow money from local lenders at 5-10% monthly interest. This was an important aspect as especially resource-poor farmers cannot support the digester installation and keep animals, although they know the advantages of biogas.

Previously, animal manure was an environmental problem in villages in the district, mainly in crowded and lowland areas where it caused pollution in the air, water and soil. After installation of the digesters, all 35 families recognized better environmental conditions, less smell, fewer flies and cleaner waste water. Summarizing details of experiments conducted with pig slurries, Pain et al (1990) concluded that the digestion reduced odour emission by between 70 and 74%. According to the women who were responsible for food preparation, use of biogas meant that they could attend to other work, while cooking. This is in contrast to the situation when using solid fuels such as fire wood requiring much closer supervision. The women stressed that they could now cook in a clean environment free of smoke. Their pots and pans were clean and they did not have to spend time on tedious cleaning. They stated that they could cook all food items on gas.

Input and output of digesters working in small farms

Table 4: Input and output of 31 digesters working on small farms around Ho Chi Minh City, Vietnam

	Mean	Range
Size of family	5.9	3 - 12
Manure loading (kg/d)	16	2 - 27
Ratio water/manure	5.1	2.9 - 8.1
Loading rates (kgDM/m^3)	0.7	0.1 -1.2
Temperature of loading (°C)	26.4	25.7 - 28.5
Temperature of effluent (°C)	27	26.0 - 29.1
pH of loading	6.7	6.4 - 7.1
pH of effluent	7.2	6.8 - 7.5
Gas production (litres/unit/day)	1,235	689 - 2,237
Gas/capita (litresl/person/day)	223	68 - 377
Methane (%)[a]	56	45 - 62
COD[b] of loading (mg/litre)	35.6	22.4- 46.0
COD of effluent (mg/litre)	13.5	8.8 - 23.9
COD removal rate (%)	62	42 - 79

[a] From 9 digesters

[b] COD=Chemical Oxygen Demand (the amount of oxygen consumed for the oxidation of the reductive substances contained in a litre of liquid waste sample by a strong oxidizer)

The average manure DM percentage was 25% and the loading rates ranged from 0.1 to 1.2 kg DM/m^3 digester liquid volume. Biodigestion decreased COD from 35,610 mg/litre in the inlet to 13,470 mg/litre in the effluent indicating a process efficiency of 62% (COD removal rate). The volume of gas per capita per day enough for cooking three meals was about 200 litres. The loading rates were low and gas production could be improved by increasing the amount of manure fed to the digesters. Beside cooking meals, using gas, five farmers cooked animal feeds, three made wines, one made cakes and two prepared tea and coffee in their cafeterias. This demonstrates that there are several reasons for uptake, as discussed by Dolberg (1993).

Technical problems with the digesters

Main causes of damage to the digesters were the sun, falling objects, people and animals (Table 5). In cases where the digesters had been totally exposed to the sun, the plastic film was broken after 2 years. Seven digesters had films older than 2 years and four of them had been changed by technicians or farmers. The material cost for changing was about 15 US$ and one work-day was needed. Most digesters installed during 1995 were protected by roofs made from local materials, mainly palm leaves. Also, simple fences were made around the digesters to prevent damage from animals or people.

Slightly more than 40% of the biodigester plants had problems especially with the plastic tubes (Table 5). An interesting observation was that in 70% of the cases (12/17) the farmers could correct the problems by themselves and only in 30% of the cases did they need help from technicians. Repairs were mainly simple and farmers could teach each other. The first farmers who had digesters installed more than 2 years ago needed help from technicians, while farmers who had installed their digesters within the last year could resolve their problems by themselves. They had received information, experience and guidance from their neighbours. With increasing age of the plants more problems would be expected. Nevertheless, as more plants are installed in a village there will be more experienced farmers to do repairs and the help required of technicians would therefore be less. Also if there are good written instructions summarizing experiences from users, demand for the technical personnel will be less.

Table 5: Technical problems with polyethylene tube digesters in ThuanAn district, Vietnam

Damage by	Location of damages			
	Digester	Reservoir	Other	Total
Sun	4			4
Falling objects	2	1		3
People	2	1		3
Animal	1	1		2
Material qual.	1		1	2
Wind		2		2
Overloading	1			1
Total	11	5	1	17
Self-help[c]	6	5	1	12

[c] Farmers fixed digesters by themselves

This result shows that technical problems with the polyethylene digesters were resolved more easily than with other materials, such as concrete, steel and red mud. In many developing countries, the biogas programs have failed because of inefficient maintenance due to lack of technical personnel (Kristoferson and Bokhalders 1991). When the farmers do not take care of the digesters, only a small problem can cause gas production to cease making the farmers disappointed. The participation of the farmers has played an essential role in the dissemination of the technology. Some digesters which were not studied were installed by farmers themselves in the district.

Table 6: Comparison of demonstration farms and digesters installed at two extensionist groups in Vietnam

Item	BaVi	ThuDuc
Demonstration farms:		
Total participants	7	8
Main income from agriculture	1	6
Govemt employees	6	0
Enough fire wood	3	0
Enough wood & lack of manure	1	0
Demonstration digesters:		
Working after 2 years	2	6
Enough gas produced	0	6

Problems in the extension of biogas technology

There are some constraints and problems in the dissemination of biogas technology in developing countries. The question is how to solve them and what priorities to make. Some of the biggest problems in the Bavi and Thu Duc areas are pointed out in Table 6 in order of priority. In Bavi, the most important problem was unsuitable selection of demonstration farms (where main income was not from farming activities) which resulted in low feedback from farmers on the technologies of installing, maintaining and repairing the digesters (Table 7).

Table 7: Problems in plastic tube biodigester development in order of priority according to the extensionists in two extension centres in Vietnam

Priority	Bavi	Thu Duc
1	Extension methodology	Investment of farmers
2	Installation technolology	Plastic quality
3	Unstable animal production	Unstable animal production
4	Investment of poor farmers	Technical maintenance
5	Plastic availability	Efficiency of gas production & use
6	Plastic quality	

The selection of demonstration farms will promote the degree of farmer participation in digester introduction and provide technical feedback. In the first year, the Thu Duc group installed 60 digesters with the orientation of "farmers pay" in order to strengthen their motivation. Full-time farmers (most activities are on-farm) with high demands for fuel were selected as demonstrators. They paid more time to their farming activities and were more motivated to look after the digesters carefully, and considered the digesters as "animals". Several meetings between farmers and extensionists were held. Many small but important innovations were learned from farmers when extensionists spent time working and discussing with them. After 3 years more than 200 units have been installed by the Thu Duc group and the technology has been improving.

Although the biogas technology has been developing steadily around Ho Chi Minh City, there are still many questions from farmers, such as amounts of loading of on-land and floating digesters, how to prolong plastic life under farm conditions, how to use slurry for crops if the fields are far from the digester, incorporation of fish ponds and other uses of the gas. The other problems, such as investment problems of poor farmers, variable animal production and plastic quality were also mentioned. Many aspects involved in the technology should be studied carefully under real farm conditions. Sustainable use of natural renewable resources will be facilitated when the feed is grown, the animals are fed and the excreta are recycled on the farm in ways that reduce the use of imported inputs including energy (Preston 1995a). This idea has been displayed in integrated farming systems in many developing countries in South-east Asia. In this respect, Dolberg (1994) pointed out the need to develop the ability of researchers to be sensitive to the farmer's perspective and convert feedback from farmers into hypotheses for research and new possible solutions, which would then have to go through the same iterative process of trial and error. On-farm work will accelerate the research process and make it move faster than if the scientists confine themselves to the research station and laboratory. In order to realize this process, the professional agriculturists in developing countries should be re-trained for sustainable tropical agriculture in their home countries (Preston 1995b).

Allowing some time for the farmers to "digest" the biodigester technology is essential. It took about 3 months from the time the first digester was installed as a demonstration to the moment when the first digester was purchased by a farmer. It took an additional 6 months for the first digester to be installed by a farmer by himself (Bui Xuan An and Preston 1995). It is essential to strengthen the relationship between farmers and scientists in order to receive the feedback. According to Dolberg (1995a), an important condition for success of that approach is that the leading scientists take it seriously and are prepared to spend time in the field with farmers, showing how to deal with feedback from farmers and to convert it into researchable problems.

It should be noted that the technology of the polyethylene tubular digesters is not fully developed and the technology depends very much on natural, as well as socioeconomic conditions. Therefore, it is necessary to study on-farm conditions in different areas to improve the technology. An exchange of experiences between institutions should take place which should improve results. Communication between the institutions and between technical personnel is not sufficient. A network of all institutions and people involved in the biogas technology should be built over the country and overseas. Some recommendations for future developments and research of biogas programs in Vietnam based on foregoing criteria were pointed out by Dolberg (1995b).

Conclusions and recommendations

The polyethylene tubular film biodigester technology is a cheap and simple way to produce gas for small-scale farms in Vietnam. It is appealing to rural people because of the low investment, fast payback, simple technology, positive effects on the environment and womens' lives in rural areas. The farmers' participation is essential in technology feedback, maintenance, repair and education of others farmers. The extension of the technology requires the farmers' motivation which can be ensured by selecting full-time farmers with high fuel demands for demonstrations, supporting credit systems to poor farmers and strengthening farmer-extension-scientist relations. In future, research should start by involving farmers, creating feedback from the farmers and letting this feedback serve as a foundation for the formulation of research problems. One immediate problem to attend to is the use of the slurry.

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References

Bui Xuan An Ngo Van Man, Duong Nguyen Khang, Nguyen Duc Anh and Preston T R 1995 Installation and performance of low-cost polyethylene tube biodigesters on small scale farms in Vietnam. Proceedings National Seminar-workshop in Sstainable Livestock Production on Local Feed Resources. Agric. Pub. House: Ho Chi Minh, pp.95-103.

Bui Xuan An and Preston T R 1995 Low-cost polyethylene tube biodigesters on small scale farms in Vietnam. Electronic Proceedings. 2nd International Conference on Increasing Animal Production with Local Resources, Zhanjiang, China, p. 11.

Botero R and Preston T R 1986 Low-cost biodigester for production of fuel and fertilizer from manure (spanish). Manuscrito ineditado CIPAV, Cali, Colombia, pp1-20.

Casley D J and Kumar K 1988 The collection, analysis, and use of monitoring and evaluation data. Johns Hopkins Univ. Press, Baltimore and London, 174 pp.

Chater S 1986 New biogas digester for African small holders. ILCA Newsletter 1986, 5:4.

Desai A V 1992 Alternative energy in the Third World- a reappraisal of subsidies. World Development Oxford, 20: 959-965.

Dolberg F 1993 Transfer of sustainable technologies in Vietnam. Development of Sustainable Livestock Technologies for Ecologically Fragile Zones in The Tropics. SIDA MSc course in sustainable livestock production systems Report.

Dolberg F 1994 The farmer-extension-scientist interface: a discussion of some key issues. Proc. National Seminar-workshop in sustainable Livestock Prod. on local feed resources. Agric. Pub. House Ho Chi Minh, pp.118-122.

Dolberg F 1995a On-farm Research: A discussion of some practical examples and procedures. In: Tropical Animal Feeding: A manual for research workers (Editor: T R Preston,). FAO Anim. Prod. And Health, Rome, 126: 253-264.

Dolberg F 1995b Development of sustainable livestock technologies for ecologically fragile zones in the tropics. SIDA MSc course in sustainable livestock production systems. Report, pp. 5-6.

Ellis G and Hanson B 1989 Evaluating appropriate technology in practice. J. Contemporary Asia, 19: 33-47.

Gunnerson C G and Stuckey D C 1986. Anaerobic Digestion- Principles and Practices for Biogas Systems. The World Bank Technical Paper # 49 , Washington, DC, pp 93-100.

Hieu Luu Trong, Ly Le Viet, Ogle B and Preston T R 1994 Intensifying livestock and fuel production in Vietnam by making better use of local resources. Proceedings National Seminar-workshop in sustainable Livestock Production on local feed resources. Agric. Pub. House: Ho Chi Minh, pp 9-16

HMSO 1977 Chemical Oxygen Demand (Dicromate Value) of Polluted and Wastewater. In: Methods of the Examination of Waters and Associated Materials. HMSO, London, UK.

Karki A B, Gautam K M and Joshi S R 1994 Present structure of biogas sector in Nepal, In: Foo E L (Eng-leong.foo@mtc.ki.se), "Ecotech 94" Electronic conference, Jun. 1994.

Khan S R 1996 Low cost biodigesters. Programme for Research on Poverty Alleviation, Grameen Trust Report, Feb-1996.

Khoi Nguyen Van, Vinh Huynh Thi and Luu Huynh Thi Ngoc 1989. Evaluation of biogas digesters in Cantho City. Proc. First Nat. workshop on biogas application in Vietnam. Polytechnic Univ. of Hochiminh City, pp 28-35.

Kristoferson L A and Bokhalders V 1991 Renewable energy technologies- their applications in Developing Countries. Intermediate Technology Publications, London, pp 112-117.

Marchaim U 1992 Biogas Processes for Sustainable Development. Bull. FAO Agric. Services, Rome, 95: 165-193.

Pain B F, Misselbrook T H and Crarkson C R 1990 Odour and ammonia emmissions following the spreading of anaerobically-digested pig slurry on grassland. Biological Wastes, 34:259-276.

Pound B, Bordas F and Preston T R 1981 Characteristics of production and function of a 15 cubic meter Red-Mud PVC biogas digester. Tropical Anim. Prod. 6: 146-153.

Preston T R 1995a Tropical Animal Feeding: A practical manual for research workers. FAO Anim. Prod. And Health, Rome, 126: 155-166.

Preston T R 1995b Research, extension and training for sustainable farming systems in the tropics. Electronic Proc. 2nd Intl.. Conference on Increasing Animal Production with Local Resources, Zhanjiang, China, p.3.

Qiu D X, Gu S H, Liange B F and Wang G H 1990 Diffusion and innovation in the Chinese biogas program. World Development.Oxford, 18: 555-563.

Sarwatt S V, Lekule F P and Preston T R 1995 Biodigesters as means for introducing appropriate technologies to poor farmers in Tanzania. Electronic Proc. 2nd Intl. Conference. on Increasing Animal Production with Local Resources, Zhanjiang, China, p.6.

Soeurn Than 1994 Low cost biodigesters in Cambodia. Proc. National Seminar-workshop in sustainable Livestock Prod. on local feed resources. Agric. Pub. House Ho Chi Minh, pp.109-112.

Solarte A 1995 Sustainable livestock systems based on local resources: CIPAV's experiences. Electronic Proc. 2nd Intl. Conference on Increasing Animal Production with Local Resources, Zhanjiang, China, p.2

Thong Hoang Van 1989 Some experiences on the development and the application of biogas digesters in Dongnai province. Proc. First Nat. Workshop on Biogas Application in Vietnam: Polytechnic Univ. Press. Hochiminh City, pp 60-69.

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