Feasibility Study on Anaerobic Bio Gas Plants in Sri Lanka

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Abstract

Environmental issues such as greenhouse effect and improper waste disposal methods are attracting special attention of the community. The concept of controlled anaerobic digestion is perhaps a much overlooked example of a way to reduce greenhouse gas emissions and to provide a better waste disposal method for organic waste. Today environmental pollution is a significant hazard and it occurs due to improper waste disposal techniques. People are not aware of the control techniques of waste disposal methods. Biogas digester is one of the best solutions for the control of waste, and more importantly, it can be used as a reliable renewable energy source. The research is focused on the development, popularization and sharing the best practices of biogas technology in Sri Lanka. This analysis basically discusses the raw material usage, applications of biogas, working status, type of funding for construction, locations of installation, composition, waste disposal methods, uses of biofertilizer, attitude of users of plant on the technology, willingness of user to obtain training on biogas technology, problems and failures encountered during operation, overall satisfaction of biogas consumers in Sri Lanka. This project is definitely not supposed to be revolutionary or radically new, but rather to be a starting point for further research and development in this area.

Introduction

Biogas is a useful anaerobic gaseous fuel, which can be produced by using organic materials such as kitchen wastes, cow dung, hay, toilet wastes, wood, etc. Therefore biogas is a small scale cost effective source of energy. Also, anaerobic digestion is not a radical or new concept for the modern society[1]. Large scale industrial digesters and small domestic digesters are in operation in many places around the world. The purpose of all these digesters is to produce combustible biogas, which can be used to provide thermal energy

with various ranges of applications. Here in Sri Lanka, there is quite a bit of ideological interest in anaerobic digestion and biogas

production, particularly from domestic users, but there are not many examples of digesters in operation. And also, farmers are interested in this topic primarily as an alternative energy source (biogas), and they can take the advantage of an efficient effluent as a waste disposal system for the farm [2]. They can use produced biogas for domestic use and removed slurry as a fertilizer for their crops. However there seems to be a problem in finding ways to put controlled anaerobic digestion into practice. There is almost a small library of information from all over the world on this topic.

There could be a number of possible reasons for this including the high capital cost of setting up an anaerobic digester project, lack of working models and lack of a source of ideas to base individual projects on, i.e. - trouble-shooting and project development at domestic level.

Background

Biogas can be produced by fermenting organic materials in the absence of air with the help of bacteria to breakdown materials to intermediates such as alcohol and fatty acid, and finally to methane, carbon dioxide and water. This process is called anaerobic fermentation. The main fuel component of biogas is methane. In contrast, biogas is produced in digesters by anaerobic fermentation. A period about 15 days enables anaerobic bacteria to convert organic matter to biogas, which however is too short for conversion of methane to other gasses such as ethane, propane, and butane[3]. Anaerobic fermentation is a simple and low cost process, which can be carried out economically in rural areas where economic waste is generated, which otherwise can pollute the environment and pose health hazards. It is accepted that

largely animal and human wastes are excellent feed stock for biomethanation [3].

Anaerobic fermentation is a biological process which takes place in the absence of air. A number of stages are involved in this process; hydrolysis and acidogenesis, acetogenesis and de-hydrodination, and Methanogenesis [4]. Initially, the organic material is hydrolyzed by enzymes into simple sugar, alcohol and amino acid. These are then converted to volatile fatty acids, hydrogen, carbon dioxide, water and a small amount of methane. Then the methane forming bacteria converts fatty acids into methane, CO_2 and water. The optimum fermentation temperature is between 35-38 °C which is known as the mesophyll range, and the rate of reaction slows down when the temperature is below 30 °C. Composition of biogas is, CH_4 (55-75%), CO_2 (25-50%), H_2S , H_2O (Vapour) and others (5%). For the purity of biogas, SO , CO_2 , H_2S , H_2O are to be removed as unnecessary gases [5].

Methodology

The final output of this project is to prepare a survey report on existing biogas digesters with their best practices and drawbacks in design, operation and maintenance. The project focus is on design and development of a precast PVC anaerobic biogas digester for domestic use, which could be fabricated and sold at lower cost. Before embarking on the design process, the team decided to conduct a survey to collect basic information. At the beginning, 130 locations were identified all around the country and 69 locations were analyzed depending on the capacity, type, raw (feeding) material used, and application of biogas and bio fertilizer produced. Then a survey questionnaire for constructed biogas plants was prepared in consultation with experts. Data collected from each location was analyzed.

Analysis and Discussion of Survey Data

(I) Raw Materials

Different amounts of biogas and methane can be produced depending on the contents of the raw materials. Manure, energy crops and crop residues, municipal and industrial materials are the main types of raw materials used for biogas production.[6] In Sri Lanka, there is a high potential to use cow dung (as manure),

kitchen waste, toilet waste and other residues. As shown in Figure 1, 81% of the plants surveyed use kitchen waste as the main feed material and 24% use cow dung. About 21% of digesters accommodate toilet waste whereas 32% of digesters are fed with fish waster, garden waste and waste from slaughter houses.

Figure 1 - Raw (Feeding) Material used in Biogas Plants (%)

(II) Applications of Biogas

Many countries use biogas for cooking and lighting as major applications[7]. According to the survey results, biogas is mainly used for cooking (71.4%) in Sri Lanka. There are minor applications based on lighting (4.8%) and electricity (6.3%).

(III) Working Status of Biogas Plants

It was revealed that about 17.5% of the plants are not in working status. Reasons for non-operation were no responsible person to operate, no adequate biogas is produced from the plant, design failures, non-availability of feeding material, etc.

(IV) Locations of Biogas Plant Installation

Among the digesters under survey, about 41.3% are constructed in households, and the rest are in industry (15.9%), hospitals (4.8%), community plants (6.3%) operated by municipal councils, and 4.8% in temples. Figure 2 shows the enthusiasm shown by households and the numbers could be increased by conducting awareness programs highlighting the benefits which could be achieved from a biogas plant. During the survey, some users mentioned that if a government subsidy is given for construction of biogas plants, there are many people from domestic sector willing to partially fund the construction. In this context, a proper

mechanism should be prepared to provide financial assistance for the people and to recover the money once the benefits are received.

Figure 2 - Locations of Biogas Plant Installation

(V) Biogas Composition

It was noted that most biogas plants generate biogas rich in methane content, of around 48.8% which is closer to the value given in literature[5,8]. A record methane percentage of 74% was reported from a biogas plant installed in a hotel despite overloading the digester with excess waste water from washrooms. Biogas in this location is used to operate barbeque grill in the evenings for the guests. Figure 3 shows the average and maximum composition of methane content.

Figure 3 - Maximum and Average Biogas Composition

(VI) Waste Disposal Methods

In Sri Lanka, waste disposal methods are open dumping, burning and recycling[10]. Data was collected on the previous disposal method of waste by the users before the construction of the biogas plants. From the results shown in

Figure 4, it is significant that about 60.3 % of users previously practiced open dumping of waste, creating environmental pollution and health hazards to the community. From Figure 4, it can significantly conclude that as a result of open dumping of waste, there were issues such as of our (54%), mosquito and flies breeding in their surroundings (42.9%) and water pollution (19%). About 40% of users practiced other methods such as burning, recycling and feeding animals with the waste generated in their premises.

Figure 4 - Waste Disposal Methods before Construction of Biogas Plant

(VII) Type of Funding for Construction of Biogas Plant

Another important factor for the successful operation of biogas plants is the commitment and accountability. From the data it was identified that about 38% of the digesters have been constructed as donations and in few occasions, the beneficiaries are not keen on maintenance and operation of the plant which is a major reason for abandoning the plants. Almost all biogas plants constructed with user's own funding operated successfully which highlights the commitment and the accountability of such users.

(VIII) Uses of Biofertilizer

Bio fertilizer (slurry) collected at the outlet tank is rich in Nitrogen (N), Phosphorous (P) and Potassium (K)[8]. Out of users interviewed about 41.3% of users do not use bio fertilizer for any activity. This is mainly due to lack of awareness about the value of this slurry. It is important to frequently update with information about the best practices and share them among the users. Majority of users (47.6%) uses the bio slurry for flower gardening and vegetable cultivation, where very promising results were obtained by using bio slurry. A very small percentage of users

1.6% apply the bio slurry as a pesticide and 4% sell the bio slurry outside.

(IX) Attitude of Owners/Users of Plant on the Biogas Technology

It was surprising to see the attitude of users of biogas technology, with about 23% of the users expressing a negative attitude towards the technology. This is widely seen in the government organisations since the person who started (initiated) the project might have been transferred and no proper person in charge is appointed. The new person is unaware of the technology and a negative attitude is built-up as a result. Therefore commitment from top officials is also required for smooth functioning of the biogas plant in public institutions. Furthermore, it is important to monitor such biogas plants after construction and handing over to users.

(X) Willingness of Owner/User to obtain training on Biogas Technology During the survey, the knowledge of the operator on biogas technology and troubleshooting methods were recorded. It was revealed that about 23% of the operators do not have basic knowledge on the process. Many users have acquired knowledge from literature and internet, in addition to knowledge acquired during workshops conducted by various organisations.

It is worthwhile to mention that around 66% of users are willing to take part in training programs, whereas 20.6% do not need any training. The rest of the users were not specific about their training requirements.

(XI) Overall Satisfaction

Despite a few issues in the operation and maintenance of biogas plants, a vast majority of users (82.5%) have a positive attitude and satisfaction with the biogas plant and the technology at large. Most of them have come out with some constructive ideas for the development of the biogas technology and further popularisation. These suggestions are discussed in the recommendations and conclusions section.

(XII) Problems and Failures Encountered during Operation of the Biogas Plant

From the survey carried out among the users, there are several problems and some design failures identified. The most frequent problems identified are intensive odour and heavy

corrosion of cookers (22%) due to non-availability of a sulphur filter (22.2%), blocking of inlet and outlet pipes frequently due to bends and smaller diameter of the pipes (11%), formation of a crust (6.3%) on the surface of the slurry inside the digester reducing the biogas production, conflicts between users for biogas in community biogas plants, etc.

Conclusion and Recommendations

After analysis of data obtained during the survey, following are some immediate observations from the survey completed.

1. Problems with Sulfur Dioxide (SO₂) and other sulfur products exist in many plants. It expedites corrosion thus reducing the lifetime of cookers.
2. Durability of connecting hoses is unsatisfactory. In several cases, moisture is trapped inside the hoses which block the gas supply to the desired point.
3. Monitoring and after-sales support after construction of digesters by some contractors is very poor. As a result, several digesters have been abandoned.
4. In some plants, inlet and outlet pipes (especially with PVC elbows) are narrow in diameter and it created frequent blocks to the flow.
5. Some owners want to analyze slurry (bio fertilizer) for NPK values before using them on the fields.
6. Odor from some digesters was noted and neighbour complaints were recorded. In some occasions, public health inspectors have intervened and requested owners of the plants to close the outlet tank by using a lid.
7. Social and equity problems in sharing biogas in some community biogas units.
8. As a result of odor of biogas (due to the presence of Sulfur in biogas), cookers are kept outside the kitchen.
9. Prospective users expect some subsidy from the government to share the initial cost of construction.
10. Need for gas storage methods for excess biogas generated in some locations.
11. Space required (occupied) by biogas plant should be reduced (for houses with small extents of land).
12. Awareness about the technology and benefits is poor in some cases.
13. Moisture in biogas has reduced the life of cookers.

14. Lack of knowledge on the suitable (appropriate) raw materials to feed-in.

15. No additional information, technical support and maintenance provided to users by some contractors after the construction.

16. Lack of awareness about the market and the value for bio-fertilizer.

17. In some government organisations, the enthusiasm was not seen among the present officers in-charge and the operators since the project was initiated by another person who has been transferred to another organisation.

18. Crust on top of the slurry inside the digester is formed, and as a result, biogas production was reduced and in some plants the crust was removed by users. Subsequently, the plant started to produce gas again. The possible reason for this problem is lack of water fed into the digester with other feeding material. This problem could be overcome by having a proper mixing mechanism inside the digester.

19. Several organizations maintained records on the feeding material, quantity of gas used for cooking, etc., and the operators are very positive on the biogas technology.

20. It was observed that in biogas plants where waste water is fed to the plant, the input quantity of waste water exceeds the daily input limit, thus by creating undigested material coming out from the outlet. The latter is a strong reason for heavy odour especially in hotels where the waste water from washrooms are also sent to the digester.

21. It is important to note that a few organisations are using biogas plant only to dispose waste material, but the biogas produced is not utilized but sent to the atmosphere which is a severe environmental hazard as methane is a green house gas.

22. The commitment in community biogas plants from the organisations and the beneficiaries are very poor, and as a result, several plants were abandoned due to social issues.

23. With the inputs gained from the survey conducted among the selected biogas digesters constructed by various contractors, several shortcomings were noted. Based on the survey, some design requirements were identified for future considerations. The biogas digester should be easy to manufacture, transport and install, easy for maintenance, simple operation, optimum materials for fabrication process, cost effective, size of the digester (height & diameter) and minimum land (space) requirement for installation,

capacity of the digester (Volume) and biogas production should be adequate for the end user, input waste material and waste water quantity per day should be available for sustainable operation of the biogas plant, should be eco-friendly, since there is considerable amount of Sulfur in the biogas, every biogas plant should be provided with a Sulfur filter to minimize the corrosion of cooker and other metal parts more importantly to reduce bad odour coming out from biogas.

Further when biogas plants are constructed through donations, it is very important to provide adequate knowledge on biogas technology, including operation and maintenance as well. In addition, the value of bio fertilizer (slurry) should be highlighted among the stakeholders. The danger of releasing methane to the atmosphere should be stressed during workshops and other dissemination programs. Periodic monitoring should be done and feedback on the best practices, issues and troubleshooting methods is to be recorded.

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