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Biogas Quality Across Small-Scale Biogas Plants

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ABSTRACT- Fermentation-based bioenergy production is gaining popularity owing to its ease of use and broad range of feedstock options. Anaerobic fermentation of biological waste resources is widely regarded as a cost-effective and well-proven technique that allows for waste management and energy generation at the same time. In the developing world, The use of small-scale biogas plants to change waste into gas by aerobic digestion of organic materials is becoming more common. Biogas produced in small-scale biogas systems is of poor grade, was assessed in this study since it has a direct impact on its usage (as a fuel for biogas cookers) and may affect the choice to purchase such equipment. At 107 small-scale biogas facilities, the composition of biogas was tested using a multifunctional portable gas analyser. A questionnaire survey of biogas plant owners (n = 107) was used to gather additional data at the home level. The average daily biogas output is 0.499 m3, which is insufficient to meet the needs of rural families that rely on other sources of energy. In terms of biogas arrangement, biogas plants earlier than five years had a mean content of 65.44 percent methane (CH4) and 29.31 percent carbon dioxide (CO2), whereas biogas plants elder than 5 years had a mean content of 64.57 percent CH4 and 29.93 percent CO2.

KEYWORDS- Biogas, CO_2, Energy, Environment, Technology.

I. INTRODUCTION

Energy has an impact on the state and rate of development; as a result, a major issue for the developing countries is obtaining cheap and environmentally benign renewable energy (SDG)[1]. Energy poverty manifests itself as a lack of access to power and safe cooking facilities, both of which are necessary for fulfilling basic human requirements. As a result, bioenergy generation via fermentation reactions is gaining popularity owing to its ease of use and broad range of organic waste feedstock. With its twin advantages Anaerobic fermenting of biological material is commonly considered as a major cost-effective and mature technique for waste treatment and concurrent power production. Small-scale biogas plants are increasingly being used in developing countries to convert Through waste degradation, they may constitute a financially feasible technology that generates biogas as a principal output while also creating digestate (which may be utilized as fertiliser) as a metabolic end [2]–[6].

Household power use is influenced by a variety of variables, including socioeconomic factors, household features, and regional considerations[7]. Tiny gasifiers also have an amount of significant ecological, financial, and support, like as less forest loss, very few hours dedicated to firewood gathering or cost cash reserves on fuelwood/fossil fuel buys, lowering the require for propylene for kitchen, job creation, decrease of natural issue in effluent waters, and odorants decrease, and the reduction of greenhouse gas emissions[8].

Authorities and developmental aid donors have pushed and economically supported small-scale biogas technologies all across Asia, notably Vietnam due to the advantages stated above. Long-term, consistent operation and maintenance are critical for small-scale biogas plant advantages to be maximized. However, if these important issues are not addressed, the technology's advantages may be jeopardized.

In compared to other sources of renewable energy, biogas generation via small-scale methane facilities is more easy, decentralized, and can function under a variety of circumstances in tropical locations like as South Asian, notably Vietnamese. Animal dung or people faces is the most frequent feedstock source, since it is typically the most troublesome waste item in terms of waste management for rural homes. One of the major explanations for the administration's provision for small-scale biogas technology is that it is a cost-effective way of lowering greenhouse gas emissions and smells from animal waste when utilized correctly. Biogas is primarily utilized for cooking, heating, and lighting in rural homes, fuelwood, dried dung, coal, or LPG are being phased out as energy sources (LPG) that are widely used for these reasons. Adoption of new and unfamiliar digester technology in homes is usually challenging. As a result, suggestions for different models already in use in the nation are required. The design of biogas facilities varies according to geographical location, feedstock availability, and climatic circumstances. Table 1 shows the most prevalent kinds of feedstock for selected Asian nations. The fixed dome type is the most popular in Asia. There are 2 exclusions: Indonesian, wherein different model was utilized depending on the islands, and India, where many models were used depending on the areas and islands, where the floating drum model was the most popular followed by the permanent dome[9]–[11].

Since the 1960s, anaerobic ingestion of physical dung has been performed in Vietnam. Since then, its popularity has increased, owing in part to government and international organizations, such as SNV, promoting the technology (Netherland Development Organization). Between 2003 and 2013, the Vietnamese Department of Farming and Rural Expansion and SNV (using a 10% government subsidy to assist capital expenditures of small-scale biogas technology) built approximately 200,000 small-scale biogas plants. Between 2006 and 2011, SNV and MARD's follow-up biogas initiative planned to construct 140,000 biogas digesters. In Vietnam, there are now about 500,000 small-scale biogas plants. The goal was met, and digesters now provide cooking fuel to approximately 600,000 people, saving about 260,000 tons of CO2 each year. However, biogas technology in Vietnam is still far from reaching its full potential in terms of using existing livestock and agricultural wastes.

The primary goal of this paper is to assess the quality of biofuels generated in small biogas fitted in center Vietnam in aspects of synthetic and physical variables in regards to the age of the implemented digester, as small-scale biogas innovation is one of the most rapidly growing and encouraging sustainable energy energy sources, especially for rural households. Biogas quality has a direct effect on its use, which might influence a person's decision to buy one. Biogas quality evaluation is also essential to supply authorities with sufficient information to inform future regulatory decisions.

A. Supplies and Procedures

The study was place in two regions in Thua Thien Hue Province, in Central Vietnam: Huong Tra and Phong Dien. Huong Tra is a rural district on Vietnam's central coast in the north, with a population of about 115,000 people and a land area of 521 km_2. Figure 1 shows Thua Thien Hue province and the target area.

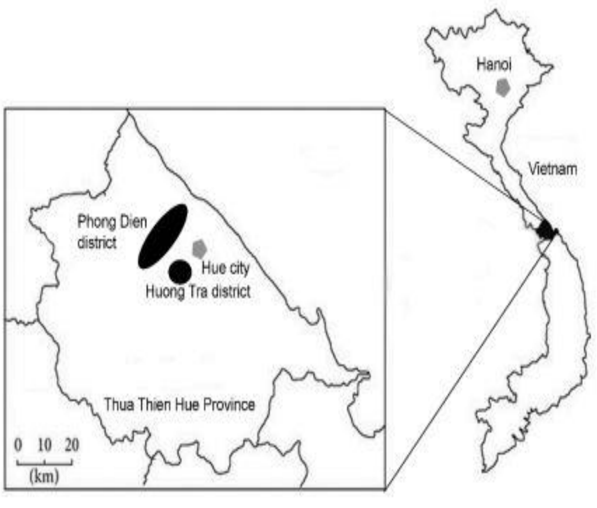

Figure 1: The above figure shows Thua Thien Hue province and the target area.

The region is situated on the outskirts of Hue and therefore qualifies as a peri-urban region. Phong Dien is a city in Vietnam with a population of about 105,000 people and a land area of 954 km2. The geography of the area is diverse, including mountains, plains, and coastline.

1) Biogas Technology Description in the Target Area

In the target region, both kinds are prevalent. Both kinds are Chinese fixed dome variants, with KT1 being the best for a good soil structure that can be readily dug. Figure 2 shows the (a) Stationary domed design of a small-scale biogas plant (KT1). (a) Stationary domed prototype of a small-scale biogas plant (KT2).

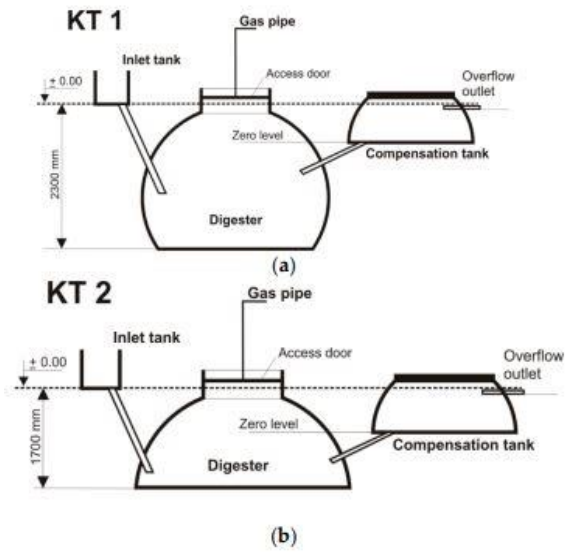

Figure 2: The above figure shows the (a) Small-scale biogas plant—fixed dome model (KT1). (b) Small-scale biogas plant—fixed dome model (KT2)

KT2 is utilized in areas where soil extraction is difficult or where there are reports of high groundwater levels or floods. Both kinds are unheated and are often constructed underground to reduce temperature changes and save space. The input tank and inlet line are used to fill the digester. The biogas is gathered in the upper section of the digester, and the discrepancy among the slurry in the fermentor and the biosolids in the compensating tanks creates a gas pressure. After the gas is discharged via the gas line, the slurry flows back into the digester from the compensation tank. The research by goes into great depth on both kinds and their possible issues. Because they are constructed underground, The temperature of the Vietnam small-scale biogas operations is the same as the adjacent soil. The season of year has an impact on the temperate of the air, the sludge blending tank, the ground, as well as the digesters. The typical summer temperature in Central Vietnam is about 34°C (mesophilic conditions), which creates an ideal environment for bacterial fermentation; however, the temperature drops to 15–25°C during the winter, which may result in reduced biogas output[12], [13].

2) Questionnaire Survey Data Collection

From June to July 2013, a questionnaire study was conducted with owners of small-scale biogas facilities. Biogas plants were chosen at random from a list of government subsidy beneficiaries maintained by the Ministry of Agriculture and Rural Development's local unit. The winners were also recipients of one of two ongoing small-scale biogas plant construction projects, one funded by the SNV and the additional by the Czech Expansion Activity. There were nine questions in the questionnaire (Table 2). In addition, during field trips in June and September 2016, the information was collected findings were crosschecked with local facilitators to ensure their validity and dependability.

B. Cooking and water heating using biogas

Biogas generated by home biogas systems is mostly utilized for cooking in developing nations. This is also true in the current research, where biogas is used mainly for cooking by 100 percent of homes, for an mean of 2.8 hours per day. Biogas is often utilized for home cooking and heating water, followed by the preparation of pig feed. Biogas production averages 0.499 m3 (0.086) per day. This quantity of biogas utilized for cooking may equal to 8–10 m3 per month and 96–120 m3 per year, correspondingly. Conversely, according to a research by, a normal agricultural family of six people requires 0.8 to 1 m3 of biogas per day.

This variation in median everyday methane production might be accounted by, who states that permanent domed methane gasifiers may leak around 55 percent of CH4 annually and that feedstock temperature affects biogas production. As a result, the majority of respondents (60%) continue to use supplementary energy sources such as LPG and/or electric are also options (for rice cooker cooking) as well as fuelwood.

1) Lighting and Electricity Production with Biofuels

The use of biogas for lighting and electricity production is another significant potential use.

Although biogas lights are more efficient than kerosene lamps, they are still inefficient when compared to electric lamps. Furthermore, since electricity is now widely accessible in Vietnam, biogas lights are only used on rare occasions. Fewer than 10 percent of our responders utilized biogas lamps. Because 1 m3 of biogas is comparable to illuminating 60–100 watt lights for roughly 6 months or preparing 2–3 dinners per day for 5–6 people, farmers often utilize it for heating instead of lighting. Power production is favored when farmers have an excess of biogas, as noted during conversations with farmers. In such scenario, They purchase a combustible motor, which converts methane into physical energy in a heat motor, which then turns on a generator to create electricity.

II. DISCUSSION

The vast majority of responders (90 percent) work as rice farmers. Many of them, however, are also engaged in off-farm businesses including trading, rice noodle manufacturing, and rice wine production. Pig slurry is the primary feedstock for biogas plants in all of the homes surveyed, and pigs are kept in concrete pigpens in all of them (with a concrete floor). Other animals' manure (65 percent) is also utilized as a feedstock addition in the studied homes. Chicken dung accounted for 29% of the total, while human excreta accounted for 36%. (Figure 3). If adequate amounts of these additives are available, they are used. Every home's plant is physically connected to the chicken pen, while toilet outputs are connected to the biogas plant in 37% of instances. Only one chicken shed was linked to the biogas plant; the rest of the time, the chicken excrement was manually poured into the digester inlet. In general, the feedstock input was standardized since biogas owners were given one of two ongoing projects to construct tiny -scale biogas florae, and there was requirements for the amount of cattle required. In addition, our prior research provides further information on small-scale farmers' manure management methods in Vietnam.

III. CONCLUSION

If utilized properly, Small-scale gasifiers might be a very useful tool for waste control, and they could even help to reduce the consequences of climate heating. This technique has a unique combination of advantages in that it is a renewable energy source, it helps the environment, and it allows dung to be treated and reused. However, if it is used incorrectly, its advantages may be jeopardized. Pig slurry was the most frequent feedstock used in this research followed by a mixture of pig sewage and human excreta for a slight biogas plant. The majority of biogas units were connected to the pig stable through a lavatory or a stall door. The average daily biogas output is 0.499 m3, which is insufficient to meet the needs of a rural family of six people. As a result, 60 percent of studied homes continue to utilize alternative energy sources. A multipurpose portable gas analyser was used to determine the composition of biogas. The average methane (CH4) level in biogas plants under 5 years were 65.44 %, while the average carbon dioxide (CO2) contents were 29.31 %; in biogas plants older than five years, the mean content of CH4 was 64.57 percent, and the mean content of CO2 was 29.93 percent. The sole dependent factor affecting biogas quality was the size of the biogas plant and the composition of the biogas, as determined by the CH4:CO2 index and the calorific value. Furthermore, the kind of biogas plant had an impact on CH4, CO2, and biogas calorific values. There are no, or only slight, variations among evaluated qualitative biogas metrics when considering the effect of age on small-scale biogas plants. Conclusion: Small-scale biogas facilities may maintain a consistent level of biogas quality throughout their lifespan.

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