



## **Production and Quality of Biogas from Pilot Biodigesters using Cow Manure**

**LYTOUR LOR\***

*Faculty of Agricultural Engineering, Royal University of Agriculture, Phnom Penh, Cambodia  
Email: llytour@rua.edu.kh*

**MACHITO MIHARA**

*Faculty of Regional Environment Science, Tokyo University of Agriculture, Tokyo, Japan*

**BUNTHAN NGO**

*Royal University of Agriculture, Phnom Penh, Cambodia*

**LYHOUR HIN**

*Faculty of Agricultural Engineering, Royal University of Agriculture, Phnom Penh, Cambodia*

**DYNA THENG**

*Faculty of Agricultural Engineering, Royal University of Agriculture, Phnom Penh, Cambodia*

**CHANMAKARA MEAN**

*Faculty of Agricultural Engineering, Royal University of Agriculture, Phnom Penh, Cambodia*

**BART FREDERIKS**

*United Nations Industrial Development Organization, Vienna, Austria*

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**Abstract** Biogas systems are being applied at commercial pig farms and at starch processing plants to manage their wastes and produce biogas for generating electricity or heat for on-site use. The installation numbers are increasing in Cambodia. The data on potential biogas production quantity from different feedstocks as well as on biogas quality are required to design the biogas systems. The purposes of this study was to determine biogas production and biogas quality from dairy cow manure produced in pilot digesters, and to analyze the variation in biogas production and quality during the year of 2019 and 2020. Pilot biogas digesters were installed at the Biogas Technology and Information Center, a research unit located in the Royal University of Agriculture, to obtain these data, since it is easier to do the experiments with the pilot digesters than that with commercial ones. The experiments were conducted during the year of 2019. In the experiments, 3 identical floating drum biogas digesters were used. Each bio-digester has 1 m<sup>3</sup> of volume and has been supplied mixture of 5-10 kg of fresh manure from dairy cattle with 5-10 liters of water every day. The daily biogas production quantity was recorded using a gas flow meter attached to the outlet of each bio-digester; also the gas quality, such as methane, carbon dioxide, oxygen, and hydrogen sulfide was measured using a portable biogas analyzer. The average rate of biogas production was around 37 liters of biogas per kg of wet manure. Average percentage of methane was around 52%, and average concentration of hydrogen sulfide varied from around 390 ppm to 604 ppm. These two parameters are the main indicators of biogas quality.

**Keywords** biogas, floating drum digester, cow manure, methane, hydrogen sulfide

### **INTRODUCTION**

Global warming is the worldwide concern which is caused by greenhouse gas emissions. In Cambodia, methane is a major greenhouse gas from animal production. Ministry of Environment

(2002) projected that methane emission from domestic livestock would be 545 Gg in 2020 compared to 303 Gg from rice production, 2 Gg from grassland burning, and 5 Gg from agricultural residue burning.

Recently in Cambodia, animal production has increased in all kinds of animals, especially commercial farms. In 2017, there were 83 commercial cattle farms, 653 pig farms with total number of cattle and pig 20,363 heads, and 742,771 heads, respectively (MAFF, 2018a). According to Prakas no. 549 of the Ministry of Agriculture, Forestry and Fisheries issued on December 12, 2018, all commercial animal farms are required to manage their waste properly, especially using biogas systems (MAFF, 2018)

Currently, some commercial farms and agro-processing plants have already installed biogas plants to treat their waste and convert biogas to electricity for use on farms. To design biogas systems, data on potential biogas production and quality from various feedstocks are required. These data are available in other countries but not in Cambodia. To obtain these data in local condition, the use of pilot digester is more appropriate since it is difficult to do on commercial biogas systems.

## OBJECTIVE

The objectives of this study were (1) to determine biogas production and quality from dairy cow manure by pilot digesters and (2) to analyze the variation in biogas production and quality during the year of 2019 and 2020.

## METHODOLOGY

### Experimental Procedure

The experiment was conducted in 2019 and early 2020. Fresh cow manure was collected from dairy cattle farm located on the campus of the Royal University of Agriculture. The ratio of manure to water was 1:1 to bring down the percentage of DM to around 10% in the mixture (Farouk et al., 2017). The mixture was thoroughly mixed and solid pieces of grass were removed before feeding into the digesters to avoid sludge build up in the digesters. Daily manure used was 5kg/day or 10kg/day (fresh manure). At the beginning feeding rate of 5kg/day was used to start up the digester and then was increased to 10kg/day. Ground water was used to mix with the manure.

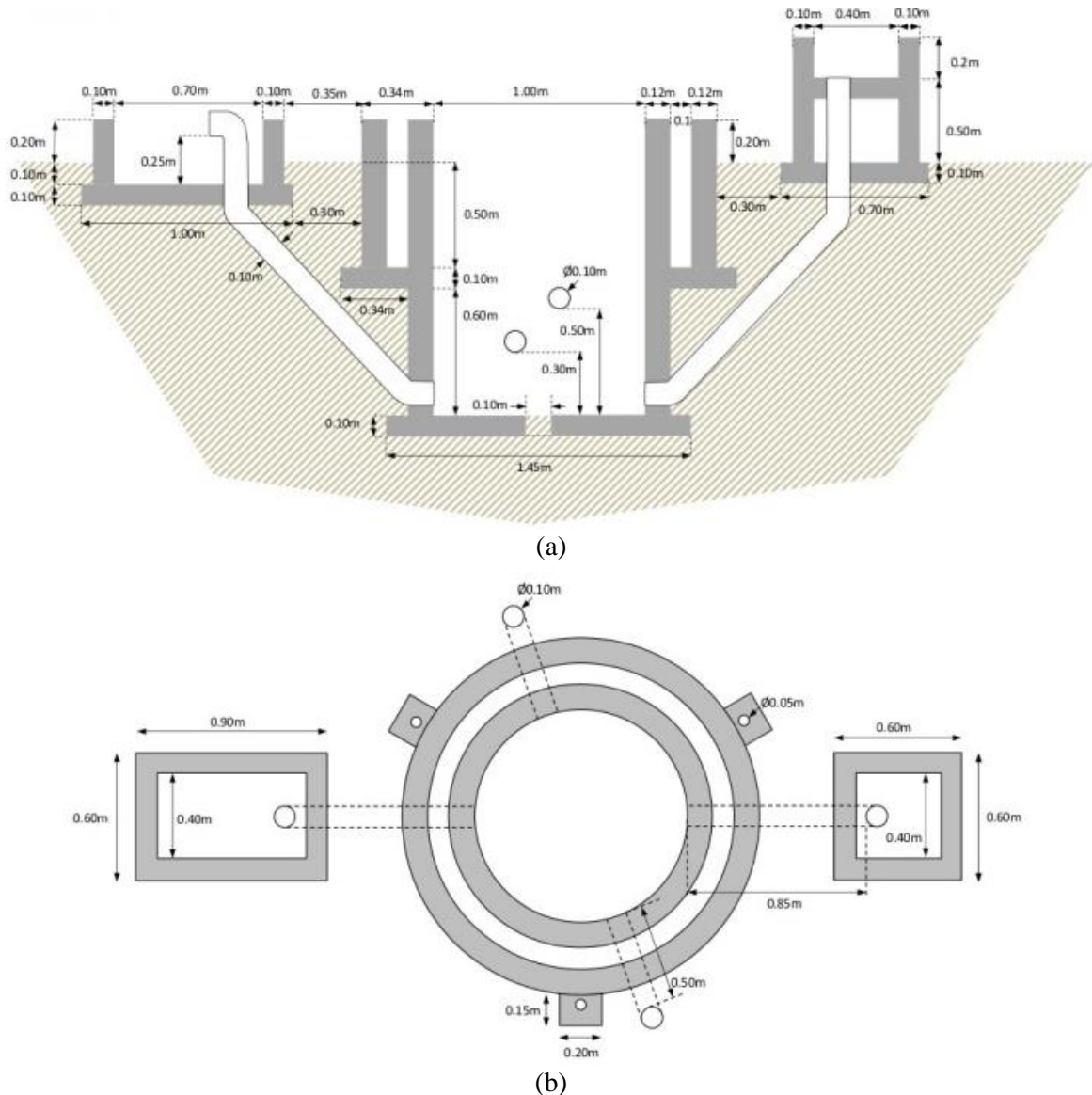
**Table 1 Amount of feedstock and water used**

Digester	Mass of Feedstock (kg)	Mass of Water (liter)	Mix Ratio	Remark
Digester 1	5 to 10	5 to 10	1:1	- 25 February to 11 March 2019, 8kg/day of cow manure used - 12 March to 29 July 2019, 10kg/day of cow manure used - 30 July 2019 to 31 January 2020, 5kg/day of cow manure used
Digester 2	10	10	1:1	
Digester 3	10	10	1:1	

Three floating drum biodigesters of identical design were used, see Fig. 1. This design was selected because it would ease the modification of the digester for various experiments. It is equipped with two sampling pipes on the sides of the digester from which substrate can be extracted for analysis. Each biodigester has a total volume of 1m<sup>3</sup>. The hydraulic retention time was around 47 days, which depends on daily feeding rate of 5 kg or 10 kg, to ensure complete anaerobic digestion of the feedstock.

The duration of data collection was shown in Table 2. Digester 1 was started up in December 2018 and started to produce stable biogas in February 2019 and the daily biogas production was recorded. It took longer than 1 month before the digester started to produce biogas. After the low biogas production was observed for Digester 1, it was opened in September 2019 to make sure that

there was no sludge building up in the digester. The digester 1 was restarted up again and began producing biogas in October 2019. Digester 2 and Digester 3 was completed the construction and started up in July 2019. During long holidays such as Cambodian New Year in April and Pchum Ben in September and Water Festival in November, data was not collected daily.



**Fig. 1 Drawing of the pilot digester (a) side view (b) top view**

From July to early August 2019, the biogas composition was measured once every two weeks. It was done daily since late August 2019 when the air injection experiment was conducted on Digester 2 to remove H<sub>2</sub>S.

Daily biogas production was measured by using gas counter which was attached to the outlet end of the pipe. To avoid direct emission of methane into the atmosphere, it was burned by using a biogas stove after passing through the gas counter.

For the quality of the biogas produced, contents of methane, carbon dioxide, oxygen, and hydrogen sulfide were measured using a portable gas analyzer. The gas analyzer, Geotech Biogas 5000, was regularly calibrated to ensure its accuracy in measuring. At the beginning, the biogas quality was measured weekly. Later on, it was measured daily since there was a need to test hydrogen sulfide removal using air injection into gas holder of the digesters. The content of hydrogen sulfide before and after the air injection need to be measured daily.