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Device for Measuring Composition of Methane in Biogas

Dr. Prafull Kumar [1]

[1] Department of Agriculture, Sanskriti University, Mathura Uttar Pradesh-281401, India.

Abstract

In this paper an inexpensive, portable tool was designed for quantifying the content of methane biogas sample. The device's major component was a methane sensor with MQ-4. This sensor was put in airtight glass container, along temperature, humidity, and pressure sensors, interface having a programmed Arduino Uno cloned for operation and logging of data. Sensors were capable of detecting methane as low as 450 ppm within the jar but respond linearly for concentration with range from 4500 to 110,500 parts per million. A gas chromatograph fitted with thermal conduction detector was used to evaluate measurements made by the sensor to study. Examination of an absence of gas digester biogas samples used the tool produce an absolute error of 0.80 ± 0.22 per cent comparison of GC measurement. Employing 10 ml of sample size of biogas, the tool could accurately quantify methane content as small as 20 per cent per volume. Through the sample of 80 ml, content of methane could be measured small 3.4 per cent. This unit was constructed at a cost of 35- 40US dollars. A field edition with LED monitor as well as the power pack will be installed for below US$ 45-55.

Keywords: Absence of oxygen digestion, Arduino, Methane measurement, Biogas,MQ-4 sensor.

Introduction

Methane is produced naturally under absence of oxygen conditions, as a consequence of microbes mediate process. Measurements of methane is important because of the function of methane as a potential GHG and also as a fuel. Ruminants, absence of oxygen sediments, pipe, waste dumps, composting heaps and landfills are known sources of methane. Production of Biogas by digestion not involving air has now become technology for non-conventional energy production in Europe. Some benefit of the process, like reduction of GHGs, the inactivating of pathogens, nutrient recyclement and potential for versatile, energy supply which is demand driven, make it a valuable mean which contribute and promotes renewable energy production.

The cycle of absence of oxygen digestion is having the capability of conversion of complex feedstock to methane, that agricultural by-products, organic waste, animal manure, and energy crops. In many European countries, the energy crops usage as feedstock for biogas plants is normal, mainly because of their yield od high methane, which made digestion of lower-yield animal feasible, and because of limited supply of industrial waste. But energy crop production is debated since it will require agricultural land and will have competition with feed and food supply. In addition, the producing of biogas by energy crops is concentrated for maize, and having the sustainability of biogas maize producing at issue.

The integrating of energy crop into crop rotation would be a crucial measure in relation to a sustainable production of biogas. The crop rotation can give flexible benefit like disease controlling, reduced inputs for agrochemicals and fertilizers, lesser erosion of soil, more effectiveness in use of nutrients and water, low economic climatic risk and more yield of biomass. These will be incorporated into 2 cropping systems, capture crop or seasonal crops as major crop, secondary crop due to a 2nd harvest later major crop. Gain of the characteristic of the range for potential crop of biogas is required for proper planning and designing of crop rotation. This concerns effect on the soil structure and fertility, disease and weed control, and bio mass yield, knowledge of digestibility the characteristic of methane production within the absence of oxygen digestion cycle is also very important. Higher yields of methane had potentials that are desired for biogas production which is highly effective.

A number of study already exist which evaluate and compared potential of methane produce of crop specy. Such studies, however, examine a relatively limited number for various species of crop. Various parameter had been documented for correlate with potential for biomass production of methane, and several model had been built to

predict different yields of methane from biomass. Many chemical components like acid detergent lignin, cellulose, acid detergent fibre (ADF), hemicellulose, crude fat have previously found positive associations.

Correlation studie, however, are typically focused on only a few data, mainly analyzing waste biomasses, or concentrating on variations in methane yield with 1 crop. Crop being use as feedstocks for production are typically harvest as crops seasonally, and stored by wet absence of oxygen storage through ensiling for 1-round supply to absence of oxygen digestion plant. Ensiling has been shown to maintain methane crop yield of biomass up to a year or more, but silage fermentation products may have a major effect on crop biomass specific methane yields. Nonetheless, the literature did not include parameter for ensiling, like volatile fatty acid and alcohol, in association studies.

MQ-4 is a lower cost sensor which can between 300 and 12,000 parts per million of methane and be used the ambient temperatures is 15 and 55 C and humidity is not more than 95%. This connected circuit of Arduino for logging of data logging, then usage collected data to cause alarm, making it cheap for detect natural gas leakage as well as tracking methane proposed by making use of a MQ-2 sensor (that is counterpart to MQ-4) for measuring methane for absence of oxygen digesters biogas. Our paper concentrated on attaching MQ-2 sensor towards Arduino board as well as the GUI to view sensor resulted in real time on the personal computer. Results of CH_4 compositions reported in the paper ranged from hundred to one thousand ppm, thus making it impossible that examined sample was biogas sample by an absence of oxygen digesting. Biogas CH_4 content usually ranges among fifty and seventy percent by the volume on the free-of-moisture base. This has posed a challenge when making usage of MQ-4 or MQ-2 for analysis of the biogas since content of methane is more than the sensor's range of measurement. Biogas needed diluting before calculating its content of methane. Furthermore, biogas always had a higher content of moisture, that can affect sensor sensitivity.

Use of a MQ-4 sensors for the methane measurements in biogas are discussed in this paper. This describes construction of devices that include a chamber for holding sensors and maintaining suitable environments condition, a sample of injection, an Arduino logger and control as well as necessary electric connection. Device's functions checked checking for leaks and evaluating the producibility of measurements, impact of environment factors, the sensor's line range and the sensor's response time. This device was used for measuring methane of bio gas produced from fluid bed absence of oxygen digester on a laboratory scale, which treated from a cellulosic ethanol plant. For both case, a gas chromatography fitted with thermal conductivity detect compares the methane readings collected from the system to readings.

The paper provides overview for certain fundamental aspect of absence of oxygen digestion deemed important for digestion and biochemical reactions of waste. It then defines food waste as substratum for absence of oxygen digestion, and its optimum condition for increased biogas production activity. Finally, the efficiency of various pretreatment method and absence of oxygen reactor configuration in digesting of waste of food has been checked for increasing content of CH_4 in biogas[1].

The study experiments was performed using absence of oxygen digestion method for investigating production biogas by wastes from vegetables. The pilot-scale, complete-mix digester work volume of 70 l used. The protocol experimental was established in order to analyze effects of change of organic rate of loading on efficiency of biogas produce and for reporting its output in a steady state. This digester was run for varying levels of 2 and 2.75 kg organic feed. This biogas produce had 49.7-64 per cent methane composition and 0.12-0.4 m3 biogas output levels[2]. This study has shown that during a start-up process 4 parallel reactor digesting manure fish waste silage were working stable. Several important archaea and bacteria have been identified which degrade the substrate which is in protein rich state. Particularly, it seems that important to have micro-organisms involved in syntrophic methane production. The detailed characters of microbial community presented in the work can useful in operation of plants of biogas which degrade substrate with larger protein concentration[3]. Typical food waste and northern China straws biochemical experimental methane potentials (BMP) were assessed individually at 35 ° C in a 1 L sealed reactors, respectively. Lab scale mixture for various FW and straws composition within a minimum organics load of 5 g were conducted. optimal FW-to-straw mixing ratio tends to be closer to five is to one, and methane output yields reached to 0.392 m3/kg-VS, thus incremented to 39.5 percent and one fifty percent, respectively, compared to digestion tests. In addition,

concentration of gas and CH_4 was 0.58 m3/kg-VS and 67.62% [4]. The aim analysis was investigating effects on biogases and methanes yield of chemical compositions of the crops containing energy. A total of forty-one different plant was analyze and their chemical was calculated in batch processing. Strong negative association for methane and biogas yielded with range of -0.90 was seen for the content of acid detergent lignin content less than 10% of the total solid. Over 80% of sample variance could be clarified based on the simple regression analyzing. Based on the analysis of the principal component and analysis of multiple regression hemicellulose and ADL are suggested for appropriate model variables due to species of potential plant -wide biogas yield predictions[5]. The purpose of review paper is analyzing different feedstocks, which are widely used around the globe. Working operation of the method of absence of oxygen digestion, current trend with its advantages and disadvantages are discussed with a view for drawing further research and development towards sustainable environment production. In current situation, aberrant use of fossil fuel and environmental effects of greenhouse gas have leverage efforts of research into the production of non-conventional energy from organic waste and resources. The international demand for energy is strong, and much of the energy is produced from fossil fuels[6]. This study explains and explores OFMSW's chemical, physical, and bromatological characteristic identified by a number of author by various cities and countries, and their relation to production of methane. The principal assumption is that variations are country not based on region. Cultural patterns and management structures of OFMSW did not allowed generalization, individual analyzes of particular cities allowed genera to be understood in higher production of methane. The OFMSW characteristics were significant as well as the condition which the CH_4 produce test carried out[7]. The paper discusses existing upgrading technologies and biogas cleaning including their structure, upgrade in the quality, recovery of methane and losses. Additionally, the production, utilizing the biogas and gas quality specifications for injection of grid and usage of vehicles were investigated. On the basis of findings of comparisons of a number of technologies, a number of recommendations were made for more research on the correct lower cost technologies, in particular by making use of solid waste as lower cost materials for biogas purification and upgradation [8]. The findings that enable such communities to be built rationally to encourage greater effectiveness in large-scale, functional systems. Through using this approach, the composition of an ideal biogas-producing consortium can be calculated, and this systematic technique makes the design for any biogas plant of the optimum microbial community structure. In this way, metagenomics studies will lead to substantial improvements in biogas production output and economic development[9]. biomass of Seaweed had come up as option for processing non-conventional fuel like absence of oxygen digestion (AD) biogas. Setting of Digester temperature is one most important factor for viable digester operation which is economically in relation to the rate of biogas production, especial in country such as India, as majority of yearly temperatures were less than range of mesophilic. In the study effect by digester temperature during Luminaria digitates AD on methane and biogas efficiency of production was evaluated[10].

METHODOLOGY

A schematic computer diagram appears in Fig. 1. System consists of airtight Mason jar that placed sensors in. To make a strong seal, the jar fitted with screw top lid having an O-ring. 58 grams of indicating-Drierite granules were scattered at the bottom of the container to remove the moisture in the container from the gases. The computer employed two sensors; the BME280 sensor and the MQ-4 sensor. The BME280 is integrated sensor which is capable of detection of humidity (0-100 percent relation humidity), pressure, and the temperature (approximately 40-85 hPa). MQ-4 (200-10,000 ppm) is methane sensors and has been designed to test load and resistance with the appropriate electrical circuit (Arduino was compatible with Mini MQ4 Gas Sensor, 2017). Both the sensors were plug to a bread-board with 160 pins that was placed in the container. The bread-board attached to the programmable clone of Arduino R3.

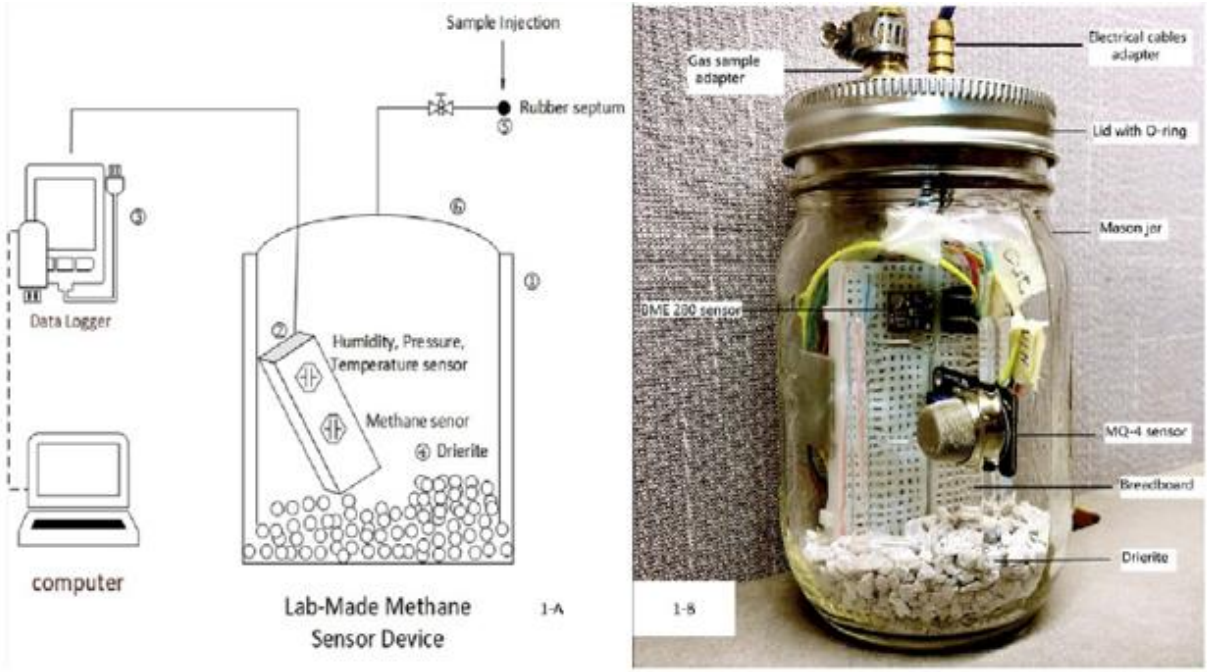

Fig. 1: Schematic Diagram of and the Photo Measurement Methane Device

Outside a jar to collect the sensor data. The signal measurements were in (mV). The 2 hole was drilling through jar cover, one for transferring electric cable in a safe manner and other to insert adapter.

Prior to use for heating the unit, the MQ-4 sensor was switched on 24 h. The procedure had been as follows after heating up the part. Next, the device's lid was removed so that air would replace the gas inside the container. When the MQ-4 sensed the methane percentage reached zero the lid were replacement safely. This clamp were loosen, a specified amount of the sample of gas was fed in chamber using a syringe through rubber septum, and clamp were tightened. This volume of injection controlling the sampling dilution by air chamber, and the volume were chosen that concentrated of methane was with detection range of the MQ-4 sensor. The signals from sensor were converted to concentrated of methane by making use of the algorithm.

Device validation test

Various test were performed for validating device's work. Unit had been first tested for gas leakage after assembly. Six air injections were inserted into chamber each 12 min, each 10 ml, and chamber's pressure were controlled. Such injection was made without chamber returning to ambient pressure. Pressure were tracked overnight in 12 hours after sixth injection. The data obtained by the identification of leaks were also being used for test the linear nature of pressure measurement. During the next test the effect of humidity was observed on sensor's response to air injection. Tool was inserted in 3 various volumes of air. Relative humidity and Sensor signal After each injection was tracked for eight to ten min.

The system was then used in a study of regular biogas that contained 60 % methane and 40% CO_2 for tracking methane. Standard samples of biogas ranging from 5ml to 90ml (in increments of 5ml), were injected into the system chamber for 18 separate sample. After through injection, methane, the relative humidity, heat, temperature was monitor for $8e^{10}$ minutes. A 1ml of sample were removed, inserted into GC before gas was being vented from system chamber. The chamber then opened the lid to vent. When methane fell to less than 0.05 volume percent, the lid was closed. The next sample of regular biogas has been injected after being hold for relative water vapour content to drop less than 1 per cent. Injections were repeated 3 times for each volume.

Gas chromatograph (GC) measurement

A chromatograph of gas fitted with a detector of thermal conductivity had been used for measuring content of methane injected samples and gas sample collected by chamber of test. A SUPELCO 80/100 HAYESEP Q analytical column had been used in GC, carrier gas is helium. CH_4, CO_2 and Air can be measured by the GC (as sum of O_2 and N_2). The GC's working condition were: temperature of the column was 61 ° C; temperature meter 152 ° C; and the temperature of injector 81 ° C. The GCwas calibrated from Airgas using regular gas having 60 percent CH_4 and forty percent carbon dioxide, and thirty percent methane, 20 percent carbon dioxide, Eleven percent oxygen and thirty-nine percent Nitrogen. Amount of injection had been 1 ml.

device's Application

This tool was employed in measuring content methane of the biogas produced by an absence of oxygen fluidized bed digester on a laboratory scale. Fed of stillage by an ethanol cellulosic pilot plant of Stan Mayfield Bio refinery, fluidized bed digester was operating for more than three years. Each half hour to 1 hour, samples of biogas were collected from digester, a part of which analyzed by making use of GC and 10 ml was inserted into system. Throughout the measurement process, the flow rate of feed to the digester was intentionally varied to create changes in the biogas' methane composition. The digester was tracked over a span of 2 days with measurements of gas carried out every day over a 12-h span.

CONCLUSION

A system has been assembled that costs $37 to determine the content of methane biogas samples. It was found that Humidity affected sensor sensitivity, and drying sample, upper limit of sensor's range had increased by least 10 times upto 110,000 parts per million. While the detection limits were lower at 400 ppm, a response which is linear was obtained from more than 4000 parts per million. The tool may be employed in measuring content in methane in biogas small as 2.4 per cent. Lower content of methane can be tested by making use of materials which can withstand larger pressure with a bigger sample size. The system was robust even after ten months of use, with no reduction in accuracy or reproducibility. The system may be modified for online measurements of biogas.

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