Low Cost Methane Estimation System
of Sheep farm

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List of contents

Abstract

Livestock acts as a significant source of anthropogenic greenhouse gasses (GHG) emissions. Enteric methane (CH_4) from ruminants is one of the major sources of GHG in this sector. There are several methods to measure CH_4, emissions in ruminants, but these methods are expensive and demand highly skilled labour which limits its utilization, especially in developing countries like Bangladesh. Alternatively, less accurate but inexpensive and easy to implement methods can be used.We used a sensor-based gas leaked device for studying enteric CH_4, emissions and intake dynamics in grazing sheep.

This portable combustible gas leak detector adopts ABS material, ergonomic design, easy to operate, using large screen dot matrix LCD display. The sensor uses the catalytic combustion type which is anti-interference capability, the detector is with a Long and flexible stainless goose neck detect probe and used to detect gas leak in the restricted space, when the gas concentration exceed a preset alarm level, it will make audible, vibration alarm. It is usually used in detecting gas leakage from the gas pipelines, gas valve, and other possible places, tunnel, municipal engineering, chemical industry, metallurgy, etc.

Our device measure the CH_4 concentration in sheep's eructed air breath and shows us the concentration value at ppm, can be used to estimate CH_4emissions in grazing ruminants. The results of our estimated methane concentration range from186 ppm to 442 ppm.

Keywords: Methane, Gas detector, Emission, grazing sheep

Introduction

Methane emitted by ruminants constitutes approximately 15% of global CH_4 emissions (Gerber et al. 2013). Therefore, CH_4 mitigation research has rapidly increased in the last decade. The gold standard method for measuring CH_4 emissions from ruminants is the respiration chamber. However, these are relatively expensive to build and operate, the number of animals/treatments that can be screened is limited, and this method also cannot be used with grazing animals. In the last decade, several new CH_4 measurement methods have been developed that can be used to screen large number of animals and that can be used on-farm (Hammond et al. 2016).

Enteric methane (CH_4), generated in the gastrointestinal tract of domestic animals, is the single largest source of anthropogenic CH_4emissions (Knapp et al., 2014). Methane is mainly produced in the rumen by Archaea microorganisms as a by-product of fermentation. Methane emission results in 3 - 14% loss in gross energy intake (Hellwing et al., 2016), and increases atmospheric GHG concentrations, which causes global climate changes and adverse phenomena such as floods and droughts, modifications in level and patterns of precipitation, and heat waves in cities (La Notte et al., 2018).

Open-circuit respiration chambers (Waghorn, 2014) are recognised as the most accurate method to measure enteric CH_4 emissions whereas the sulfur hexafluoride tracer technique (SF6, Johnson et al., 2007) and the automated head-chamber system (GreenFeed, Zimmerman & Zimmerman, 2012) are accepted as methods to estimate CH_4 emission. The use of these methods is expensive and demands highly skilled labour which limits utilisation, especially in developing countries. Alternatively, less accurate and certain methods have been developed. One approach uses CO_2 emission and CO_2:CH_4 ratio in exhaled air by animals to estimate CH_4 (Madsen et al., 2010). Another method is the Laser CH_4, Detector (Chagunda& Yan, 2011), in which CH_4 concentration in the air between the device and the animal is measured.

Several investigators also have explored the application of hand-held Laser-based Methane estimation Device (LMD) in relation to enteric CH_4 concentrations in air emitted by ruminants (e.g. Chagunda et al. 2009; Chagunda 2013; Ricci et al. 2014; Bruder et al. 2017; Sorg et al. 2017; Sorg et al. 2018). Interest in the LMD is driven by the non-invasive and non-contact nature of its CH_4 concentration measurements, but researchers need to integrate single time-point measurements to provide a quantitative estimate of CH_4 concentrations and must also manipulate data substantially before analysis. This is required because CH_4 is a simple molecule, which easily finds its way into the lungs from the rumen and so leads to breath-CH_4. However, the interest is to determine rumen CH_4 from ruminants, which appears mainly in eructated air. The LMD is simple to operate and portable, so is easily taken between farms or sites.

However, the rate of CH_4 emissions is not constant and can vary over 6-fold during the day, which is affected by diet, feed allowance and feeding pattern (Müller et al. 1980; Jonker et al. 2014). The objective of this current study was to estimate the methane concentration from sheep by using a low-cost methane detector system at six hour interval for a day.

Materials and methods

In this experiment, we used CE ATEX Goose neck CH_4 LPG LEL gas leakage detector (Fig 01) which was imported from china via alibaba.com

It adopts ABS material, ergonomic design, easy to operate, using large screen dot matrix LCD display. The sensor uses the catalytic combustion type which is anti-interference capability, the detector is with a Long and flexible stainless goose neck detect probe and used to detect gas leak in the restricted space.

A 500 L empty water tank, hoose pipe with manually prepared mask were required for the set up. Total four sheep of mature body weight measuring from 16 kg, 13.8 kg, 20.8 kg and 22.8 kg respectively were selected from that farm and identified accordingly. We designed a system to collect air breath with a manually prepared mask connected to a empty tank via pipe and the goose neck detector device was set within an outlet of the tank.

Vacuitainer tubes were required to collect air sample from the tank by a three way canula, before and after the collection of respiratory expired air into the tank, as the reading from the gas detector can be justified further via gas chromatography or other means.

Starting from 0 hour at 11:30 AM of a day, we made the tank air tight. Then sheep were brought near to the tank set up one after one and air sample were collected from their breath for 5 minutes (Fig 02) for each. After 5 minutes, the reading shown in the display of the gas detector was recorded as well as sample from the tank were collected via three way canula into the vacuitainer tubes.

In this way, we measured the concentration of methane gas in air of empty tank and recorded accordingly.

Figure 01 : Portable Gas (CH_4) leakage detector

Product Parameter :

Sensor Type: Catalytic sensor

Detect gas: CH4/Natural gas/Hz/ethyl alcohol.

Measure range: 0-100%lel or 0-10000ppm

Alarm point: 25%lel or 2000ppm,adjustable

Accuracy: ≤5%F.S

Alarm: Voice + light + vibration.

Language: Support English & Chinese menu switch

Display: LCD digital display

Shell Material: ABS

Working voltage: 3.7V

Battery capacity: 2500mAh Lithiumbattery

Charging voltage: DC5V

Charging time:3-5 hours

Ambient environment: -10-50°C, 10-95%RH

Product Size: 175*64mm(not including the probe)

Weight: 235g

Packing: Aluminum case

Manufacturer : Xi’an Huafan Tech. Co. Ltd.

Results

Sheep ID	Time	Time Interval (hour)	Reading of detector (ppm)
01	11:30 AM	0	442
	5:30 PM	6	228
	11:30 PM	12	256
	5:30 AM	18	301
02	11:30 AM	0	219
	5:30 PM	6	242
	11:30 PM	12	233
	5:30 AM	18	214
03	11:30 AM	0	242
	5:30 PM	6	233
	11:30 PM	12	301
	5:30 AM	18	333
04	11:30 AM	0	306
	5:30 PM	6	186
	11:30 PM	12	251
	5:30 AM	18	289

Table : 01

Among the 4 reading at 6 hours time interval for each sheep, CH_4 production rate in the 24-h period ranged from 442 ppm at 11:30 AM to 219 ppm at 5:30 PM, and max CH_4 production rate in the day ranged from 186 ppm at 5:30 PM to 442 ppm at 11:30 AM in 1st Sheep (Table 1). In most cases, CH_4 emission rate was lowest before morning feeding and highest approximately three hours after afternoon feeding.

SUMMARY

The concept of using an off-the-shelf hand-held methane gas detector to measure CH_4 concentrations from animals is very appealing and innovative because the it can be used as is after taking it out of the box (taking into consideration the calibration recommendations) and is easy to carry from animal to animal and from farm to farm. However, it can be challenging to get good-quality samples (especially when used outdoors), as well as to analyse and interpret data. For these reasons, studies need to be more coordinated in order to develop a standardised protocol for using the detector to measure enteric CH_4 concentrations from ruminant livestock.

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Review of Literature

Methane is formed in the rumen of ruminants by methanogenic bacteria under anaerobic conditions. This process enables ruminants to utilise the energy in low-quality feeds like grass and fodder with high cellulose content. Pseudo-ruminants like pigs and horses also produce methane but in much smaller quantities. Methane production by fermentation in insects, e.g. termites is now seen as significant on a global scale (Denman et al. 2007). Ritzman and Benedict (1938) published early data on methane yields by cows, sheep, goats, horses and elephants. They found that methane emissions are 4–7% of gross energy intake for ruminants fed at maintenance level. Blaxter and Clapperton (1965) found that methane emissions depended on feeding level and digestibility. The relation they found is used to calculate emissions at a detailed level. In developing countries, a large proportion of the feed consists of low-quality straw and fodder. Indian research estimated 9% methane yields in Indian cattle fed at maintenance level with low-quality feeds.

Crutzen et al. (1986) estimated the methane emissions from wild and domesticated animals, and humans. They found 80 Tg (range 65–100) CH4/yr. World herds of domesticated animals have increased since 1950. Crutzen found an increase in methane emissions of 0.6 Tg/yr or 0.75% per year between 1966 and 1986 from domesticated animals. Lerner et al. (1988) made a global database of methane emissions from livestock per gridcell of 1 × 1°. They found emissions of more than 5000 kg per km2 per year in small regions such as the Netherlands and Belgium, Bangladesh, parts of northern India and New Zealand. They also found that half the global emissions are from only five countries: India, the former Soviet Union, Brazil, the USA and China. Methane emissions from ruminants are increasing because of their increasing numbers and increasing milk production. FAO (2006) based on IPCC methodology, estimated a global total of 84 Tg CH4/yr from ruminants for the year 2005. An overview of methane from ruminants is given by Kelliher and Clark (2010). They estimated an emission of about 100 Tg/yr from ruminants for 2010, of which 14 Tg is from China, 12 Tg from Brazil, 11 Tg from India, 5.5 Tg from the USA, 3 Tg from Australia, 3 Tg from Pakistan, 3 Tg from Argentina, 2.5 Tg from Russia, 2.3 Tg from Mexico and 2 Tg from Ethiopia.

Eructated methane concentration in exhaled air samples to estimate methane emission was first reported by Garnsworthy et al. (2012), the measurement of CH4 concentration in air eructed by cattle during milking (often called the ‘sniffer’ technique) provides an estimate of total daily emission by individual animals on-farm. As detailed by Garnsworthy et al. (2012), a sampling inlet is placed in the feed manger of an automatic milking system and gas concentrations in manger air are continuously sampled, analyzed and logged at 1-sec intervals. A custom designed program identifies and quantifies CH_4 concentration peaks (eructation) together with peak frequency (eructation rate). An index of CH_4 emission rate (MER) is calculated during each milking for each animal as the frequency of eructation per min multiplied by the area under the curve (integral) of each eructation peak.

Handheld laser methane detector, the another approach to monitor exhaled air CH4 concentration is the use of handheld laser CH_4 detectors (LMD) to measure CH4 concentration in the air between the animal’s nose ormouth and the LMD (Chagunda, 2013; Ricci et al., 2014). Measurements of CH_4 concentration are taken manually by a portable apparatus approximately 1-3 m from the animal and are based on infrared-absorption spectroscopy for CH4. The sequence of data acquisition consists of short periods of 2-4 continuous min. The resulting data consist of a series of peaks which represent the animal’s respiratory cycle. Only peaks reflecting the increase in CH4 concentration due to exhalation or eructation are used in the analysis (Ricci et al., 2014).

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Biography

Shourav Datta Roni, son of Raghu Nath Datta and Rupna Datta, was born on November 3, 1997. He passed Secondary School Certificate examination from Anowara Govt. Model High School, Chattogram in 2013 (GPA-5.00) and then passed his Higher Secondary Certificate examination from Govt. City College, Chattogram (GPA-5.00). He is now doing his year-long internship programme for fulfilling the requirement of the Doctor of Veterinary Medicine (DVM) degree in Chattogram Veterinary and Animal Sciences University, Chattogram, Bangladesh. He has immense interest to work on microbiology.