**Concentration of methane gas at different levels of the animal shed**



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**Concentration of methane gas at different levels of the animal shed**



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**Abstract**

Methane is one of the greenhouse gasses (GHG) that is responsible for the current increase in the temperature and the climate system of earth. Methane is the second most abundant GHG, right after CO2. CH4 is 25 times more potent than CO2 when it comes to trapping heat in the atmosphere and also, it accounts for about 20% of global emissions. Ruminant livestock can produce 250 to 500 L of methane per day. This study was carried out to determine the differences in concentration of methane at different parts of an animal shed. Gas was collected at different periods of time from different locations of the shed. There were four categories for this study, concentration at different heights inside the animal shed, concentration at different times of the day, concentration at an altitude that was at the level of the roof of the shed where a pipe was attached compared to a higher altitude above it where the pipe ended and concentration when the spaces around the pipe was blocked and when it was not. The current study indicated that the concentration of methane is highest near the roof (62.69 ppm), less at the middle (61.86 ppm) and least at the bottom (54.39 ppm). It also showed that the concentration of accumulated methane was higher at noon (58.48 ppm) than in the morning (46.18 ppm). Concentration of methane near the roof where the bottom of the pipe was attached was higher (59.65 ppm) compared to the top of the pipe situated on the roof of the adjacent building (46.33 ppm). Concentration of methane when the empty spaces around the pipe was covered was lower (51.14 ppm) than when it was uncovered (51.94 ppm). It can be interpreted from the study that methane concentration has variations at different levels and at different times of the day inside the shed. The highest concentration of methane can be found near the level of the roof and at noon.

**Keywords:** Methane, gas, concentration, emission, compare, shed.

**Introduction**

Greenhouse gas has been an issue of major concern regarding climate change for almost a century. There are a number of greenhouse gasses that have been found as the key reasons that our climate is warming up rapidly. Methane gas, one that emits mostly from agricultural sources has also been flagged as one of the key reasons. About 44% of livestock emissions are in the form of methane while the remaining part is shared between Nitrous Oxide (29%) and Carbon Dioxide (27%) (FAO - News Article: Key facts and findings, 2021). This leads to the fact that the livestock supply chain emits 3.1 Gt CO2-eq of CH4 per annum, or 44 percent of anthropogenic CH4 emissions (Smith et al., 2007). While there have been many studies showing the percentage of emissions with respect to different species corresponding to their diet, fiber intake, ratio of microbes in their gut etc., very few studies have been done to find out the percentage of gas that can be found within the shed. This study was carried out to find out the different percentage of emission that can be found at different locations inside and outside the animal shed. The aim of this study is to enlighten ourselves with the comparison of the different concentrations of gasses present within and outside the shed to better understand the possible steps that can be taken to further our efforts to utilize the animal-emitted methane gas from the animal shed. To the author’s knowledge, no such studies have yet been carried out in Bangladesh.

**Objectives:**

1. To evaluate the comparative concentration of methane at different heights within the shed.
2. To compare the level of concentration of methane at the bottom and top of a pipe attached to one end of the shed.
3. To compare the concentration of methane in the shed at different times of the day.
4. To compare the concentration of methane before and after covering the leaks around the pipe that was attached.

**Review of literature:**

The enteric emission of methane by the livestock is significant in number. They are responsible for 95% of global enteric methane emission due to their increasing number, enormous body size and appetite combined with microbial fermentation of the feed in their gut. The accuracy of estimation of methane in case of ruminants depend largely on a number a factors and cannot probably be precisely calculated due to limited information. Even so, many scientists have accumulated various methods of collection of gasses from animals, e.g. Storm, Hellwing, Nielsen and Madsen, 2012. Various methods of collection of methane have been described below:

1. **Measuring methane by means of chambers:**

 The aim of this method is to measure the exhaled methane of animals with the help of a chamber by measuring the difference in concentration of gases. In this system the subject animal is kept in a chamber where the inflow and outflow of gasses can be controlled and measured. Any other leak in the chamber except for the inflow and outflow systems is completely closed. Gas is flown via these systems through a flow meter and gas sensors. The concentration of gasses is measured via these instruments. The difference in concentration of the incoming and outgoing gasses indicate the production of different gasses e.g. methane by the animal.

This method requires minute calculations involved since keeping an animal in such a closed enclosure may cause to vary its DM intake and therefore lead to variations in the emission of gasses. At the same time it may cause the animal a significant amount of stress as well. And so, these factors have to be taken into consideration while measuring the concentration.

1. **Measure methane with the SF6 (Sulfur Hexafluoride) Tracer Technique:**

 Since it was interpreted by some scientists that the chamber technique of gas measurement was not applicable for animals reared via free ranging system, SF6 Tracer Technique was discovered. The aim of this technique was to calculate the emission of a gas that mixes with the rumen fluid the same way CH4 does.  For this purpose a non-toxic, physiologically inert, stabile gas was needed that lead to the selection of SF6.

 SF6 is filled into small permeation tubes. The rate of diffusion of the gas out of the permeation tubes is measured by placing them in a 39 °C water bath and measuring the daily weight loss until it is stable. The permeation tube is then placed in the rumen of an experimental animal and collection of air can start. The sampling apparatus consists of a collection canister, a halter and capillary tubing. The capillary tubing is placed at the nose of the animal and connected with the evacuated canister. The tubing regulates the sampling rate. The sampling time is typically one day. The concentration of SF6 and CH4 in the canister is determined by gas chromatography.

This method includes a number of problems that include: 1) Maintaining a constant release rate from the permeation tubes, 2) effect of release rate upon emission rate of methane, 3) inconsistency between CH4 release determined by chambers and SF6 release determined by this technique etc.

Tests of permeation tubes before and after the experiment have shown differences in permeation rate. The permeation tubes are weighted in a laboratory under controlled environment and the release rate should be the same in the rumen. However, a 6-11% lower release rate in tubes placed in rumen fluid than in air has been observed (Vlaming J.B., 2007)

It has also been found that permeation tubes with high release rates give higher methane emissions than tubes with low release rates. And so, it has been recommended to use permeation tubes with similar release rates when comparison of different treatments is required (Vlaming J.B., 2007, Pinares-Patiño et al., 2008).

A 7% lower methane emission with the SF6 technique than with chambers with cattle was observed (Johnson et. al., 1994). This can be explained by the few percent of methane that is lost via rectum.

1. **In vitro gas production technique (IVGPT) for methane measurement:**

The basic principle of IVGPTs is to ferment feed under controlled laboratory conditions employing natural rumen microbes. Feed are subjected to different treatments followed by incubation at 39 °C with a mixture of rumen fluid, buffer and minerals for a certain time period, typically 24, 48, 72, 96 or 144 h. The amount of total gas produced during incubation is measured and its composition is analyzed to obtain data on the in vitro production of methane. Also it is possible to determine in vitro degradation of the feedstuffs, making it possible to determine whether a reduction in methane production is due to total feed degradation.

1. **The CO2 technique:**

A newly developed method for estimating methane emissions from livestock is by using CO2 as a tracer gas (Madsen et al., 2010). Instead of using externally added SF6, the naturally emitted CO2 is used to quantify CH4 emission. The CH4/CO2-ratio in the production of air of the animals is measured at regular intervals and combined with the calculated total daily CO2 production of the animals. The calculations are the same as for the SF6 tracer technique, only with CO2 as the tracer gas instead of SF6.

1. **Other measuring techniques:**

 A few other measuring techniques have also been adopted instead following the aforementioned techniques that involve possible alteration of the feeding habit of the animal resulting in varying results. As a result, a number of scientists have adopted various other techniques which let the animal be free in its usual atmosphere while determining the concentration of the desired gasses. These methods can roughly be divided into non-micrometeorological techniques and micrometeorological techniques. Micrometeorological methods include measuring flow of gas in the free atmosphere and relating these flows to animal emissions. Non-micrometeorological methods focus on systems rather than individual animals while micrometeorological methods are based on measurements of wind velocity and methane concentration, but the number of measuring points and the theories used to calculate emission rates differ between methods.

The technique that we adopted in our experiment for collecting methane did not involve major changes in the animal-house that might have led to a significant difference in the concentration of the collected gas.

**Materials and Methods**

 The study was conducted in the CVASU animal farm and the postgraduate laboratory under the Department of Animal Science and Nutrition, Chattogram Veterinary and Animal Sciences University (CVASU), Khulshi, Chattogram. The pipe, vacutainer tubes and other necessary instruments were mostly provided by Animal Science and Nutrition department laboratory.

**Study period:**

The overall research was conducted from February, 2021 to September, 2021.

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Figure 1: Preparation of the animal shed in CVASU campus

**Materials:**

Vacutainer tubes, syringes (10ml and 20ml), pipe (40 feet long, 3 inches in diameter), three way syringe valve, refrigerator and GC (Gas Chromatography) machine for gas analysis.

**Preparation of the animal shed:**

The experiment was carried out on the sheep shed of CVASU under the department of Animal Science and Nutrition.

The shed was about 18 feet in length and 14 feet in breadth. The floor was about 2.5 feet above the ground and was made of wood. The roof was gable type and was made of colored plastic material. At the center of the roof the height from the floor was about 12 feet. The entire room was cleaned with water and allowed to dry before the initiation of the experiment. At a later period a pipe was also attached to the roof connecting it to the roof of the adjacent building.

**Installation of pipe:**

Since methane is lighter than air, a pipe was set-up at one side of the farm to determine if methane accumulated more at the top of the pipe than at the bottom of it. The pipe was about 40 feet long and 3 inches in diameter. It was fit into the narrow space of about 4 inches in breadth between the edge of the roof and the wall of the building next to the farm. The bottom end of the pipe was kept inside the shed the upper end was tied to the top of the building adjacent to it.

**Covering up the roof:**

The space left at the side of the pipe was later covered up in full length with jute bags to prevent leakage of gasses from the shed. The aim was to concentrate the amount of gases in the shed to allow methane to travel through the pipe towards the rooftop.

**Analysis of the concentration of gas:**

The concentration of gas was determined by analyzing it with Gas Chromatography(GC) machine.

**Collection of gas:**

Two periods in the day were chosen for collection of gas from the shed, those are morning and noon. The gas was collected both while the animals were inside the shed and outside the shed. For collecting gas, 10 ml and 20 ml syringes were used for suction followed by using a three way valve to prevent any loss or contamination of the collected gas. The gas was then pushed inside vacutainer tubes and stored. Storage of samples was done by keeping the tubes in refrigerator at 40C temperature until analysis was completed.

**Results**

**Concentration of methane at different heights inside the shed:**

Methane was found in more concentration at higher level (6-8 feet) of the shed. At mid-level (3-6 feet) of the shed the concentration of methane was a little lower than at the top. The least amount of concentration was found at the bottom of the shed (<3 feet).

**Table 1:** Concentration of methane at different heights of the shed

|  |  |
| --- | --- |
| Parameters | Concentration of methane(in ppm) |
| Top of the shed | 62.69 |
| Middle of the shed | 61.86 |
| Bottom of the shed | 54.39 |

**Concentration of methane at different time of the day:**

Methane was found in more concentration at noon rather than in the morning.

**Table 2:** Concentration of methane at different time of the day

|  |  |
| --- | --- |
| Parameters | Concentration of methane(in ppm) |
| Morning | 46.18 |
| Noon | 58.48 |

**Concentration of methane while space around the pipe is covered or uncovered:**

The concentration of methane was slightly lower when the space around the pipe was covered than when it was uncovered

**Table 3:** Concentration of methane while space around the pipe is covered or uncovered

|  |  |
| --- | --- |
| Parameters | Concentration of methane(in ppm) |
| Covered | 51.14 |
| Uncovered | 51.94 |

**Concentration of methane at different lengths of the pipe:**

The concentration of methane decreases while going up towards the top of the pipe on the roof. Methane is found in more concentration at the bottom of the pipe than at the top.

**Table 4:** Concentration of methane at different lengths of the pipe

|  |  |
| --- | --- |
| Parameters | Concentration of methane(in ppm) |
| Bottom of the pipe | 59.65 |
| Top of the pipe | 46.33 |

**Discussion**

The Experiment was designed to analyze the concentration of methane at different levels in an animal shed. The current experiment suggests that in that sheep shed the study was carried out on, the concentration of methane appeared to be more at higher altitude inside the shed than at a lower altitude. Since methane is lighter than air, it is supposed to accumulate more at a higher altitude (Haskin, 2021). The study also shows that methane concentration is lower at the upper end of a pipe attached to the roof of the shed while it is higher in concentration at the bottom of it. Even though it should have accumulated in more concentration at a higher altitude. The reason of such a result could be that even though the expectation was that methane go inside the pipe and reach a higher altitude, there is no guarantee that the accumulated gases will enter the lumen of the pipe. In other words, it is possible that the gasses escaped from the shed through the holes in the fence rather than entering the pipe that was set for it to enter. It is further indicated by the study that the concentration of methane is more in the animal shed at noon than it is in the morning which is supported by Chaudhary et al., (2020); Bjerg et al., (2011). It is possible that the emission of methane was higher at noon due to the feeding routine in the farm. Feed is provided in the morning and at a later time at noon. At the same time, the animals were allowed to graze from the morning till noon after which they brought in again inside the shed. It is possible that the emission of gas was higher at noon because of the ongoing process of fermentation of the feed provided in the morning and the grasses consumed throughout the day which was being digested further by methanogenic bacteria producing a higher concentration of methane gas in the shed at noon. It is also evident that the difference of concentration of methane is less when the space around the pipe is covered and more when it is uncovered. The reason could be that following the empty spaces around the pipe getting blocked, the accumulated air escaped through the holes on the fences around the shed due to the ongoing air flow in the atmosphere rather than entering the pipe. Hence, the low concentration of methane is seen when the empty spaces around the pipe were covered.

**Conclusion**

Methane remains as one of the green-house gases responsible for increasing the temperature of earth and the climate. As the world approaches towards a sustainable future, the plan is to limit the global temperature rise to 1.5°C which is a paramount task for the entire world. Since agriculturally produced methane gas is one of the key reasons to the rise of GHG, focusing on utilizing gases produced in such a manner would definitely help the world to head towards a better future. This study suggests that the production and accumulation of methane inside the animal shed differs from one place to another and even at different times of the same day. Methane accumulates more at the top of the animal shed than at any other place within the shed. It also accumulates less at an even higher altitude than it does inside the animal shed. The production and accumulation of methane appears to be more at noon than in the morning too. Utilizing these information, if the accumulated methane can be utilized as an energy source, it would help the farmers further economically and also decrease the accumulation of agricultural methane in the environment.

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