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Photo: B. Hansen

RUMINANTS AND METHANE 2:4

Methods and techniques for measuring GHG emissions from ruminants

GHG EMISSIONS FROM RUMINANTS

In recent years, greenhouse gas (GHG) emissions from ruminants have gained increased attention. Anthropogenic emissions of enteric methane (CH4) are estimated to be responsible for about 18% of global GHG emissions (Gerber et al, 2013). The most important GHG are methane (CH4) and nitro oxide (N_2O). Enteric emissions of CH4 from domesticated ruminants, arising primarily from the fermentation of feed in the rumen, are considered to be one of the three largest sources of methane on a global scale. The emission of methane by cattle and sheep is a major pathway for carbon loss that results in reduced productivity (Johnson and Johnson, 1995). If the energy could be rechannelled into weight gain or milk production, it would increase production efficiency while

Respiration chambers NIBIO Tjøtta. Photo: V. Lind

reducing methane emission to the atmosphere. At pasture, the challenge in managing pastoral ecosystems is to reach an equilibrium between pasture growth and animal intake. When proper grazing management practices are adopted, animal productivity increase while CH_4 emissions per kg of animal product decreases (DeRamus et al, 2003). In Norway, GHG emission from agriculture are estimated to account for 4.5 % (SSB, 2018) of the total national emissions. Of this percentage, ruminant production is calculated to be responsible for about 60% (Harstad and Volden, 2009).

RESPIRATION CHAMBERS (RC)

Respiration chambers have been used as indirect calorimeters for the measurement of respiratory exchange, CH_4 and energy losses of ruminants for more than 120 years. Whole animal open-circuit RC with varying degrees of complexity are currently the most commonly used types (Global Research Alliance, 2018). The principle of whole animal RC systems is that inflowing air is circulated through the chamber and around the animal to mix incoming and emitted CH_4 within the volume of the chamber, while sampling incoming and exhaust air for gas analysis. Methane emission is determined by multiplying the airflow through the system by the concentration difference between inflowing and outflowing air. Common for all open-circuit RC is the need to correct measurements of concentration and flow to standard temperature and pressure conditions, and to account for humidity. These corrections are crucial due to their effects on gas volume. Measurements are normally performed over periods of 1-7 sequential days. Measured recovery of a known amount of CH_4 should be a standard procedure for testing and calibrating any RC used (Gerrits et al, 2018). If the absolute accuracy of CH_4 release is known, the recovery can be used as a correction factor to calibrate measurements for individual RC and compare measurements across research centres. In Norway, there are no RCs for cattle, but for small ruminants, six open-circuit RCs are located at NIBIO Tjøtta (Lind et al, 2020).

SF_6-TECHNIQUE

The SF_6-technique was developed by Zimmerman (1993) and the first reported use for estimating ruminant CH_4 emission was by Johnson et al (1994). The technique is suitable for penned as well as free ranging and grazing animals and relies on the placement of a small permeation tube (bolus) with a known SF_6 gas release rate into the reticulorumen of the animal. A pre-evacuated collection vessel (canister) is fixed to the animal and connected to tubing with an in-line flow restrictor (to regulate sampling rate) and samples of the exhaled air are continuously collected non-invasively. The tubes are extended and fixed to a halter so that they end near the nose and mouth of the animal. Collection vessels are replaced every 24 hours. Sampling is normally continued over a minimum period of five sequential days, with background air

SF_6-equipment at ewes. Photo: V.Lind

GreenFeed system in barn and at pasture. Photo: C-Lock Inc.

samples collected alongside animals simultaneously. Daily CH_4 emission is calculated using the ratio of CH_4:SF_6 in the canister with each gas corrected for background concentration, in conjunction with the pre-determined SF_6 permeation rate of the bolus tubes. The concentration of [CH_4] are expressed in ppm and the concentration of [SF_6] in ppt. Although mean CH_4 emission may not differ, within- and between animal variation has been considerably larger using the SF_6 technique for sheep (Pinares-Patiño et al, 2011) and dairy cattle (Grainger et al, 2007), relative to the RC technique. Such variability needs to be considered to establish the number of animals and number of within-animal measurements required.

In Norway, there is equipment for the SF_6-technique for sheep at NIBIO Tjøtta (Lind et al, 2019) and for cattle at NMBU Ås (Kidane et al, 2018).

AUTOMATED HEAD CHAMBERS - GREENFEED

The GreenFeed system (C-Lock Inc., Rapid City, South Dakota, USA) is a static short-term measurement devise that measures CH_4 and CO_2 emission from individual cattle or sheep by integrating measurements of airflow, gas concentration and detection of head position during each animal's visit to the unit (Zimmerman and Zimmerman, 2012; Huhtanen et al, 2015). The gas emission is measured using a combination of an extractor fan and sensors, which induce a measured airflow past the animal's head, allowing emitted air to be collected and sampled. The animal is enticed to voluntarily visit the unit using a feed supplement that is delivered within a hood. Animals can visit the unit at any time, but in practice a "visit" only results in a feed reward and measurement of CH_4 emission after a specified time has elapsed between visits. Methane emission measurements using a GreenFeed unit are typically carried out over short (3-7 min) periods, repeated several times within a day, over several days/weeks/months, and depends on each animal's voluntary visit to the unit. The system can be used in a variety of environments, in loose-housing barns and at pasture. Because the animal can move about freely, head position relative to airflow is important for successful CH_4 measurements (Hammond et al, 2016). When used outdoor, wind can reduce the fraction of CH_4 captured and therefore wind anemometers can be included to use a correction factor for wind. Supplemental feed may be a concern in both pastoral grazing systems and animal nutrition studies where there is the possibility of an excessive contribution of enticement feed to the diet. The animals need to be trained to use the system regularly.

In Norway, Greenfeed systems for cattle are used at Tomb agricultural school (owned by NorgesFôr), at Mære agricultural school and at the Animal Production Experimental Center at NMBU Ås (both owned by Geno). During spring 2020, a portable GreenFeed unit for cattle will be in use by NIBIO.

PAC – PORTABLE ACCUMULATION CHAMBERS

PAC are essentially airtight boxes without airflow and build for sheep/small ruminants. Methane emission is measured from individual animals over 1 or 2 hours while CH_4, CO_2 and other gases accumulate, and oxygen depletes. The PAC acts to trap all exhaled gases during the collection period and takes a single CH_4 measurement at the end. Methane emission is estimated as the concentration of CH_4 (corrected for background) multiplied by net chamber volume, adjusted for standard temperature pressure, divided by time of measurement (Goopy et al, 2011). The time of use should be limited to avoid negative effects of increased chamber CO_2 concentration. PAC techniques provides a single spot sample of accumulated gases emitted by an animal. PAC may be useful for screening a larger number of sheep in relatively short time periods, as they may be delivered with e.g. 12 boxes per unit. The PAC method may be useful when aiming to identify animals with naturally low methane

Portable Accumulation Chambers. Photo: NSG

emissions for the selection process of next generation. Moderate repeatability of measurements of CH_4 emission by individual sheep using PAC was reported in studies at different sites. The time of measurements relative to feeding and any postprandial changes in CH_4 emissions is a potential source of variation in these measurements and thus should be accounted for when the technique is used.

In Norway a PAC system is hosted by Norsk Sau og Geit (NSG).

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